Prospects of changes in the productivity of fruit garden and vegetable crops due to modernization of the fruit and vegetable network

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Abstract. Forecasting the productivity of fruit and vegetable crops requires taking into account the specific characteristics and indicators of the field. However, it should not be forgotten that the production of fruit orchards is mainly done by perennial plants, while vegetable crops are mainly one-year plants. In our opinion, several factors should be taken into account in order to forecast the yield of fruit and vegetable crops, and we used the method of multifactorial regression analysis to determine the relationship. By finding a solution to this problem in the course of the research, it was determined the interrelationship of several factors related to the modernization of production, which affect the level of productivity in vegetable cultivation. The article analyzes the role of fruits and vegetables in ensuring food security of the country, its importance in the life of people and the state of cultivation today. At the same time, the beneficial properties of grown products for the human body were analyzed, their differences from fruits and vegetable products grown in other countries Keywords: Efficiency, Factors, Classification, Modernization, Innovation, Mechanism, Advanced Technologies.

1 Introduction

In recent years, special attention has been paid to the radical reform of the agriculture sector of our country, especially the fruit and vegetable sector, including attracting investments to modernize production, introducing resource-saving technologies, and providing producers of agricultural products with modern equipment [1, 2].

According to the Decree of the President of the Republic of Uzbekistan No. PF-5853 of October 23, 2019, until 2030, the annual growth of the added value in agriculture will be 5%, the export volume of agricultural and food products will increase by 20 billion US dollars, and the productivity of labor in agriculture will increase by one worker. It is planned to increase from the current 3960 US dollars to 6500 US dollars in one year [3-6].

Under such circumstances, under the influence of the process of production modernization, tasks such as forecasting the system of growing fruit and vegetable products in advance, increasing productivity in the future, and forecasting the state of growth of the production volume continue to gain relevance [7, 8]. It should be noted that the development of the fruit and vegetable sector depends on many factors [9]. Therefore, among a number of

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methods of economic analysis, the use of mathematical modeling methods makes it possible to realistically assess the dynamics of development, covering the factors affecting it [10-12].

In the scientific literature, we can observe the use of various options and methods of forecasting the volume of production, productivity and market conditions. According to Djumanova, there are 130 different methods of developing forecasts in practice, and they can be conditionally divided into 3 different important groups in forecasting socio-economic processes. They are the extrapolation method, the expert evaluation method of forecasting, and the modeling methods.

2 Materials and Methods

To make a forecast, we first run a multivariate regression analysis model.

$$y = \alpha_0 \sum_{i=1}^{n} a_i x_i \tag{1}$$

where, y – the resulting indicator; $x_1, x_2, \ldots, x_n$– factors influencing the final performance, - unknown parameters.

In order to determine the relationship in the given linear model $y=f(x_1, x_2, \ldots, x_n)$, it is necessary to determine the parameters of the unknowns $a_1, a_2, \ldots, a_n$, for this it is advisable to use the method of least squares.

After the number of unknown parameters exceeds 2, it is advisable to implement it using existing software packages.

According to the results of the research, forecasting the productivity of fruit and vegetable crops requires taking into account the specific characteristics and indicators of the field. However, it should not be forgotten that the production of fruit orchards is mainly done by perennial plants, while vegetable crops are mainly one-year plants. In our opinion, several factors should be taken into account in order to forecast the yield of fruit and vegetable crops, and we used the method of multifactorial regression analysis to determine the relationship. By finding a solution to this problem in the course of the research, it was determined the interrelationship of several factors related to the modernization of production, which affect the level of productivity in vegetable cultivation (Table 1).

Table 1. The main factors affecting productivity in fruit and vegetable cultivation.

Selected factors	
In fruit growing	**In vegetable growing**
Y - yield, quintals/ha; X1 - total orchard area, hectares; X2 – price of mineral fertilizers used per hectare, UZS; X3 - labor cost per unit, UZS; X4 - number of horticulture equipment, units; X5 - value of the UMM spent on one hectare of land, UZS	Y - yield, quintals/ha; X1 – cost of mineral fertilizers, UZS; X2 – point credit of cultivated area; X3 – total cultivated area, ha; X4 - labor cost, UZS; X5 - number of equipment used in vegetable growing, units; X6 - value of the UMM spent on one hectare of land area, UZS

In this case, the average yield of vegetable products is considered as a result factor, the factors affecting its growth, the price of mineral fertilizers used per 1 ha of cultivated area, the change in soil quality, the total cultivated area, the labor cost per 1 ha, the number of techniques used in vegetable growing and 1 Important factors affecting productivity, such as the cost of fuel and lubricants used per hectare of land area, were taken as a basis (Table 1).

Y – yield, quintals/ha;

X_1 –cost of consumable mineral fertilizers, UZS;

X_2 – crop area land quality score;
X_3 – total cultivated area, ha;
X_4 – labor cost, UZS;
X_5 – number of equipment used in vegetable growing, pcs;
X_6 –value of the GST for 1 ha of land area, UZS.

3 Results and Discussion

Using the same method, the factors influencing productivity in fruit cultivation were also analyzed. Below are the values of the factors influencing the regression analysis of yield change in fruit cultivation (Table 2).

Y – yield, quintals/ha;
X_1 – total area of orchards, ha;
X_2 – cost of mineral fertilizers used per 1 ha, UZS;
X_3 – labor cost per 1 ha, UZS;
X_4 – number of gardening equipment, pcs;
X_5 – cost of the GST spent on 1 ha of area, UZS.

Table 2. Values of factors affecting the regression analysis of changes in the yield level in vegetable production.

Years	Y	X1	X2	X3	X4	X5	X6
2005	133.3	365797	53	8506	226806	177	118961.5
2006	138.2	435390	53	10772	260827	200	141614
2007	145.3	503567	53	11718	326034	222	160002.5
2008	187.8	572100	53	9333	438177	246	172487
2009	196.6	635812	54	9088	588856	264	202273.5
2010	199.2	730710	54	8642	791301	287	231998.5
2011	201.8	839830	54	9170	1201233	291	284212
2012	201.7	965397	54	8906	1519497	309	310042
2013	203.4	1206718	54	8042	2027186	321	348090
2014	208.4	1508360	54	8075	2772077	329	431730
2015	208.8	1690070	54	8333	2849056	337	535460
2016	208.9	1937008	54	8834	3206634	376	791300
2017	209.9	2182335	54	8444	3622298	428	861000
2018	224.4	2434850	54	9773	3730967	503	963500
2019	219.8	2849750	54	11136	3992134	579	1039350

Based on the values of the factors in the tables given above, the calculation of the following correlation matrix using the STATA program of the pairwise correlation coefficients representing the relationship between the resulting factors obtained for fruit and vegetable products and the factors influencing it is as follows (Tables 3 and 4).

Table 3. Values of factors affecting regression analysis of gross yield change in fruit production.

Years	Yield, quintals/ha	Area, ha	Spending on mineral fertilization, UZS	Labor cost, UZS	Number of techniques, pcs	GST expenditure on 1 ha area, UZS
t	Y	X1	X2	X3	X4	X5
2008	59.5	858	505358	316567	135	109382
2009	62.4	876	543395	379846	141	128271
2010	63.9	895	578081	561499	153	147121
2011	67.4	912	602167	710345	158	180232
2012	70.1	924	633861	898544	164	196612
2013	71.2	935	681571	1084992	169	220740
2014	75.2	937	702650	1336695	173	273780
2015	81.9	947	773169	1470387	179	339560
2016	87.2	951	795656	1690934	187	501800
2017	79.9	967	875221.6	1690934	193	546000
2018	77.9	1017	100650.5	2288787	198	611000
2019	79.3	1048	116754.5	2517632	212	659100

Table 4. Matrix of pairwise correlation coefficients of correlation levels of factors affecting productivity in vegetable production.

	Y	**X1**	**X2**	**X3**	**X4**	**X5**	**X6**
Y	1.0000						
X1	0.7434	1.0000					
X2	0.8850	0.6160	1.0000				
X3	-0.3551	0.0008	-0.4596	1.0000			
X4	0.7732	0.9807	0.6762	-0.1466	1.0000		
X5	0.7825	0.9675	0.6402	0.0807	0.9188	1.0000	
X6	0.6981	0.9863	0.5678	0.0486	0.9560	0.9558	1.0000

Factors affecting productivity, such as mineral fertilizer prices, soil quality, cultivated area, labor costs, changes in the number of machinery used in vegetable growing, and the cost of fuel and lubricants, were taken into account. In the same way, the productivity change in fruit growing and the pair correlation matrix were calculated (Table 5).

Table 5. Matrix of pairwise correlation coefficients of the correlation levels of the factors influencing the productivity level in fruit growing.

	Y	X1	X2	X3	X4
Y	1.0000				
X1	0.7506	1.0000			
X2	0.8363	0.9787	1.0000		
X3	0.8658	0.9726	0.9830	1.0000	
X4	0.8183	0.9297	0.9667	0.9553	1.0000

By creating these matrices, it is possible to determine whether or not there is a strong relationship between adjacent factors, that is, whether or not there is multicollinearity.

Accordingly, there is no problem of multicollinearity to create a regression model based on the level of yield and factors affecting it in vegetable growing, but there is a strong correlation between the factors affecting the gross yield in fruit growing, so only X1, X3 and X4 factors were included in the matrix. Taking this into consideration, the following model was generated when performing a multivariate linear regression model in STATA based on the above data.

The analysis of the solutions given in the tables shows that 933.75 free term is not analyzed in vegetable growing. The coefficient in front of x_1 is $-0{,}001X_1$ – when the value of mineral fertilizers used on the field changes by 1 unit, it has a small negative effect on productivity, X_2 – the change of soil quality by one unit affects the productivity level by 20.4 units (Tables 6 and 7).

Table 6. Regression analysis of factors affecting productivity in vegetable production.

Y	Coefficients	Standard error	T statistics	P value	95% coefficient	Intervals
X1	-0.000567	0.000788	-0.72	0.492	- 0.0002385	0.000125
X2	20.36065	16.06038	1.27	0241	16.67467	57.39596
X3	-0.052682	0.0048628	-1.08	0.310	-0.016819	0.0059454
X4	0.000181	0.000269	0.67	0520	-0.000439	0.00008
X5	0.3890496	0.2203376	1.77	0.115	-0.1190497	0.8971489
X6	-0.0000165	0.000683	-0.24	0.815	-0.000174	0.000141
const	-933.7479	854.1737	-1.09	0.306	-2903.478	1035.978

Table 7. Regression analysis of factors affecting productivity in fruit growing.

Y	Coefficients	Standard error	T statistics	P value	95% coefficient	Intervals
X1	-0,3780121	0.741526	-5.10	0.001	-.0553355	-0.20269
X3	0.001	$8.24e^{-0.6}$	2.41	0.047	$3.51e^{-07}$	0.00039
X4	0.7919	0.1850364	4.28	0.004	0.354384	1.229468
X5	-0.000262	0.000156	-1.68	0.136	-.00011	0.0000106
const	275.6627	59314	4.65	0.002	135.4055	415.92

At the same time, if the factors X_3 and X_6 changes in the total cultivated area and the price of agricultural products have a small effect on productivity, the introduction of modern techniques used in agriculture creates the basis for the increase of productivity in vegetable growing. Accordingly, the function of the change in the level of productivity will be as follows:

$$\hat{y} = -933.75 - 0{,}001\mathrm{x}_1 + 20{,}4\mathrm{x}_2 - 0{,}01\mathrm{x}_3 + 0{,}0001\mathrm{x}_4 + 0{,}38\mathrm{x}_5 - 0{,}0001\mathrm{x}_6 \quad (2)$$

And in fruit growing, according to the results, we can see the influence of factors 275, 66 and X1, X3, X4, X5, in which the increase in the land area and the price of GNP is inversely proportional to the level of productivity, while the increase in the level of mechanization and labor costs is directly proportional to productivity. Accordingly, we can write the productivity change function in fruit growing in the following form:

$$\hat{y} = 275.67 - 0.3783\mathrm{x}_1 + 0.001\mathrm{x}_3 + 0.79192\mathrm{x}_4 - 0.00026\mathrm{x}_5 \quad (3)$$

It has been observed that the level of productivity in the cultivation of vegetable products increases over the years. In this case, the coefficient of determination was calculated.

$$D = R^2 = 0{,}89 \quad (4)$$

The level of productivity in fruit growing has increased over the years, albeit in a small amount, so the coefficient of determination was calculated.

$$D = R^2 = 0{,}91 \quad (5)$$

In accordance with the results of the calculations made on the basis of replacing the unknown numbers in the developed trend functions with the real numbers obtained using the models and formulas used above, based on the dynamics of the productivity level of vegetable crops from 2005-2019 until 2021-2030 and the volume of gross fruit cultivation during the years 2008-2020 a forecast for 2021-2030 was developed according to the trend of change.

The coefficient of determination (R^2) in determining the overall quality indicator of the multifactor linear regression econometric model is calculated using the following formula:

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \quad (6)$$

yi– the expected level of the resulting indicator;

y – arithmetic average value of the resulting indicator;

$\hat{y}$ – defined, forecasted, leveled quantities of the resulting indicator; n is the number of observations.

The coefficient of determination shows the influence of the factors included in the model on the final indicator in percentage. Indicators related to all factors are expressed in values within the range [0;1], and if their value is close to 1, it justifies the importance of the role of the factors included in the model in the true assessment of the level of the resulting indicator. On the other hand, because it is possible to compare models with different numbers of factors, and the amount of these factors does not affect the R^2 statistic, a smoothed coefficient of determination is usually used:

$$R^2_{\text{smooth}} = 1 - \frac{s^2}{s_y^2} \tag{7}$$

To determine the statistical significance of this multifactor regression model and its compatibility with the studied process, Fisher's F-criterion was used as a basis, and the following formula is used to calculate its value, namely:

$$F = \frac{R^2}{1-R^2} * \frac{(n-k-1)}{k} \tag{8}$$

where: n – number of observations; *k* –number of factors in a multivariate regression equation.

At the next stage, the calculated value of the F-Fisher criterion (F_{calc}) was compared with the theoretically calculated value $(F_{table}(\alpha; k; n\text{-}k\text{-}1))$. If $F_{calc} > F_{table}$, then the model used is relevant or adequate for the process being studied. After that, reliability of multifactor regression econometric model parameters and correlation coefficients is checked based on Student's t-test. Their value was compared with the values of random errors using the following formula:

$$t_b = \frac{b}{m_b}; t_a = \frac{a}{m_a}; t_r = \frac{r}{m_r}. \tag{9}$$

Based on the application of the econometric model, the random errors of the parameters and correlation coefficients are calculated according to the following formulas:

$$m_b = \sqrt{\frac{\sum(y-\hat{y}_x)^2/(n-2)}{\sum(x-\bar{x})^2}}; \tag{10}$$

$$m_a = \sqrt{\frac{\sum(y-\hat{y}_x)^2}{(n-2)} \cdot \frac{\sum x^2}{n\sum(x-\bar{x})^2}} = \sqrt{S^2_{\text{residue}} \frac{\sum x^2}{n^2\sigma_x^2}} = S_{\text{residue}} \frac{\sum x^2}{n\sigma_x}; \tag{11}$$

$$m_{r_{xy}} \sqrt{\frac{1-r_{xy}^2}{n-2}}. \tag{12}$$

By comparing the values calculated by the Student's t-test (t_{calc}) and the values in the table reflecting the obtained results (t_{table}), the validity of the accepted H_0 hypothesis was checked. For this, the reliability probability (ά) and the degree of freedom ($\gamma = n - k - 1$) of the value of the factors in the table developed on the basis of the t-criterion are found within the conditions. Where, n - number of observations, k - number of factors.

The results obtained on the basis of the above econometric model and its structural formulas are compared with real indicators in practice, and relevant conclusions and recommendations are developed.

The result of the calculated coefficient of determination R^2 in the change of vegetable productivity is equal to 0.89, and in fruit production it is equal to 0.98, indicating that the result indicator is strongly connected with the included factors, and the remaining 0.11 and 0.02 shares can be considered as the influence of factors that have not been taken into account (Table 8).

Table 8. Criteria for testing the quality and significance of a multifactor econometric model.

Multifactorial correlation coefficient, R	**Multifactor determination coefficient, R^2**	**Adjusted R^2**	**Standard error of the estimation**	**F**	**P-value**	**DW**
On yield changes in vegetable production						
0.89	0.89	0.82	3.19	10.78	0.306	1.91
On productivity changes in fruit growing						
0.94	0.94	0.91	3.13	17.7	0.002	1.87

In general, the results developed on the basis of the constructed econometric model show that the calculated value of the F criterion for the analysis of factors affecting the level of productivity in vegetable growing is F_{calc} = 10.78, and for the change in fruit productivity it is equal to 85.7, as well as the degrees of freedom in the productivity of vegetable growing according to the picture γ_1=6 and γ_2=15-6-1=8 in the denominator, γ_1=4 in the fruit crop yield and γ_2=12-4-1=7 in the denominator, the value of the Fisher criterion, i.e. the significance level, vegetable productivity Fjad for p=0.98 at the level, and in fruit yield p=0.99 → F_{table} =0.0011.

In accordance with the results of calculations based on putting real numbers obtained using the models and formulas used above instead of unknown numbers in the developed trend functions, a forecast of productivity in the period 2021-2030 was developed based on the dynamics of the level of productivity in the cultivation of vegetable crops in 2005-2020 (Figure 1).

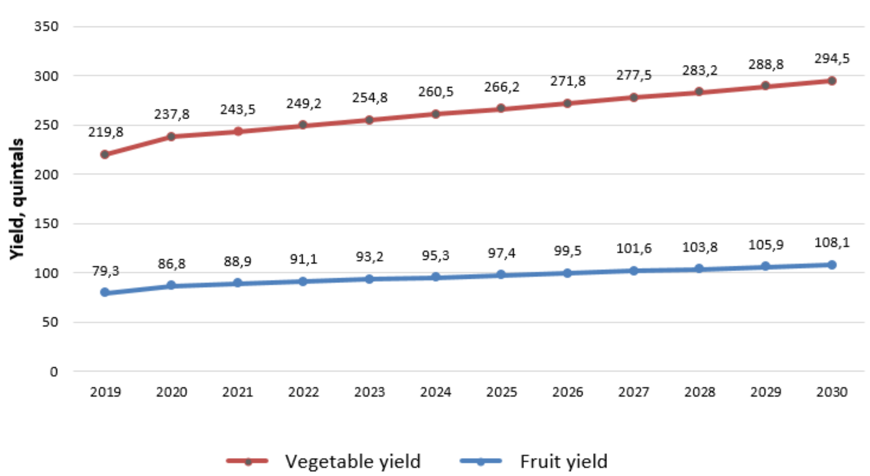

Fig. 1. Forecast indicators of the productivity of fruit and vegetable crops in Jizzakh province (Uzbekistan) until 2030.

The level of productivity in orchards was based on the dynamics of 2008-2020, and the forecast of productivity for the period 2021-2030 was developed. As can be seen from the data in the picture, the productivity of vegetable crops in Jizzakh region will be 237.8 quintals/ha in 2020 by 2030 due to the modernization of fruit and vegetable production. from 294.5 quintals/ha and the productivity of fruit cultivation in 2020 is 86.8 quintals/ha. from 108.1 quintals/ha in 2030. can be observed to increase to On the basis of such econometric model methods, we will be able to forecast the increase in productivity of each type of crop at the scale of the farm, district and republic.

4 Conclusions

It is necessary to analyze the dynamics of the productivity of fruit and vegetable crops grown in our republic under the conditions of modernization of production processes based on mathematical modeling.

To cover all modernization factors affecting productivity, to predict the productivity of the coming years and to make a realistic assessment of the dynamics of productivity growth creates opportunities to somewhat facilitate the practice of economic analysis of the processes of development of the vegetable industry.

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