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Human Capital and Gender Effects on Agro-Industrial Investment in the Turkestan region

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Abstract

Agricultural investment is an important driver of regional development, particularly in predominantly rural regions where employment, labour productivity and entrepreneurial activity determine the sustainability of the local economy. This article examines the relationship between human capital, gender characteristics and agricultural investment in the Turkestan region. The empirical analysis covers the period from 2015 to 2024 and combines descriptive statistics, correlation analysis and an exploratory ordinary least squares regression model. Investment in agricultural fixed assets is used as the dependent variable. At the same time, labour productivity, the share of women managers in peasant and farm households, average monthly wages and agricultural employment are included as explanatory variables. The results indicate that agricultural investment in the Turkestan region increased from KZT 8.5 billion in 2015 to KZT 142.8 billion in 2024. Over the same period, labour productivity and average wages increased, agricultural employment declined, and the share of women managers rose from 22.6% to 29.9%. The regression model identifies a statistically significant negative association between the share of women managers and agricultural investment. However, this result should be interpreted with caution because the analysis is based on only ten annual observations, and the explanatory variables are strongly correlated. The estimated relationship may reflect differences in farm size, access to productive assets, financing conditions or other unobserved structural characteristics rather than a direct effect of women's participation in agricultural management. The findings demonstrate the need to improve the availability of gender-disaggregated data on agricultural loans, subsidies and investment support.

Keywords: Women, Gender Equality, Gender Inclusion, Employment, Finance, Entrepreneurship, Leadership

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1. INTRODUCTION

Agriculture plays a strategically important role in Kazakhstan's economy by contributing to food security, rural employment, regional development and the formation of sustainable production chains. In the context of technological modernisation, agricultural investment has both sectoral and broader socioeconomic significance. It supports the renewal of machinery and equipment, the introduction of modern production technologies, the development of processing activities, improvements in labour productivity and the competitiveness of rural territories.

In recent years, investment activity in Kazakhstan's agricultural sector has demonstrated positive dynamics. State support programs, machinery modernisation, the expansion of agricultural processing and the implementation of regional investment projects have accompanied growth in fixed capital investment. More than 260 agricultural investment projects were planned for implementation in 2025, with over 6,000 new jobs expected to be created through the establishment of production facilities and modernisation initiatives (EastFruit, 2025; Prime Minister of the Republic of Kazakhstan, 2025). However, an increase in investment volume does not automatically ensure higher economic efficiency. The outcomes of investment depend on the quality of human capital, professional competencies, labour productivity, employment structure and the ability of agricultural producers to use financial and technological opportunities effectively.

This issue is particularly relevant to the Turkestan region, one of Kazakhstan's major agricultural regions. The region is characterised by a high share of the rural population, a large number of peasant and farm households, active agricultural entrepreneurship, and growing investment activity. Between 2015 and 2024, agricultural investment in the Turkestan region increased from KZT 8.5 billion to KZT 142.8 billion. During the same period, the region's share in national agricultural investment rose from 4.7% to 15.5%. The particularly sharp increase recorded in 2024 may be associated with the implementation of large agricultural and processing projects and the strengthening of the region's position in the national agricultural investment structure (Finance.kz, 2025).

Despite these positive trends, the regional agricultural sector continues to face structural constraints. These include limited access to long-term financing, insufficient technological modernisation among small farms, shortages of qualified personnel, declining agricultural employment and uneven access to state support instruments. Labour productivity has increased considerably, but substantial differences remain between enterprises and territories. Consequently, the effectiveness of agricultural investment depends not only on the amount of financial resources but also on the capacity of producers and workers to transform these resources into productivity growth, higher value added and sustainable employment.

Human capital is therefore an important component of agricultural investment development. Education, professional training, managerial skills, and the ability to adopt new technologies influence the efficiency with which agricultural enterprises use investment resources. Labour productivity and wages may reflect some aspects of human capital quality, while employment dynamics indicate changes in the relationship between labour and capital. In the context of mechanisation and digitalisation, investment growth may reduce demand for low-skilled labour while increasing demand for workers with technical, managerial, financial, and digital competencies.

The gender dimension is another important component of regional agricultural development. Women actively participate in rural employment and agricultural entrepreneurship, including managing peasant and farm households. In the Turkestan region, the share of women managers increased from 22.6% in 2015 to 29.9% in 2024. However, a higher level of women's representation in farm

management does not necessarily imply equal access to land, collateral, credit, subsidies, technologies, consulting services and investment programs. Women-led farms may differ from other agricultural enterprises in size, asset structure, specialisation, and access to business networks. These structural characteristics may influence their investment opportunities.

The gender factor should therefore be examined not only as a social characteristic but also as a potential component of the regional investment environment. At the same time, conclusions about gender inequalities require caution because publicly available statistics provide limited information on the gender structure of recipients of agricultural loans, subsidies, grants and other forms of investment support. The share of women managers can indicate women's participation in agricultural entrepreneurship, but it cannot directly measure their access to financial resources.

Previous studies of agricultural investment in Kazakhstan have primarily focused on financial resources, government support, infrastructure, production capacity and institutional conditions. Considerably less attention has been paid to the combined relationship between investment, human capital indicators and the gender structure of agricultural management at the regional level. This creates a need for an integrated analysis that considers labour productivity, wages, employment and women's participation in farm management as interconnected characteristics of agricultural development.

The purpose of this study is to examine the relationship between human capital, gender characteristics and agricultural investment in the Turkestan region. To achieve this purpose, the study addresses the following objectives: to analyse the dynamics of agricultural investment in Kazakhstan and Turkestan region from 2015 to 2024; to assess changes in labour productivity, wages and agricultural employment; to examine the dynamics of women's participation in the management of peasant and farm households; to estimate an exploratory regression model of agricultural investment; and to formulate recommendations for improving regional investment policy and the availability of gender-disaggregated agricultural finance data.

The scientific contribution of the study lies in integrating human capital and gender-related indicators into a single exploratory framework for analysing agricultural investment at the regional level. Unlike approaches that focus exclusively on financial, infrastructural or institutional determinants, the study considers labour productivity, wages, employment and women's managerial participation as elements of the broader investment environment. The practical significance of the research lies in the potential to apply its findings to improve regional programmes that support agricultural modernisation, professional training, women's entrepreneurship, and access to investment resources.

Given the limited number of annual observations and the strong relationships among the explanatory variables, the econometric results are interpreted as exploratory associations rather than evidence of causal effects. This approach makes it possible to identify potentially important relationships while avoiding conclusions that the available data cannot directly support.

2. LITERATURE REVIEW

The theoretical framework of this study combines human capital theory, approaches to agricultural modernisation, and research on gender inequality in access to productive resources. Agricultural investment is determined not only by the availability of financial resources and infrastructure but also by the capacity of workers, managers and entrepreneurs to adopt technologies, organise production efficiently and transform investment into productivity growth and higher value added.

Human capital theory provides the central conceptual basis for analysing these relationships. Schultz (1961) interpreted education, health and vocational training as forms of investment that increase individual

productivity and generate economic returns. In his analysis of traditional agriculture, Schultz (1964) emphasised that agricultural modernisation depends on farmers' knowledge, skills and ability to adopt new production methods. Becker (1964) further developed this approach by distinguishing between general and specific human capital. General human capital encompasses education and transferable competencies, whereas specific human capital refers to knowledge and skills valuable within a particular enterprise, sector, or production environment.

This distinction is especially relevant to agriculture. General education may improve labour mobility and access to information, while knowledge of local climatic conditions, production cycles, agricultural technologies and regional markets forms sector-specific human capital. Mincer (1958) also demonstrated that education and work experience represent investments that influence productivity and earnings. In agricultural production, these factors affect workers' and managers' ability to operate machinery, apply digital technologies, organise production processes, and respond to market changes.

The importance of human capital is also supported by endogenous growth theory. Lucas (1988) argued that accumulated knowledge and skills create external effects that influence not only individual productivity but also broader economic development. In rural economies, the dissemination of professional knowledge, managerial practices and technological experience may improve the performance of local production networks and increase the efficiency of investment across the agricultural sector.

The theory of induced innovation provides an additional explanation of agricultural transformation. Hayami and Ruttan (1985) showed that the relative scarcity of production factors influences technological change. Where labour is abundant, agricultural development may rely more heavily on labour-intensive production methods, whereas labour shortages create incentives for mechanisation and capital-intensive technologies. This approach is relevant to the regional structure of Kazakhstan's agriculture, where differences in rural population density, farm size and access to machinery influence the direction and intensity of investment.

Modern research generally considers agricultural investment as a multidimensional process shaped by access to finance, state support, infrastructure, technology, market conditions and management quality. Investment volume alone does not determine agricultural performance. The economic effect of investment depends on whether enterprises possess the human, technological, and organisational capacity required to transform capital expenditure into higher productivity, increased output, and sustainable employment.

For Kazakhstan, access to financing and the effectiveness of state support remain important determinants of agricultural development. Omarkhanova et al. (2017) identified insufficient investment activity, limited access to financial resources, and weaknesses in capital-attraction mechanisms as major constraints on the development of the agricultural sector. Petrick and Götz (2019) demonstrated that agricultural performance in Kazakhstan and other post-Soviet economies is influenced by farm organisation, management quality, integration into production chains and the design of subsidy mechanisms. These findings indicate that investment outcomes depend not only on the amount of resources allocated but also on the institutional and organisational environment in which agricultural enterprises operate.

Human capital performs an intermediary function in this process. Investments in equipment, digital systems, or processing facilities may have limited effects when farms lack qualified specialists, managerial competencies and the capacity to maintain and effectively use new technologies. Conversely, improvements in education, professional training and management quality may increase the return on agricultural investment and strengthen the competitiveness of rural enterprises.

A separate strand of literature examines gender inequalities in agriculture. Women make a substantial contribution to agricultural production and rural entrepreneurship, but they often have more limited access than men to land, credit, machinery, extension services, training and markets. The Food and Agriculture Organisation of the United Nations (FAO, 2011) concluded that gender inequality in access to productive resources reduces agricultural productivity and constrains rural development. More recent studies similarly emphasise that women's economic participation in agriculture is influenced by unequal access to assets, technologies, financial services and decision-making opportunities (CABI, 2024; World Bank, 2026).

From an investment perspective, such inequalities may affect both the capacity of women-led farms to attract capital and their ability to implement modernisation projects. UNCTAD (2019) argues that gender-sensitive investment policy can improve women's access to productive assets and increase the contribution of agricultural investment to inclusive development. This means that the gender dimension should be considered not only as a social policy issue but also as a component of investment efficiency and regional economic development.

Empirical studies show that women farmers often face stronger constraints in obtaining collateral, loans, information, training and advisory services. Jost et al. (2016) found that unequal access to resources and institutional support restricts women's adoption of climate-adaptive and technological practices. Similar conclusions are presented by Perez et al. (2015) and Mutenje et al. (2019), who demonstrate that gender differences in access to assets and technologies influence the resilience and economic performance of agricultural households.

Recent studies increasingly examine women not only as agricultural workers but also as farm managers, entrepreneurs and decision-makers. Štreimikis and Kyriakopoulos (2024) show that integrating gender indicators into agricultural policy can improve the targeting of support measures and contribute to rural sustainability. However, the analytical potential of such approaches depends on the availability of gender-disaggregated data on subsidies, credit, investment grants and other forms of support.

This issue is especially relevant to Kazakhstan. Women actively participate in rural employment and agricultural entrepreneurship, including managing peasant and farm households. Nevertheless, the presence of women among farm managers does not necessarily indicate equal investment opportunities. Women-led farms may differ in size, asset ownership, collateral availability, specialisation, and participation in business networks. These structural differences may affect their access to loans, subsidies and modernisation programs.

At the same time, the available statistical data do not allow direct measurement of the investment resources received by women-led farms. The share of women managers reflects women's participation in agricultural management, but does not indicate the amount of credit, subsidies or investment support allocated to them. Consequently, this indicator should be interpreted as a characteristic of the gender structure of agricultural entrepreneurship rather than as a direct measure of gender equality in financing.

The existing literature reveals several important research gaps. First, studies of agricultural investment in Kazakhstan predominantly focus on financial, institutional and production factors, while the role of human capital is less frequently examined at the regional level. Second, gender-related studies generally analyse employment or entrepreneurship without integrating these indicators into agricultural investment models. Third, there is a shortage of gender-disaggregated regional data on recipients of agricultural finance and state support.

Based on the reviewed literature, three main propositions can be formulated. First, the effectiveness of agricultural investment depends on human capital, including

professional skills, labour productivity and managerial competencies. Second, changes in employment and wages may reflect the broader technological and structural transformation of agriculture. Third, women's participation in agricultural management may be associated with investment conditions, but this relationship cannot be interpreted without considering farm size, access to assets and other structural characteristics.

Accordingly, this study integrates labour productivity, wages, agricultural employment and the share of women managers into an exploratory model of agricultural investment in the Turkestan region. The purpose of this approach is not to establish a definitive causal relationship but to identify associations that may further research and the development of more detailed gender-disaggregated agricultural statistics.

3. METHODOLOGY

The empirical analysis examines the relationship between human capital indicators, gender characteristics and agricultural investment in the Turkestan region. The region was selected because of its important role in Kazakhstan's agricultural economy, its large rural population, the high concentration of peasant and farm households and the rapid growth of investment activity during the study period.

The information base covers the period from 2015 to 2024. It includes statistical data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of Kazakhstan, the Ministry of Agriculture of Kazakhstan and other official and analytical sources. The analysis uses annual data on investment in agricultural fixed assets, labour productivity, average monthly wages, agricultural employment, and the share of women managers in peasant and farm households.

The dependent variable is agricultural investment in the Turkestan region. It is represented by investment in fixed assets allocated to agriculture and measured in billion tenge. In the econometric model, this variable is denoted as (INV_t).

The explanatory variables are defined as follows:

$PROD_t$ is labour productivity in agriculture, measured in thousand tenge per employed person;

$WOMEN_t$ is the share of women managers in peasant and farm households in Turkestan region, measured as a proportion from 0 to 1;

$WAGE_t$ is the average monthly nominal wage in agriculture in Turkestan region, measured in thousand tenge;

$EMPL_t$ is agricultural employment in Turkestan region, measured in thousands of persons.

The share of women managers was converted from percentages to proportions before estimation. For example, 22.6% was entered into the model as 0.226. This transformation is necessary to ensure a clear and economically meaningful interpretation of the corresponding regression coefficient.

Labour productivity is used as a proxy indicator of the effectiveness of human capital. It reflects the capacity of workers and managers to generate output using available labour, technologies and production resources. Average wages are included as an indirect indicator of labour quality and economic returns to employment. Agricultural employment reflects the scale of labour participation in the sector and may also capture structural changes associated with mechanisation and capital–labour substitution. The share of women managers characterises women's participation in agricultural entrepreneurship and management, but it does not directly measure women's access to credit, subsidies or investment support.

The empirical analysis combines descriptive statistics, correlation analysis and an exploratory ordinary least squares regression model. Because the variables differ considerably in scale and several of them demonstrate strong upward trends, logarithmic transformations are applied to investment, labour productivity and wages. The estimated model is specified as following formula (1):

$$ln(INV_t) = \beta_0 + \beta_1 ln(PROD_t) + \beta_2 WOMEN_t + \beta_3 ln(WAGE_t) + \beta_4 EMPL_t + \varepsilon_t, \quad (1)$$

where:

$ln(INV_t)$ is the natural logarithm of agricultural investment in year (t);

$ln(PROD_t)$ is the natural logarithm of labour productivity;

$WOMEN_t$ is the proportion of women managers in peasant and farm households;

$ln(WAGE_t)$ *is* the natural logarithm of the average monthly nominal wage;

$EMPL_t$ is agricultural employment;

$beta_0$ is the intercept;

$\beta_1, \beta_2, \beta_3, \beta_4$ are the estimated regression coefficients;

$varepsilon_t$ is the error term;

(t) denotes the year from 2015 to 2024.

The coefficient for the share of women managers is interpreted as a semi-elasticity. Since the variable is entered as a proportion, an increase of one percentage point corresponds to a change of 0.01 in ($WOMEN_t$). Therefore, the approximate percentage change in investment associated with a one-percentage-point increase in the share of women managers is calculated as formula (2):

$$Percentage\ change\ in\ investment = 100 \times [\exp(0.01 \times \beta_2) - 1] \quad (2)$$

The coefficient for agricultural employment is also interpreted as a semi-elasticity because the dependent variable is expressed in logarithmic form, while employment is measured in level terms.

Correlation analysis is used to examine the direction and strength of pairwise relationships among the variables. It is also used to identify potential multicollinearity. Particular attention is paid to correlations between labour productivity, wages and employment because these indicators may reflect common structural and time-related changes in the agricultural sector.

The regression model is evaluated using the coefficient of determination, adjusted coefficient of determination, F-statistic, t-statistic, and p-values. The Durbin–Watson statistic is used to assess residual autocorrelation. Variance inflation factors should also be calculated to evaluate the severity of multicollinearity among the explanatory variables.

The empirical analysis is conducted in several stages. First, a database covering the period from 2015 to 2024 is compiled. Second, the dynamics of agricultural investment in Kazakhstan and the Turkestan region are examined. Third, changes in labour productivity, wages and employment are analysed. Fourth, the dynamics of women's participation in the management of peasant and farm households are assessed. Fifth, pairwise correlations and the exploratory regression model are estimated. Finally, the results are interpreted with reference to the limitations of the available data.

The methodology has several important limitations. First, the regression model is based on only ten annual observations. With four explanatory variables and an intercept, the number of residual degrees of freedom is very small, reducing statistical power and increasing sensitivity to individual observations.

Second, several explanatory variables are strongly correlated. Labour productivity, wages and employment reflect interconnected processes of technological modernisation, inflation, labour restructuring and capital accumulation. High multicollinearity may inflate standard errors and cause regression coefficients to change sign across alternative specifications.

Third, most variables demonstrate pronounced time trends. Therefore, some of the identified relationships may reflect common temporal dynamics rather than direct economic links. The model should consequently be

interpreted as exploratory. It does not provide a basis for establishing causal effects.

Fourth, the share of women managers is used as a proxy for the gender structure of agricultural entrepreneurship. It does not directly capture access to loans, subsidies, collateral, investment grants or technological support. The available data, therefore, does not permit a direct test of financial discrimination or unequal access to agricultural investment resources.

Fifth, publicly available data does not provide a complete breakdown of investment by farm size, ownership structure, or the manager's gender. Omitted characteristics such as farm scale, specialisation, asset ownership and participation in state programs may influence the estimated coefficients.

Because of these limitations, the results are interpreted as statistical associations observed within a short regional time series. They identify patterns that may guide further research but should not be treated as definitive evidence of causal relationships. A more robust analysis would require panel data covering several regions, gender-disaggregated information on recipients of agricultural finance and alternative model specifications based on growth rates or first differences.

4. ANALYSIS AND RESULTS

The empirical analysis identified the main trends in agricultural investment, labour indicators and women's participation in farm management in the Turkestan region. Table 1 presents the dynamics of investment in agricultural fixed assets in Kazakhstan and the Turkestan region from 2015 to 2024.

Table 1. Investment in fixed assets in agriculture in Kazakhstan and the Turkestan region for 2015–2024

Year	Kazakhstan, KZT billion	Turkestan region, KZT billion	Share of Turkestan region, %
2015	180,5	8,5	4,7
2016	195,3	9,2	4,7
2017	210,8	10,8	5,1
2018	245,6	12,5	5,1
2019	280,4	15,3	5,5
2020	565,4	18,6	3,3
2021	620,0	22,4	3,6
2022	710,0	28,0	3,9
2023	773,2	35,2	4,6
2024	919,0	142,8	15,5

Note: compiled by the authors

Investment in agriculture in Kazakhstan increased from KZT 180.5 billion in 2015 to KZT 919.0 billion in 2024, approximately 5.1 times. The most substantial acceleration occurred after 2019, reflecting the growing importance of food security, agricultural modernisation, and the implementation of state-supported investment projects. Investment growth in the Turkestan region was considerably faster than the national average. Regional agricultural investment increased from KZT 8.5 billion in 2015 to KZT 142.8 billion in 2024, representing approximately a 16.8-fold increase.

Between 2015 and 2023, regional investment increased gradually from KZT 8.5 billion to KZT 35.2 billion. A particularly sharp rise occurred in 2024, when the volume of investment was more than four times higher than in the previous year. As a result, the share of the Turkestan region in national agricultural investment increased from 4.7% in 2015 to 15.5% in 2024. However, this change was not uniform. The regional share declined to 3.3% in 2020 and remained below 5% until 2023. The exceptional increase in 2024 may therefore reflect the implementation of several large projects rather than a stable long-term

change in the regional investment structure. This concentration should be considered when interpreting the econometric results, as the 2024 observation differs substantially from those of preceding years and may strongly influence the estimated coefficients.

Changes in the labour structure of agriculture accompanied investment growth. During the study period, labour productivity increased, average nominal wages rose, and the number of people employed in agriculture declined. At the national level, labour productivity in agriculture increased from approximately KZT 1.2 million per employed person in 2015 to KZT 5.0 million per employed person in 2024. This trend suggests an increase in output per worker. It may reflect mechanisation, technological modernisation, changes in farm structure, and a reduction in the number of workers employed in relatively low-productivity activities.

Agricultural employment declined from approximately 1.25 million persons in 2015 to 1.05 million persons in 2024. The simultaneous increase in investment and decrease in employment is consistent with a gradual substitution of capital for labour. Investments in machinery, irrigation systems, digital technologies and processing equipment may reduce demand for manual labour while increasing demand for employees with technical, managerial and digital skills.

In the Turkestan region, the average monthly nominal wage in agriculture increased from KZT 65.2 thousand in 2015 to KZT 162.0 thousand in 2024. This increase may reflect inflation, changes in labour demand and a gradual improvement in the economic return to agricultural employment. However, nominal wage growth alone cannot be taken as evidence of human capital improvement, as broader price dynamics may also influence it. Labour productivity, wages and employment therefore capture interrelated aspects of agricultural transformation, and their common trends should be considered when evaluating individual regression coefficients.

Table 2 presents the dynamics of the share of women managers in peasant and farm households, the reported gender pay gap and investment per farm.

Table 2. Gender-related indicators of agricultural development for 2015–2024

Year	Proportion of female managers in farms, %	Gender pay gap, %	Investments for 1 farm, million tenge
2015	22,6	—	154,0
2016	23,8	—	158,3
2017	24,8	—	176,2
2018	25,9	—	192,9
2019	27,0	8,5	223,4
2020	28,2	8,3	261,2
2021	29,1	8,1	303,5
2022	30,2	8,6	370,9
2023	30,1	8,2	456,0
2024	29,9	8,3	1794,0

Note: compiled by the authors

The share of women managers in peasant and farm households increased from 22.6% in 2015 to 29.9% in 2024. The highest value was recorded in 2022, when women accounted for 30.2% of farm managers. The indicator then declined slightly to 30.1% in 2023 and 29.9% in 2024. These data demonstrate the substantial participation of women in agricultural entrepreneurship and management. Nevertheless, representation among managers does not directly indicate the volume of investment resources received by women-led farms. The available statistics do not provide a breakdown of agricultural loans, subsidies, or investment grants by the farm manager's gender.

The reported gender pay gap remained relatively stable at approximately 8% between 2019 and 2024. This indicator should be interpreted with caution because the available data do not provide a detailed breakdown by occupation, enterprise size, or form of employment. Investment per farm increased gradually from KZT 154.0 thousand in 2015 to KZT 456.0 thousand in 2023. In 2024, it rose sharply to KZT 1,794.0 thousand. This increase is consistent with the exceptional rise in total regional investment during that year. It may indicate higher capital intensity, but it may also reflect the concentration of investment in a limited number of relatively large projects. Therefore, the indicator should not be interpreted as evidence that every farm received a comparable amount of investment.

The correlation matrix presented in Table 3 provides additional information on the relationships among the variables.

Table 3. Correlation matrix

Variable	Investment	Labour productivity	Share of women managers	Average wage	Agricultural employment
Investment	1.0000	0.8354	0.5232	0.7728	−0.7147
Labour productivity	0.8354	1.0000	0.8284	0.9793	−0.9454
Share of women managers	0.5232	0.8284	1.0000	0.9223	−0.9613
Average wage	0.7728	0.9793	0.9223	1.0000	−0.9907
Agricultural employment	−0.7147	−0.9454	−0.9613	−0.9907	1.0000

Note: compiled by the authors

Investment is positively correlated with labour productivity, with a coefficient of 0.8354. A positive relationship is also observed between investment and average wages, with a correlation coefficient of 0.7728. These results indicate that higher investment volumes occurred during the same period as increases in productivity and wages. The pairwise correlation between investment and the share of women managers is positive but more moderate, at 0.5232. Thus, in the unadjusted relationship, higher women's participation in farm management is associated with higher investment.

Agricultural employment is negatively correlated with investment, with a coefficient of −0.7147. This result is consistent with the observed combination of investment growth and declining agricultural employment. At the same time, the matrix demonstrates extremely strong correlations among the explanatory variables. The correlation between labour productivity and wages is 0.9793, while the correlation between wages and agricultural employment is −0.9907. The share of women managers is also strongly correlated with wages and employment. These values indicate severe multicollinearity. Consequently, the individual regression coefficients may be unstable, have inflated standard errors and change sign when several correlated variables are included simultaneously.

The model has a high coefficient of determination. The included variables jointly explain 96.78% of the variation in the logarithm of agricultural investment, with an adjusted R^2 of 0.9420. The F-test indicates that the explanatory variables are jointly statistically significant. However, these indicators should not be interpreted as evidence of a highly reliable model. The estimation is based on only ten annual observations and includes four explanatory variables, leaving a very small number of residual degrees of freedom. In addition, the strong correlations among labour productivity, wages, employment and the share of women managers reduce the stability of the individual coefficient estimates (Table 4).

Table 4. Exploratory OLS regression results

Variable	Coefficient	Standard error	t-statistic	p-value	Significance
Constant	42.0207	31.8927	1.3176	0.2448	—
ln(Labour productivity)	−2.3219	1.6555	−1.4025	0.2197	—
Share of women managers	−0.5328	0.1568	−3.3978	0.0193	**
ln(Average monthly wage)	5.1476	3.8558	1.3350	0.2394	—
Agricultural employment	−26.3670	14.8564	−1.7748	0.1361	—

Note: compiled by the authors.

The coefficient for the share of women managers is negative and statistically significant at the 5% level. Its value is −0.5328, with a p-value of 0.0193. Since the WOMEN variable is expressed as a proportion from 0 to 1, an increase of one percentage point corresponds to a change of 0.01 in this variable. The estimated percentage change in investment is therefore calculated as follows:

$$100 \times \left[\exp\left(0.01 \times (-0.5328)\right) - 1\right] \approx -0.53\%$$

Accordingly, holding the other variables constant, a one-percentage-point increase in the share of women managers is associated with an approximately 0.53% decrease in agricultural investment. This result should not be interpreted as evidence that women's participation reduces investment activity. The negative coefficient may reflect differences in farm size, asset ownership, collateral availability, specialisation, or access to support programs. It may also be affected by the strong multicollinearity among the explanatory variables and the exceptional increase in investment observed in 2024.

The result differs from the positive pairwise correlation between investment and the share of women managers. In the correlation analysis, the coefficient is 0.5232, indicating that the two variables generally increased together over the period. The change in sign after the inclusion of productivity, wages and employment suggests that the regression coefficient is sensitive to the joint movement of the explanatory variables. This further supports a cautious interpretation.

The coefficient for the logarithm of labour productivity is −2.3219, but is not statistically significant. Therefore, the model does not provide sufficient evidence that labour productivity is independently associated with investment after controlling for other variables. The negative sign may result from multicollinearity, common time trends or the simultaneous decline in agricultural employment.

The coefficient on the logarithm of average wages is positive at 5.1476 but statistically insignificant. This indicates that the available data do not allow wage growth to be identified as an independent determinant of agricultural investment. The result may also reflect the influence of inflation and the close relationship between wages and labour productivity.

Agricultural employment has a negative coefficient of −26.3670 and a p-value of 0.1361. Although the coefficient is not statistically significant at conventional levels, its sign is consistent with the descriptive evidence that investment growth was accompanied by declining employment. This may reflect mechanisation, capital–labour substitution and changes in the demand for agricultural skills.

Overall, the results show that agricultural investment in the Turkestan region increased rapidly and was accompanied by higher labour productivity, rising wages, lower employment and greater participation of women in farm management. At the same time, the econometric estimates are strongly affected by the small sample size, common time trends, multicollinearity, and the exceptional 2024

observation. The regression findings should therefore be regarded as exploratory associations rather than evidence of causal effects. More robust conclusions require panel data covering several regions and gender-disaggregated information on agricultural loans, subsidies, grants and investment support.

5. DISCUSSION

The results demonstrate that agricultural investment in the Turkestan region was accompanied by substantial changes in labour productivity, wages, employment, and women's participation in farm management. However, these relationships are complex and should not be interpreted as direct causal effects. The short time series, common trends among the variables, strong multicollinearity and the exceptional increase in investment recorded in 2024 limit the stability of the econometric estimates.

The rapid growth in agricultural investment underscores the growing importance of the Turkestan region in Kazakhstan's agricultural economy. Between 2015 and 2024, regional investment increased considerably faster than the national total, while the region's share in national agricultural investment rose sharply in the final year of the study. This trend reflects the strengthening of the region's investment position and the implementation of capital-intensive agricultural and processing projects. At the same time, the concentration of growth in 2024 suggests that a limited number of large projects may have influenced the observed dynamics. Consequently, the increase should not be automatically interpreted as a uniform improvement in investment access for all peasant and farm households.

The descriptive results are consistent with the view that changes in the relationship between capital and labour accompany agricultural modernisation. Investment growth occurred alongside higher labour productivity, rising wages, and declining employment. This pattern corresponds to the theoretical propositions of Schultz (1961, 1964), Becker (1964) and Lucas (1988), according to which the economic return on investment depends on knowledge, professional skills and the ability to adopt new technologies. It is also consistent with the induced innovation approach of Hayami and Ruttan (1985), which suggests that changes in the relative availability of labour and capital influence the direction of technological development.

The decline in agricultural employment should not necessarily be interpreted as a deterioration in sectoral development. It may reflect mechanisation, digitalisation, and the replacement of labour-intensive production processes with more capital-intensive technologies. Nevertheless, such a transformation creates new requirements for human capital. Agricultural enterprises increasingly need specialists with technical, digital, managerial and financial competencies. Therefore, investment policy should be coordinated with professional training, retraining and the development of agricultural extension services. Without improvements in workforce skills, the economic return on machinery, irrigation infrastructure, digital platforms and processing equipment may remain limited.

The positive pairwise relationships between investment, labour productivity and wages support the assumption that investment expansion occurs alongside improvements in production efficiency and labour remuneration. However, the regression coefficients for productivity and wages are statistically insignificant after the simultaneous inclusion of the explanatory variables. This result is mainly attributable to the extremely strong correlations among productivity, wages, and employment. In a sample of only ten observations, it is difficult to distinguish their independent contributions because they reflect closely related aspects of the same structural transformation.

The negative coefficient for labour productivity in the regression model should therefore not be interpreted as evidence that productivity growth reduces investment. The positive pairwise correlation between these

variables indicates that they generally moved in the same direction. The change in sign after controlling for wages, employment and women's participation is more likely to reflect multicollinearity, common time trends and model sensitivity than a meaningful negative economic relationship. The same caution applies to the positive but statistically insignificant wage coefficient.

The gender-related findings require particularly careful interpretation. The share of women managers in peasant and farm households increased substantially during the study period, demonstrating the growing role of women in agricultural entrepreneurship and rural management. This result is consistent with international research that emphasises women's considerable contributions to agricultural production and rural economic development (FAO, 2011; CABI, 2024; World Bank, 2026).

At the same time, the regression model identifies a negative association between the share of women managers and agricultural investment after controlling for labour productivity, wages and employment. This result differs from the positive pairwise correlation between the two variables. The difference indicates that the estimated coefficient is highly sensitive to the inclusion of strongly correlated explanatory variables. It may also reflect unobserved structural differences between women-led and other farms rather than the influence of the manager's gender itself.

Women-led farms may differ in average size, ownership of productive assets, availability of collateral, specialisation, market orientation and participation in state support programs. Smaller farms generally have more limited access to long-term lending and large investment projects, regardless of managerial efficiency. Therefore, the negative coefficient may partly capture differences in farm structure and resource endowment that are not included in the model.

This interpretation is consistent with studies showing that women in agriculture may face restricted access to land, finance, technologies, training and advisory services (FAO, 2011; Jost et al., 2016; Perez et al., 2015; Mutenje et al., 2019). Nevertheless, the present study cannot directly confirm the existence or scale of such barriers in the Turkestan region because it does not contain gender-disaggregated information on loan applications, approved financing, subsidies, investment grants or collateral ownership.

Accordingly, the statistically significant coefficient for the share of women managers should be treated as an indication of a relationship requiring further investigation rather than as evidence of financial discrimination. Establishing whether women-led farms have unequal access to investment resources would require micro-level data comparing male- and female-managed farms with similar characteristics, including farm size, specialisation, assets, collateral, productivity and participation in public support programs.

The reported gender pay gap also requires additional examination. Its relative stability at approximately 8% indicates differences in earnings. However, the available data do not show whether this gap results from differences in occupation, working hours, qualifications, enterprise size or other factors. A more reliable assessment would require individual-level wage data and the use of decomposition methods to distinguish the explained and unexplained components of the earnings gap.

The findings also highlight a broader statistical problem. The absence of systematic gender-disaggregated data limits policymakers' and researchers' capacity to evaluate the inclusiveness of agricultural investment programs. The number of women managers indicates participation in agricultural entrepreneurship. However, it does not show how much financing women-led farms receive, what proportion of their applications are approved or whether the terms of financing differ from those offered to other farms.

Regional agricultural policy would therefore benefit from the introduction of gender-disaggregated monitoring of subsidised loans, guarantees, grants, machinery leasing

and investment subsidies. Such monitoring should include not only the number of recipients but also the amount of support, farm size, sector of specialisation, repayment performance and investment outcomes. This data would make it possible to determine whether differences in financing are explained by structural characteristics or unequal access to support mechanisms.

The results further suggest that financial support alone may be insufficient for improving the investment position of small and medium-sized farms. Access to financing depends on managers' ability to prepare business plans, maintain financial records, assess investment risks, and comply with program requirements. Targeted advisory services, mentoring, financial literacy programs and assistance in preparing investment applications may therefore improve access to support instruments, particularly for farms with limited administrative and managerial capacity.

For the Turkestan region, these measures are especially relevant because the regional agricultural structure includes a large number of peasant and farm households. Small-scale agricultural production creates opportunities for entrepreneurship and rural employment but may restrict participation in large investment projects. Policy instruments should therefore differentiate between the needs of large agricultural enterprises and smaller farms, including women-led businesses.

The study contributes to the literature by integrating investment, human capital indicators and women's managerial participation within a single regional framework. At the same time, its findings confirm the need for more robust empirical designs. Future research should use panel data covering several agricultural regions, introduce regional and time fixed effects and include direct indicators of access to finance and state support. It would also be useful to estimate alternative specifications using growth rates or first differences to reduce the influence of common time trends.

The results indicate that agricultural investment development in the Turkestan region depends on the interaction among financial resources, technological modernisation, human capital, and the structure of agricultural entrepreneurship. The findings do not support a simple conclusion that any single factor independently determines investment. Instead, they demonstrate that investment policy should combine capital support with workforce development, improved statistical monitoring and measures that expand transparent and equal access to financial and technological resources.

6. CONCLUSION

The study examined the relationship between human capital indicators, gender characteristics, and agricultural investment in the Turkestan region from 2015 to 2024. The results show that the region experienced substantial growth in agricultural investment, accompanied by increases in labour productivity and wages, a decline in agricultural employment and a gradual rise in the share of women managers in peasant and farm households.

The observed investment dynamics confirm the strengthening of the Turkestan region's position in Kazakhstan's agricultural economy. However, the exceptional increase recorded in 2024 suggests that several large-scale projects may have influenced regional investment growth. Therefore, the rise in total investment should not be interpreted as evidence of an even distribution of financial resources across all agricultural enterprises and farms.

The changes in labour indicators reflect the continuing structural transformation of agriculture. Higher investment and labour productivity, together with declining employment, are consistent with mechanisation, technological modernisation, and a gradual shift from labour-intensive to more capital-intensive production. These changes increase the demand for workers and managers with technical, digital, financial and organisational competencies. Consequently,

agricultural investment policy should be closely linked with professional training, retraining and the development of managerial capacity in rural areas.

The analysis also confirms the increasing participation of women in agricultural management. The share of women managers in peasant and farm households increased over the study period, indicating their growing role in rural entrepreneurship. Nevertheless, greater representation does not automatically imply equal access to loans, subsidies, investment grants, productive assets or technological support. The available statistics do not provide sufficient gender-disaggregated information to determine whether women-led farms receive investment resources on equal terms.

The exploratory regression model identified a statistically significant negative association between the share of women managers and agricultural investment after controlling for labour productivity, wages and employment. This result should not be interpreted as evidence that women's participation negatively affects investment. The coefficient may reflect differences in farm size, asset ownership, collateral availability, specialisation, and participation in state support programs. It may also be influenced by the small number of observations, strong multicollinearity, common time trends and the exceptional investment value recorded in 2024.

Accordingly, the econometric results should be treated as preliminary statistical associations rather than causal effects. The study does not directly prove the existence of financial discrimination or unequal treatment of women-led farms. Such conclusions require microlevel data on loan applications, approved financing, subsidies, grants, collateral, farm size and investment outcomes.

The practical implications of the study underscore the need to improve regional agricultural investment policy. First, public authorities and financial institutions should introduce systematic gender-disaggregated monitoring of subsidised loans, guarantees, leasing programs, investment grants and other agricultural support instruments. Second, support programs should take into account the specific constraints faced by small and medium-sized farms, including limited collateral, insufficient financial documentation and weaker access to advisory services. Third, financial support should be combined with training in business planning, financial management, digital technologies and investment project preparation.

Human capital development should become an integral component of agricultural modernisation. Investment in machinery and infrastructure can generate sustainable results only when agricultural enterprises have the professional and managerial capacity to use these resources effectively. Regional programs should therefore include vocational training, agricultural extension services, digital skills development and support for the adoption of modern production and management practices.

The study has several limitations. The empirical model is based on only ten annual observations, which restricts statistical power and makes the estimates sensitive to individual years. The strong correlations among labour productivity, wages, employment and the share of women managers create multicollinearity and reduce the stability of the regression coefficients. In addition, the use of nominal indicators may partly reflect inflation, while the absence of gender-disaggregated financial data limits the assessment of women's actual access to investment resources.

Future research should extend the analysis to several agricultural regions and apply panel-data models with regional and time effects. It should also use real rather than nominal financial indicators, test alternative specifications based on growth rates or first differences and include direct measures of access to credit, subsidies, investment grants and state support. Surveys and microlevel data on male- and female-managed farms would make it possible to assess whether differences in investment are explained by farm characteristics or unequal access to financial instruments.

Overall, the development of agricultural investment in the Turkestan region requires an

integrated approach that combines financial support, technological modernisation, human capital development, and transparent access to investment resources. Improving regional investment attractiveness depends not only on increasing the total volume of capital expenditure but also on strengthening the capacity of agricultural producers and ensuring that support mechanisms are accessible to farms of different sizes, ownership structures and managerial characteristics.

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