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PROSPECTS FOR AGRICULTURAL PRODUCTION IN HOUSEHOLDS OF THE MAHALLA SYSTEM IN UZBEKISTAN

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Abstract

In this study, the factors affecting the volume of fruit, vegetable and berry production were analyzed using econometric and artificial neural network (ANN) models. The results of the study confirmed that factors such as population, income, prices, cultivated area and productivity have a significant impact on the volume of production. The econometric model made it possible to identify statistical relationships between factors and the resulting indicator and explain their economic content.

At the same time, the ANN model showed high efficiency in identifying complex and nonlinear relationships and demonstrated superior results in terms of forecasting accuracy compared to traditional regression models. The learning ability of the model made it possible to identify hidden patterns in historical data and reliably estimate future production volumes.

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INTRODUCTION

The mahalla system of Uzbekistan is the main source of household labor resources and employment. At the same time, the household in a broad sense is very complex, multifaceted, and plays a key role in solving socio-economic issues related to family activities.[1]

Taking this into account, in this study, it is necessary to assess the volume of production and consumption of agricultural products in households of the population of Uzbekistan and to know the trends of future demand and supply for them as a task of important strategic importance at the current stage of economic transformation. Taking into account the interests and needs of the population living in mahallas, determining the forecast of food consumption, serves to reduce employment and poverty. Taking this into account, the project study aims to forecast and assess the prospects for food production in households of the population in the mahalla system.[2]

In the mahalla system of Uzbekistan, households are formed by a single family or a group of them. They are of great importance in the socio-economic development of makhallas. Therefore, the problems of households in makhallas are receiving increasing attention from researchers and specialists in the implementation of the Strategy of Uzbekistan 2030 at the next stages.

The specific social, economic, financial and other functions of households as a sector of the economy in market conditions, as well as the principles of their relations with the state and society, have been widely

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studied by foreign and domestic scientists. They have proven that households are a source of labor resources, the main factor in ensuring employment of the population, and ultimately consumers of products created in the makhalla system.[3]

The Fogure 1. economics of the household and peasant economy in Uzbekistan has been studied by Akhmedov U.K., Berkinov B., Absamatov A. and other authors. The scientific works of these authors analyze the legal and institutional aspects of organizing small family businesses in the mahalla, econometric methods of entrepreneurship development, ways to increase household income, as well as the development of peasant farms in a small area and the production and sale of products.

Households play an important role in the agricultural economy of Uzbekistan. They are the main mechanism for the functioning of families in the mahalla system. Households not only produce food for family consumption, but also sell their products for profit in market segments and play a key role in the formation of the country's domestic product.[4]

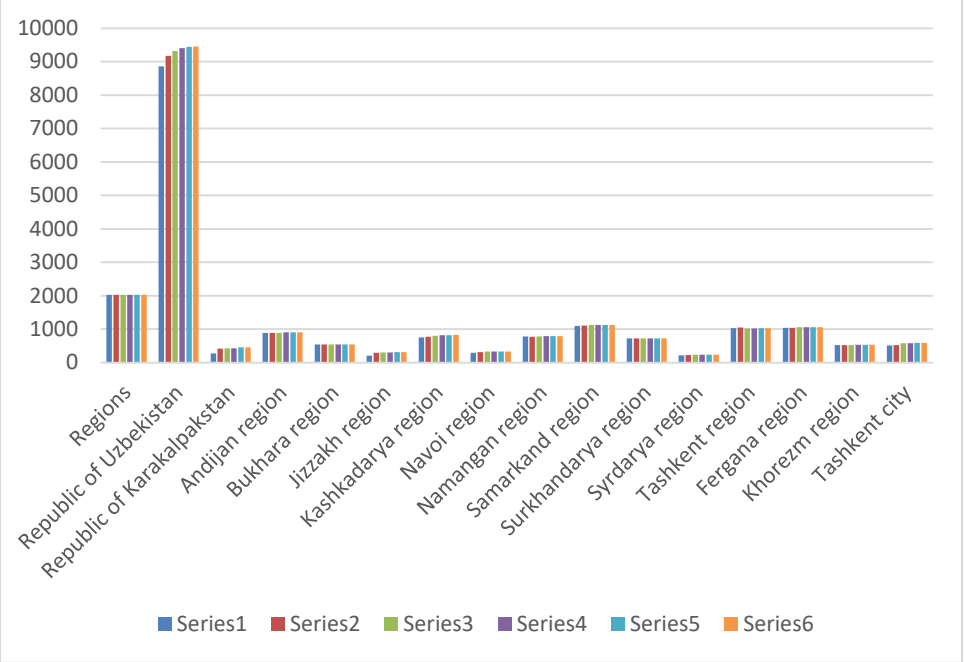

Figure 1. Number of households in 2017-2025

The number of households in the republic in 2025 amounted to 7,665.2 thousand. This figure is 172 thousand more than in 2024, and 776 thousand more than in 2020. The increase in the number of households in Uzbekistan is due to the increase in the amount of household land allocated to them for individual housing construction and dehkan farming. The total land area at the disposal of households was 579 thousand hectares in 2000, and this figure was 686 thousand hectares in 2025. Of the land allocated to households in Uzbekistan, 520 thousand hectares are used for agricultural production (in the form of dehkan farms). In general, the share of households accounts for 3 percent of the total land area of the republic (2022), 3.3 percent of agricultural land; 10.5 percent of arable land.[5]

In the republic, 7.4 percent of grain, 69 percent of potatoes, 57 percent of vegetable crops, 49 percent of fruits, and almost 50 percent of grapes are produced on households.

It should be noted that in Uzbekistan, attention is being paid to the development of diversified farms. Due to this, the volume of agricultural products produced by farmers is growing. This also increases the share of farmers in the volume of agricultural production in the republic. Due to this, there is a tendency for the share of households in agriculture to decrease. At the same time, the number of livestock and poultry heads and the high level of the role of households in the production of products are maintained. According to the data presented in Table 6.5, households produced 1.5 (371.6 thousand tons) times more products than the value of products produced on farms in 2024.[6]

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This Table 1. situation can be explained, firstly, by the extensive experience of households in the production of agricultural products, and secondly, by the high share of meat, milk, eggs, and home-processed products, which have relatively high market prices, in their products.

Table 1. Agricultural production on farms and households in Uzbekistan

Years			Volume of the main crops, tons					
	Grain production		Potatoes		Vegetables		Watermelon crops	
	Farm	House-hold	Farm	House-hold	Farm	House-hold	Farm	House-hold
2010	6123,5	1283,2	337,3	1345,7	2154,3	4064,3	595,9	566,4
2011	5755,4	1306,7	389,6	1448,8	2362,8	4411,4	653,9	618,9
2012	6068,2	1361,0	468,3	1551,7	2603,2	4796,2	730,5	663,8
2013	6293,0	1413,2	514,2	1684,5	2822,7	5200,5	782,3	751,1
2014	6488,7	1457,1	542,2	1835,4	2993,8	5681,3	841,3	826,0
2015	6587,8	1479,4	553,6	2009,9	3155,0	6150,5	906,4	915,7
2016	6642,1	1511,8	544,0	2231,6	3330,2	6792,7	1012,2	1000,0
2017	5736,0	1435,8	430,2	2346,7	2994,4	7092,6	952,5	1060,2
2018	5166,8	1218,0	422,2	2533,3	2704,1	7190,9	685,0	1166,5
2019	6271,5	879,9	520,3	2640,2	3312,8	7105,0	902,0	1178,7
2020	6275,7	789,2	668,8	2566,1	3882,3	6882,2	1064,1	1081,7
2021	6158,6	751,6	816,9	2629,7	4248,1	7041,3	1241,1	1054,3
2022	6380,2	739,3	984,0	2664,9	4408,3	7355,2	1366,9	1039,1
2023	6748,3	697,8	1116,1	2703,8	4719,9	7477,5	1487,7	1048,1
2024	7175,4	662,1	1192,1	2845,2	5110,3	7767,1	1635,6	1042,1

Figure 2 shows the dynamics of fruit and berry production volume and trends calculated by linear, logarithmic, exponential and polynomial trend models used for its forecasting.

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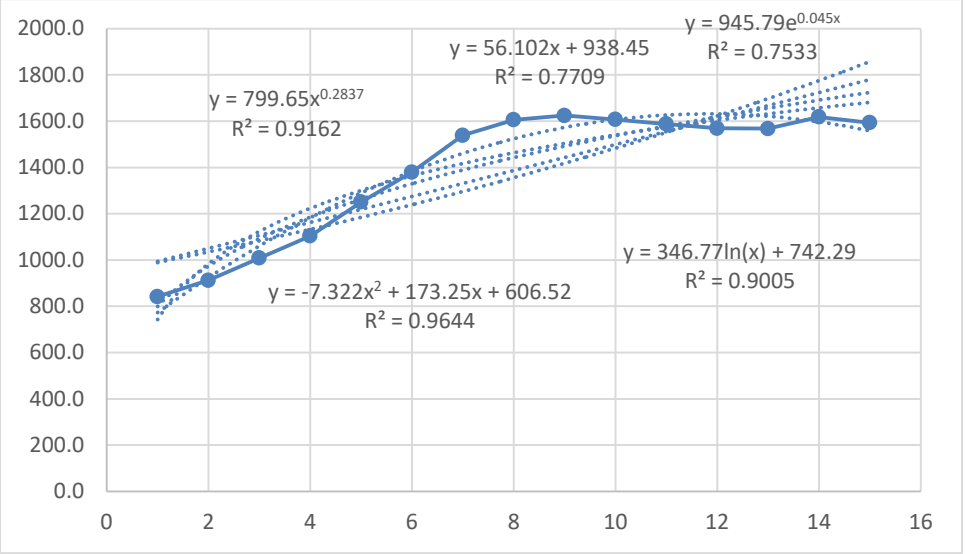

Figure 2. Econometric models of fruit and berry production

In recent years, the diversification of agricultural and livestock products in households in Uzbekistan based on population consumption and market demands, supported by the state, has not only led to the continuous development and structural changes in household agricultural production, but also had a positive impact on the efficiency of household production. Taking this into account, it is important to further increase the role and importance of households in the development of makhallas in the country and its rural areas, and to assess the possibilities of fully utilizing their potential.[7]

From this point of view, the prospects for the development of agricultural production in households in the makhalla system were determined by constructing econometric models in the form of multivariate linear, logarithmic, polyminal, power and exponential trend functions. [8]

Two types of econometric models were selected by comparing the values of the statistical evaluation criteria. The first type of the selected models determines the lower limit of the forecasted indicator (option I), and the second type determines its upper limit (option II). The lower limit corresponds to the preservation of current trends in the development of mahalla households, and the upper one corresponds to the future increase in the potential of households, an increase in the necessary investments in households, and increased state incentives for them. The forecast results developed according to the options can be implemented in the short (1-2), medium (2-3) and long (3-5 years) terms.

The set of selected econometric models for forecasting agricultural and livestock production indicators in households consists of the following.[9]

Models for forecasting agricultural production in households in Uzbekistan

а) grain:

$y_1 = -7{,}3 * x^2 + + 54{,}987 * \text{x} + 1295;\ (R^2 = 0.84);\ y_2 = -61{,}6 * x + 1625{,}3;\ (R^2 = 0.63);$ (1)

б) potato:

$y_1 = 111{,}17x + 1313{,}1;\ (R^2 = 0.98);\ y_2 = -5{,}9224x^2 + + 205{,}9x + 1044{,}7;\ (R^2 = 0.98),\quad y_3 = 1191{,}6x^{0.315};\ (R^2 = 0.96),$ (2)

в) vegetable:

$y_1 = -20{,}853x^2 + 585{,}02x + 3377{,}6;\ (R^2 = 0.97);y_2 = 251{,}37x + 4322{,}9;\ (R^2 = 0.87),\quad y_3 = 3832{,}6x^{0{,}25},(R^2 = 0.94),$ (3)

г) fruits:

$y_1 = 346{,}77ln(x) + 742{,}29;\ (R^2 = 0.90);\ y_2 = 799{,}65x^{0{,}29};\ (R^2 = 0{,}87),\ y_3$= -7,322x^2 + 173,25x + 606,52; $(R^2 = 0{,}96)$, (4)

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д) *grapes*:

$y_1 = 38{,}9x + 0{,}88; (R^2 = 0.88);$ $y_2 = -3{,}4x^2 + 93{,}42x + 93{,}42; (R^2 = 0.98),$
$y_2 = 379{,}12x^{0{,}35}; (R^2 = 0{,}94), (5)$

Econometric models of this type have also been developed to forecast the volume of livestock products.

These models show that the actual values of Student's t-test are greater than its tabular values, which proves the existence of a trend between the forecasted indicator and the unit of time, free from extraordinary fluctuations. At the same time, the value of the coefficient of determination (R2) has a high value in each model, which indicates a significant dependence of the positive change in the forecasted indicator on the time factor[10].

Using the table 2. developed models, forecast options for the development of agricultural and livestock production in Uzbek households were determined (Table 6.6).

Table 2. Forecast options for the development of agricultural production in Uzbek households (thousand tons)[11]

Indicators	**Actually (2024)**	**Forecast**					
		Short term (1-2 years)		**Medium term (1-2 years)**		**Long term (1-2 years)**	
		Option I	Option II	Option I	Option II	Option I	Option II
Grain	662,1	661,5	639,4	617,1	577,8	528,3	454,6
Potatoes	2845,2	3203,0	2958,3	3314,2	3020,2	3647,7	3205,9
Vegetable	7767	7699,5	8344,8	7905,0	8847,6	8213,2	9601,7
Fruits	1593,2	1518,7	1705,3	1440,6	1753,1	1323,3	1824,9
Grapes	912,4	995,7	1060,2	1041,8	1138,0	1111,0	1254,8
Meat	2474,6	2487,8	2731,9	2509,8	2810,1	2575,5	3044,8
Milk	11485,6	11319,2	11607,4	11471,4	11808,5	11928,2	12411,8
Eggs, mln. piece	11485,6	1411,7	1491,1	1412,3	1517,0	1414,1	1594,8

Source: forecast based on econometric models.

According to the forecast results, in the future there is a tendency to maintain high growth rates of production and consumption of all agricultural products in households. Grain production in households may grow by 5.4 (year 3, variant I) - 17.1 percent (year 5, variant II) compared to 2024. This will be mainly due to an increase in grain yields. The total area of sowed land will expand due to the expansion of secondary crops.[12]

Positive changes are also expected in the production of meat, milk, eggs and other livestock products in households during the forecast period. The growth in livestock production will occur primarily due to an increase in the number of livestock and their productivity. Comparisons show that the density of cattle, sheep and goats owned by households per hectare of arable land in the republic will increase. The density of cattle is expected to increase from 2.5 heads per hectare of arable land in the republic (3353.3 million ha in 2024) to 2.8 heads in 2-3 years and to 3.1 heads in 3-5 years. The density of sheep and goats is expected to increase from 3.5 heads (1-2 years) to almost 5 heads (3-5 years) per hectare of arable land. Such positive changes indicate that the leading role of households in the mahalla system in livestock farming in the republic will be maintained in the future.[13]

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However, panel data models and machine learning methods provide more opportunities to take into account complex socio-economic factors at the household level in the mahalla system.

Modern machine learning methods are very effective in analyzing the prospects for agricultural production in addition to classical trend models. They allow you to identify valuable patterns from large volumes of complex data.

Regression Trees and Random Forests Forecasting the result in the cross-section of various factors. For example, using them in the forecast of yields based on household land area, water supply and labor resources gives good results. Regression Trees are an effective method in determining the prospects for agricultural production in households. It allows you to make accurate forecasts in the cross-section of factors in addition to classical trend models.

Regression Trees are an effective method in determining the prospects for agricultural production in households. It provides a deep analysis of the influence of factors and allows you to forecast productivity at the household level.[14]

The Figure 3. artificial neural network (ANN) model was developed based on a multilayer perceptron architecture. The input neurons of the model were selected as factors affecting potato yields - population, income, prices, cultivated area, yield, and time trend. The output neuron represents the potato demand indicator. 5–10 neurons are used in the hidden layer, and the nonlinear relationships between the factors and the resulting indicator are determined using the ReLU activation function. The ANN model was trained on the basis of available statistical data for 2010–2024 and used to form potato yield/demand forecasts for 2025–2029.

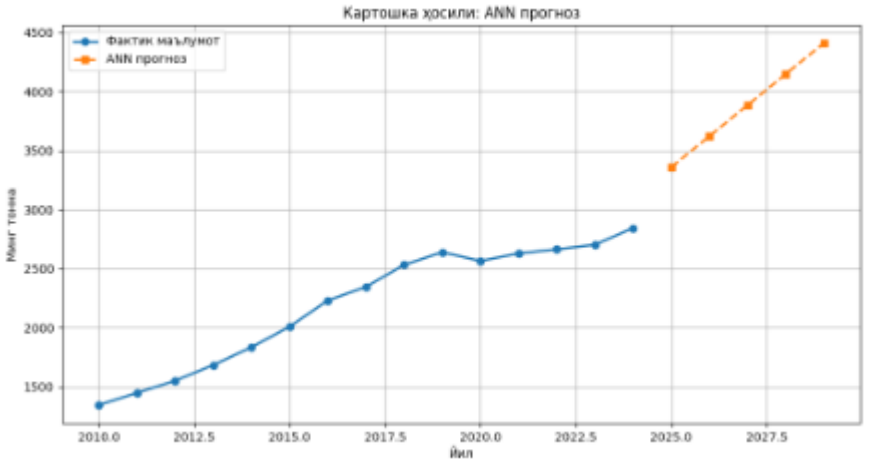

Figure 3. Potato harvest forecast for 2025–2029 based on an artificial neural network (ANN) model

The results of the Figure 4. simulations showed that the ANN model allows for a high-accuracy assessment of the future dynamics of potato yields. According to forecasts, potato production will maintain an upward trend in 2025–2029. This confirms that artificial neural networks are an effective tool for forecasting agricultural production.

In this work, two ANN models with four different algorithms were considered. The ANN value of the model is evaluated based on the minimum mean absolute error (MAE), root mean square error (RSME) and maximum linear correlation coefficient (P) of their respective outputs.

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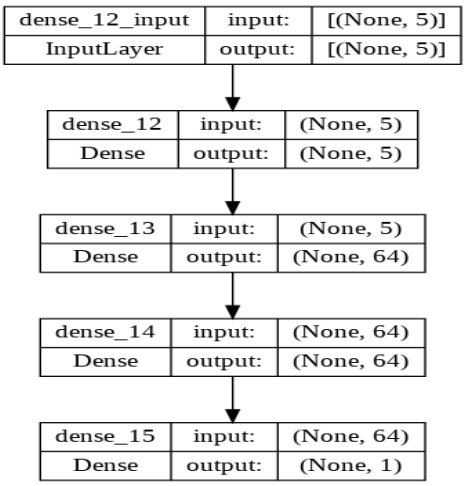

Figure 4. ANN architecture

The above architecture shows how the network is trained on input data through transfer and activation functions and then can predict the output with minimum error. Also, in this model, we used 100 epochs and five input layers and one output layer to predict the volume of agricultural products.

We can see that the error reaches a minimum level when the number of epochs in the ANN model is increased. This result is seen in Table 3 and Figure 3.

Table 3. The state after training by increasing the robustness period s in the implementation of the ANN model.[15]

Errors	A measure of model robustness
MAE	2.3547
MAPE	93,67
MSE	17
RMSE	4.12
Loss	17

Table 3. ANN model sequence optimization after 1500 iterations.

Conclusion

The findings of this study reveal that both econometric regression models and Artificial Neural Networks (ANN) are useful tools for analyzing and forecasting agricultural production. However, the ANN model outperformed traditional multiple regression techniques by generating lower prediction errors and capturing nonlinear relationships more effectively. Therefore, ANN-based forecasting can serve as a reliable decision-support tool for agricultural planning, production management, and food security policy development. The results obtained can be used in planning fruit and berry production, ensuring food security, and formulating agricultural policy. In future studies, integrating climate change, water resources, agro-technological factors, and remote sensing data into the model will further increase the accuracy of forecasts. In general, it was found that combining artificial intelligence technologies with econometric approaches is a promising direction for forecasting agricultural production.

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