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MUHANDISLIK OYLIGI

“RAQAMLI TEXNOLOGIYALARNI RIVOJLANTIRISH VA INNOVATSION MUHANDISLIK YECHIMLARI: ZAMONAVIY TENDENSIYALAR VA ISTIQBOLLAR” MAVZUSIDA RESPUBLIKA ILMIY-AMALIY ANJUMANI TO’PLAMI MATERIALLARI

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INNOVATIVE TECHNOLOGIES AND INVESTMENT EFFICIENCY IN COTTON-TEXTILE CLUSTERS: OPTIMIZING COSTS THROUGH INDUSTRY 4.0 SOLUTIONS.

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Annotatsiya. *Paxta yetishtirish jarayoni qishloq xo‘jaligining muhim tarmoqlaridan biri bo‘lib, iqtisodiy samaradorlik va ekologik barqarorlikni ta’minlash uchun resurslardan samarali foydalanish hamda xarajatlarni optimallashtirish talab etiladi. Ushbu tadqiqotda O‘zbekistonning voha hududlarida joylashgan klasterlarning paxta yetishtirish xarajatlariga ta’sir etuvchi omillar o‘rganildi. Regression model orqali jami yer maydoni, fermer xo‘jaliklari soni, tomchilatib sug‘orish ulushi, hosildorlik, irrigatsiya va melioratsiya obyektlarining mavjudligi, qishloq xo‘jaligi investitsiyalari, klaster mablag‘lari, bank kreditlari, mavsumiy ish o‘rinlari va quyosh energiyasidan foydalanish kabi omillarning ta’siri baholandi. Tadqiqot natijalari klasterlar faoliyatini takomillashtirish, agrotexnologiyalarni modernizatsiya qilish hamda barqaror qishloq xo‘jaligini rivojlantirish bo‘yicha ilmiy va amaliy asos bo‘lib xizmat qiladi.*
Kalit so‘zlar: *Paxta yetishtirish, xarajatlarni optimallashtirish, regressiya tahlili, qishloq xo‘jaligi investitsiyalari, tomchilatib sug‘orish, klaster mablag‘lari, mavsumiy ish o‘rinlari, quyosh energiyasi, barqaror qishloq xo‘jaligi.*

Abstract. *The cotton production process plays a crucial role in the agricultural sector, requiring efficient resource utilization and cost optimization to ensure economic and environmental sustainability. This study examines the impact of various factors on the production costs of cotton clusters located in oasis regions of Uzbekistan. Using a regression model, we analyze the influence of total land area, number of farms, share of drip irrigation systems, yield, availability of irrigation and reclamation facilities, agricultural investments, cluster funding, bank loans, seasonal employment, and solar energy usage on production costs. The findings provide valuable insights for improving cluster operations, modernizing agricultural technologies, and promoting sustainable farming practices. The results can serve as a scientific and practical basis for enhancing economic efficiency and environmental sustainability in cotton production.*
Keywords: *Cotton production, cost optimization, regression analysis, agricultural investments, drip irrigation, cluster financing, seasonal employment, solar energy, sustainable agriculture.*

Аннотация. *Процесс выращивания хлопка играет важную роль в сельском хозяйстве, требуя эффективного использования ресурсов и оптимизации затрат для обеспечения экономической и экологической устойчивости. В данном исследовании рассматривается влияние различных факторов на затраты на производство хлопка в кластерах, расположенных в оазисных регионах Узбекистана. С помощью регрессионной модели анализируется влияние общей площади земли, количества фермерских хозяйств, доли систем капельного орошения, урожайности, наличия ирригационных и мелиоративных объектов, инвестиций в сельское хозяйство, финансирования кластеров, банковских кредитов, сезонной занятости и использования солнечной энергии на затраты производства. Полученные результаты представляют ценную информацию для совершенствования работы кластеров, модернизации агротехнологий и развития устойчивого сельского хозяйства, обеспечивая научную и практическую основу для*

повышения экономической эффективности и экологической устойчивости в хлопководстве.

Ключевые слова: *Производство хлопка, оптимизация затрат, регрессионный анализ, инвестиции в сельское хозяйство, капельное орошение, финансирование кластеров, сезонная занятость, солнечная энергия, устойчивое сельское хозяйство.*

Cotton cultivation is an important sector of agriculture that requires efficiency improvements, cost optimization, and ecological sustainability. Especially in Uzbekistan, oases in the regions located clusters for effective use of resources, irrigation system improvement, and village farm investments. The key to impact analysis is ensuring economic stability by identifying and enhancing crucial factors that contribute to sustainable development. This research oasis in the regions located clusters of cotton cultivation expenses that affect provider factors. Research results cluster activity further improvement, agrotechnology modernization to do, and ecological terms in terms of stable village farm system formation for a scientific and practical basis to be serviced.

Stata 18.0 and SPSS 25.0 programs were used in the scientific study of these considerations. During the modeling process, econometric modeling was performed on 14 variables of a total of 114 cotton clusters in the regions of our republic based on spatial data. Initially, Cronbach's alpha test was used to check the reliability of the data being modeled.

Cronbach's alpha test is widely used to assess the internal reliability of measurement instruments. This indicator examines how closely several variables in a test or questionnaire are related to each other, and as a result, the internal consistency of the measurement instrument is assessed. Cronbach's Alpha value ranges from 0 to 1 , with a high value indicating good reliability and a low value indicating that the measurement is unreliable. Typically, if $\alpha \geq 0.7$, the measurement is considered satisfactory [1]. In the model, $\alpha = 0.8692$, which means 86.92 % - good reliability.

Test scale = mean(standardized items)
Average interitem correlation: 0.3220
Number of items in the scale: 14
Scale reliability coefficient: 0.8692

The multivariate ordinary least squares (OLS) regression model is one of the widely used methods in economic and statistical research and is used to estimate the relationship between a dependent variable and several independent variables [2]. The following steps were performed to analyze this model, and performing these steps correctly increases the reliability of the OLS model and ensures that the results are scientifically accurate [3].

1. Determining the model specification – the regression equation was formulated:

$y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_{13} * X_{13} + \varepsilon$, where y is the dependent variable, X_ix is the independent

variable, β_iy is the estimated coefficients, and ε y is the error term [4].

In this case, through a regression model, y- total cost spent, X_1- total land area of the cluster, X_2- number of farms in the cluster, X_3- percentage of land area with drip irrigation system implemented compared to the total land area, X_4- productivity level, - X_5funds allocated for the transition to drip irrigation system , X_6- a farmer's loan for switching to a drip irrigation system, X_7 - existing irrigation and land reclamation facilities, cluster funds, Important factors such as X_8- clusters' own funds, X_9- investments in agriculture, X_{10}- the cost of projects organized with cluster funds, X_{11}- the cost of projects organized with bank loans, X_{12} - seasonal jobs were analyzed. The impact of renewable energy sources, in particular X_{13}- electricity from solar panels on economic efficiency was also taken into account.

2. OLS model estimation – Model parameters were estimated using Stata software.

We used the Pearson pairwise correlation test to determine the relationships. According to it, this table presents pairwise correlations between variables related to costs and other factors, the statistical significance of which is determined by p-values.

1 presents the pairwise correlation coefficients between the various variables, along with their statistical significance (p-values in parentheses). The dependent variable Total_expenditure (total expenses) exhibits a strong positive correlation with several factors.

Table 1. Pearson pairwise correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Total_expenses~d	1.000							
(2) Total_land_area	0.782*	1.000						
	(0.000)							
(3) Number_farms	0.726*	0.850*	1.000					
	(0.000)	(0.000)						
(4) Percentage_lan~t	0.068	0.020	0.030	1.000				
	(0.475)	(0.836)	(0.754)					
(5) Productivity	0.232*	0.154	0.041	0.254*	1.000			
	(0.013)	(0.102)	(0.668)	(0.006)				
(6)	0.735	0.488	0.537	0.483	0.266	1.000		

Money_spent_ir~e	*	*	*	*	*			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)			
(7) Farmer_loan_ir~e	0.687*	0.367*	0.432*	0.261*	0.227*	0.788*	1.000	
	(0.000)	(0.000)	(0.000)	(0.005)	(0.015)	(0.000)		
(8) Irregation_lan~n	0.537*	0.380*	0.382*	0.151	0.032	0.532*	0.626*	1.000
	(0.000)	(0.000)	(0.000)	(0.108)	(0.738)	(0.000)	(0.000)	
(9) Cluster_own_fu~s	0.734*	0.564*	0.548*	0.157	0.100	0.659*	0.365*	0.268*
	(0.000)	(0.000)	(0.000)	(0.095)	(0.289)	(0.000)	(0.000)	(0.004)
(10) Investment_ag~e	0.421*	0.360*	0.305*	0.203*	0.126	0.348*	0.368*	0.283*
	(0.000)	(0.000)	(0.001)	(0.030)	(0.182)	(0.000)	(0.000)	(0.002)
(11) Value_project~s	0.496*	0.329*	0.277*	0.071	0.112	0.344*	0.384*	0.428*
	(0.000)	(0.000)	(0.003)	(0.451)	(0.234)	(0.000)	(0.000)	(0.000)
(12) Value_bank_cr~s	0.186*	0.090	-0.004	0.046	0.048	0.166	0.181	0.071
	(0.048)	(0.344)	(0.966)	(0.626)	(0.610)	(0.078)	(0.054)	(0.455)
(13) Seasonal_empl~t	0.715*	0.559*	0.562*	0.100	0.127	0.530*	0.589*	0.610*
	(0.000)	(0.000)	(0.000)	(0.289)	(0.177)	(0.000)	(0.000)	(0.000)
(14) kwt	0.213*	0.036	0.040	0.226*	0.205*	0.237*	0.237*	0.105
	(0.023)	(0.704)	(0.675)	(0.015)	(0.029)	(0.011)	(0.011)	(0.267)

These findings highlight the importance of land size, financial mechanisms, and labor in determining cost patterns, while some variables, such as credit-related factors, contribute less.

is a statistical technique used to understand the relationship between a single dependent variable and multiple independent variables. It extends the principles of simple linear regression to account for the complexity of real-world data and allows researchers to examine the combined effects of multiple predictors [5].

Table 2. Simple linear regression model

Total_expenses_inc~d	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Total_land_area	7.098	1.212	.86	0	4.694	9.502	**
Number_farms	-20.575	34.074	0.60	.547	-88.176	47.027	
Percentage_land_dr~n	-952.313	291.685	3.26	.002	-1531.008	-373.618	**
Productivity	1290.204	705.86	.83	.071	-110.203	2690.611	
Money_spent_irriga~m	.25	.33	.76	.451	-.405	.905	
Farmer_loan_irriga~m	1.346	.279	.83	0	.793	1.9	**
Irregation_land_re~n	-.354	1.163	0.30	.762	2.661	1.953	
Cluster_own_funds	.601	.094	.38	0	.414	.788	**
Investment_agricul~e	-.36	.493	0.73	.468	-1.338	.619	
Value_projects_clu~s	.199	.128	.55	.123	-.055	.454	
Value_bank_credit_~s	.023	.099	.23	.816	-.174	.221	
Seasonal_employment	8.378	2.501	.35	.001	3.416	13.341	**
Kwt	6.533	18.43	.35	.724	-30.032	43.097	
Constant	-13872.184	24992.128	0.56	.58	-63455.854	35711.486	

Mean dependent var	124996.522	SD dependent var	117990.284
R-squared	0.910	Number of obs	114
F-test	77.369	Prob > F	0.000
Akaike crit. (AIC)	2739.220	Bayesian crit. (BIC)	2777.527

**** p<.01, ** p<.05, * p<.1*

Overall, the regression confirms that land use, financial costs, and labor are strong determinants of total costs. In a multivariate linear equation, the dependent variable is expressed as the addition of a constant term and the multiplication of each independent

variable by its respective coefficients [6].

Total_expenses_incurred =−13872.184+ 7.098 (Total_land_area) −20.575(Number_farms)−952.313(Percentage_land_drip_irrigation)+1290.204 (Productivity)+0.25(Money_spent_irrigation_system)+1.346 (Farmer_loan_irrigation_system) −0.354(Irregation_land_reclamation)+ 0.601(Cluster_own_funds)−0.036(Investment_agriculture)+0.199 (Value_projects_clusters)+0.023(Value_bank _credit_projects)+ 8,378(Seasonal_employment)+6.533 kwt +ϵ

In general, based on the regression results obtained from the OLS [7] model, it was found that several variables significantly affected the outcome.

3. Testing the classical OLS hypotheses:

• Heteroscedasticity test – The residual variance was checked for constantness using the Breusch-Pagan test.

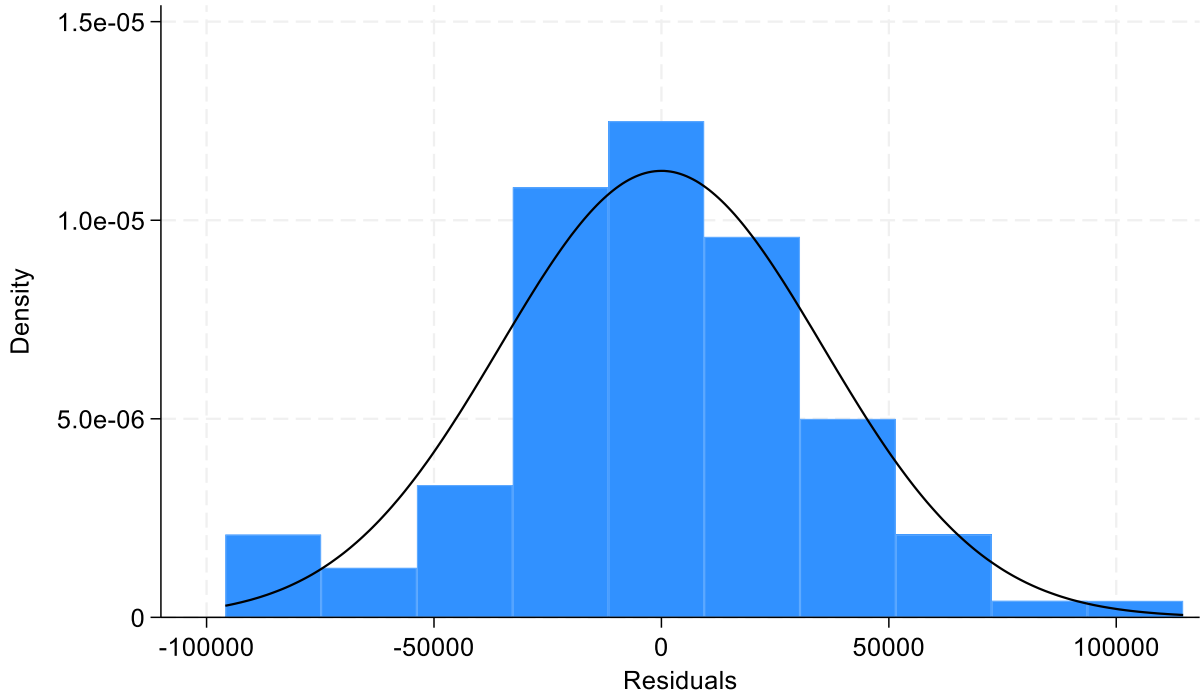
used to test for heteroscedasticity. This test checks whether the variance of the residuals is constant. If heteroscedasticity is detected, this indicates that the standard OLS estimators are not efficient and it is recommended to use robust standard errors or other alternative methods. The null hypothesis for the Breusch-Pagan test is that the variance of the errors is constant (homoscedasticity exists), while the alternative hypothesis is that heteroscedasticity exists, which can negatively affect the accuracy of the regression model. In this study, the Breusch-Pagan test was performed to test for heteroscedasticity:

Test for heteroskedasticity Assumption: Normal error terms Variable: Fitted values of Total_spent_costH0: Constant variance chi2(1) = 1.48Prob > chi2 = 0.2230

The result is chi2(1) = 1.48, p-value = 0.2230. Since the p-value is greater than 0.05, we cannot reject the null hypothesis, i.e., there is no heteroscedasticity. Therefore, the standard OLS model works correctly and robust standard errors or alternative methods are not required [8].

• Fit to normal distribution – The normal distribution of the residuals was assessed using the skewness-kurtosis test.

A histogram was drawn for the residuals:



Another basic requirement of a regression model is that the residuals are normally distributed. If this condition is not met, the results of the standard t-test and F-test may be incorrect and the reliability of the model may be reduced. The skewness-kurtosis test (sktest) is widely used to check whether the residuals are normally distributed. This test evaluates the degree of skewness and kurtosis of the residuals and determines whether they correspond to a normal distribution.

In this study, a skewness-kurtosis test was performed and the resulting p-value was 0.238 is greater than 0.05, the null hypothesis is not rejected, meaning that the residuals can be considered to be normally distributed. The histogram and normal curve also confirm this result. Thus, the results of the regression model are considered reliable and do not require additional transformation or the use of special methods [9].

Skewness and kurtosis tests for normality
----- Joint test -----

Variable	Obs.	Pr(skewness)	Pr(kurtosis)	Adj	chi2(2)	Prob>chi2
e	114	0.488	0.077	3.690	0.158	

• Multicollinearity testing – the relationship between independent variables was determined using the estat vif test [10].

A variance inflation factor (VIF)

test was performed to determine whether there is multicollinearity among the independent variables in the regression model. According to the results obtained using the estat vif command in Stata, the VIF value for all variables is less than 10, and the average VIF is 3.060. This result indicates that there is no strong multicollinearity in the model and confirms that the estimated coefficients are reliable [11].

A VIF < 10 is generally considered acceptable, and these results indicate that there is no significant correlation between the independent variables in the model. As a result, the uncertainty (standard errors) in the model does not increase, and the results are considered reliable [12].

VIF	1/VIF
7.510	0.133
4.510	0.222
4.500	0.222
4.300	0.233
2.990	0.335
2.930	0.342
2.560	0.391
2.170	0.462
2.150	0.465
1.820	0.548
1.780	0.563
1.270	0.787
1.250	0.798
3.060	

4. Model quality assessment – The overall fit of the model was checked using the R-squared and F-test.

The goodness of fit of the model is assessed by the coefficient of determination - R-squared value in Table 2 (simple linear regression model). [13] The model has a high R-squared value of 0.910, indicating that approximately 91% of the variation in total costs is explained by the independent variables. The model is statistically significant overall, with an F-test value of 77.369 ($p < 0.001$), which is confirmed by.

5. Analysis of results and conclusion - the economic and statistical significance of the estimated parameters was interpreted.

The research findings focused on identifying the important factors affecting cotton production costs. The OLS regression results showed that some variables were statistically significant and had a significant impact on cotton production costs, while others did not have an impact to the extent expected from an economic perspective.

1. Statistically significant variables:

The total land area coefficient is positive and statistically significant, confirming the increase in total costs as land area increases.

Productivity has a significant impact on cost increases, as higher yields require technological costs.

Funds allocated for drip irrigation also tend to increase costs, indicating that innovative irrigation technologies require an upfront investment.

The seasonal jobs rate is positive and significant, confirming that labor costs are one of the most important factors.

2. Statistically Insignificant Variables:

Number of farms—this variable did not have a strong impact on total costs, as expected, which means that there is no significant impact on the cost level of farms operating within clusters.

Investments in Agriculture (Qx_investitsiya) – A small coefficient of this factor indicates its low economic importance, i.e. the investment has no immediate effect on reducing or increasing costs.

Bank lending – this factor has also yielded negligible results, as loan funds may take time to directly affect production costs.

According to the results of the analysis , land area, productivity, drip irrigation and seasonal employment are the factors that have the greatest impact on the costs of cotton production. At the same time, the number of farms , agricultural investments and bank loans did not significantly shape direct costs. These results help to draw important scientific and practical conclusions in the formation of financial and agronomic strategies of clusters. It is possible to make recommendations, such as the need to modernize irrigation systems to increase economic efficiency and develop optimal strategies for attracting seasonal workers.

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