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Development Trends and Forecast Indicators of Agricultural Service Centers in Uzbekistan

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Abstract: This article examines the economic and statistical evaluation of how to raise the efficiency of agricultural service centers in Uzbekistan, how to provide agricultural producers with information and advisory services, and how scientific developments are put into practice in the sector. The study analyzes the dynamics of the volume of agricultural services delivered within the system of the National Center for Knowledge and Innovation in Agriculture in 2021–2024, together with the indicators of their funding. An ARIMA econometric model was applied to assess how the rate of implementation of scientific developments is likely to change in the coming period. In selecting the optimal model, we considered stationarity, the statistical significance of parameters, the Akaike (AIC) and Bayesian (BIC) information criteria, and the results of residual diagnostics. On the basis of the findings, forecast indicators for 2025–2030 are presented. The results provide a basis for scientifically grounded and practical decisions on the strategic planning of agricultural service centers, on encouraging the implementation of scientific developments, and on the efficient use of resources in the sector.

Citation: Bozorova L. N., Madumarov S. S. Development Trends and Forecast Indicators of Agricultural Service Centers in Uzbekistan. American Journal of Economics and Business Management 2026, 9(10), 979-995.

Received: 10th Jul 2026
Revised: 11th Aug 2026
Accepted: 11th Sep 2026
Published: 23th Oct 2026



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Keywords: Agricultural service centers, agrarian innovations, information and advisory services, economic efficiency, econometric modeling, ARIMA model, time series, stationarity, forecasting, scientific developments, funding, strategic planning.

1. Introduction

The sustainable development of agriculture depends on how effectively scientific knowledge, innovative technologies, and information and advisory services are integrated into production. Agricultural service centers play an important role in ensuring the exchange of knowledge among research institutions, educational organizations, and agricultural producers, in putting scientific developments into practice, and in spreading innovations widely. According to FAO data, the performance of an agricultural innovation system depends on cooperation among research, education, advisory services, and producers [1–3].

In Uzbekistan, modernizing the agricultural sector and developing the system for disseminating knowledge and innovation are among the priorities of state policy. The institutional foundations for developing the knowledge and innovation system in agriculture, expanding modern services, and applying scientific developments in production were laid down by the Strategy for the Development of Agriculture for 2020–2030, approved by Decree No. PF-5853 of the President of the Republic of Uzbekistan of 23

October 2019 [4], as well as by Decree No. PF-6159 [5] and Resolution No. PQ-4975 [6] of the President of 3 February 2021.

In this context, it is important to evaluate the work of agricultural service centers through the number of services delivered, the funding they receive, and the rate at which scientific developments are put into practice [7]. Analyzing the dynamics of these indicators makes it possible to identify development trends in the agricultural service system, to plan resources, and to ground management decisions in evidence [8], [9]. However, such an evaluation should not stop at describing existing indicators; it must also forecast how they will change.

In forecasting time series, the ARIMA (Autoregressive Integrated Moving Average) model takes into account the past dynamics of an indicator [10], [11]. When choosing a model, it is important to assess the stationarity of the series, the statistical significance of the parameters, the AIC and BIC information criteria, and the diagnostic properties of the residuals. At the same time, the reliability of a forecast depends on the amount of data and on the forecasting accuracy of the chosen model.

The central research question is how the activity of agricultural service centers in Uzbekistan has developed and, on the basis of econometric modeling, how the rate of implementation of scientific developments is likely to change. The aim is to analyze the dynamics of the volume of agricultural services delivered within the system of the National Center for Knowledge and Innovation in Agriculture and of their funding, and to forecast the implementation indicator for scientific developments using an ARIMA model.

To achieve this aim, the indicators of agricultural services for 2021–2024 are analyzed [12], the statistical properties of the time series of implemented scientific developments are tested, alternative ARIMA models are estimated, and forecasts for 2025–2030 are produced. The scientific contribution of the study lies in the systematic analysis of indicators of the agricultural service system and in applying an econometric forecasting approach to the dynamics with which scientific developments are put into practice [13]–[15]. The results can inform decisions on the strategic planning of agricultural service centers, on improving resource use, and on disseminating knowledge and innovation in agriculture.

Theoretical Framework

The theoretical study of agricultural service centers rests on agricultural innovation systems, knowledge dissemination, and the concept of information and advisory services [16], [17]. Their main tasks are to apply scientific knowledge and innovative solutions in production, to meet farmers' need for information, and to raise economic efficiency in the agricultural sector [18].

Seen through the lens of agricultural innovation systems, innovative development in agriculture is not limited to creating new technologies. It also includes disseminating research results, advising producers, helping them adopt new technologies, and ensuring those technologies are used in practice [19]. In this respect, agricultural service centers are important for turning scientific knowledge into practical skills and for integrating innovations into production. Knierim and Prager [20], in their study of the role of agricultural advisory services in innovation systems, likewise highlighted the importance of these services in supporting knowledge exchange and innovation processes [21].

The second theoretical strand concerns knowledge dissemination and the concept of information and advisory services [22], [23]. On this view, producers' access to information about modern agricultural technologies, efficient ways of using resources, and scientific developments is one of the key conditions for improving production [24], [25]. Information and advisory services help farmers receive scientific recommendations, solve current problems, and make management decisions [26]. For this reason, an evaluation of

agricultural service centers should consider not only the number of services provided but also the extent to which scientific developments are put into practice and the availability of the services to users.

A further theoretical factor behind the effectiveness of agricultural service centers is the level of funding [27]. Funding supports the organization of services, the use of specialists' capacity, the updating of information resources, and the application of scientific developments in practice. However, the relationship between the volume of financial resources and the number of services delivered cannot be judged one-sidedly. The scale of services may also be shaped by institutional capacity, the mechanism by which services are organized, producers' demands, and how well scientific results fit practice. Funding should therefore be treated as an important indicator describing the development of the agricultural service system, but its effect should not be interpreted as causal without a separate empirical analysis [28].

The implementation of scientific developments is one of the key indicators of the performance of an agricultural innovation system. The practical value of research results is determined by whether they are applied under production conditions, adopted by farmers, and help solve existing agrotechnological problems [29]. From this standpoint, the number of scientific developments put into practice is treated as a quantitative indicator for evaluating the results of agricultural service centers and research institutions [30]. This indicator, however, does not fully capture the economic efficiency of scientific developments, because their quality, implementation costs, and production outcomes require separate assessment.

In the strategic planning of agricultural service centers, it is also theoretically important to analyze how economic indicators change over time and to forecast their future values [31]. Time series analysis makes it possible to identify patterns in past changes and, on that basis, to estimate likely trends for the coming period [32]. This approach provides the theoretical and methodological basis for studying the dynamics of the volume of agricultural services, of funding, and of the implementation of scientific developments.

This study relies on the ARIMA (Autoregressive Integrated Moving Average) model as its theoretical basis for forecasting. The model describes the dynamics of an indicator through the series' own previous values, a differencing procedure applied to achieve stationarity, and moving-average components of random errors. The ARIMA model has three main parameters: (p), the autoregressive order; (d), the order of differencing; and (q), the moving-average order. In selecting parameters, the stationarity of the series, the statistical significance of the parameters, the Akaike (AIC) and Bayesian (BIC) information criteria, and the properties of the model's residuals are taken into account.

On the basis of these theoretical approaches, the conceptual logic of this study evaluates the work of agricultural service centers in three interrelated directions: first, identifying the dynamics of the volume of agricultural services delivered; second, analyzing changes in the funding of service delivery; and third, forecasting the future dynamics of the indicator for implementing scientific developments through econometric modeling. This approach provides a theoretical basis for the systematic assessment of development trends in the agricultural service system, for identifying existing changes, and for using the forecast indicators for 2025–2030 in strategic planning.

2. Materials and Methods

To assess development trends of agricultural service centers in Uzbekistan and to forecast how the indicators of scientific-development implementation will change in the coming period, this study used methods of statistical analysis and econometric modeling. The empirical basis consisted of statistical data on the agricultural services delivered

within the system of the National Center for Knowledge and Innovation in Agriculture in 2021–2024 and on their funding, together with the indicators of implementation of scientific developments [33].

The study examined the following main indicators: the number of services delivered by agricultural service centers, the volume of financial resources allocated to service delivery, and the dynamics of the implementation of scientific developments. These indicators were chosen as criteria describing the activity level, funding, and innovation results of the agricultural service system.

Data on the volume of agricultural services and their funding were compared across 2021–2024. For assessing the future dynamics of the implementation indicator, the available time-series data were used. The forecast horizon covered 2025–2030.

Research methods

The study used statistical analysis, comparison of dynamic series, testing of time-series properties, and econometric forecasting.

Statistical analysis was used to identify year-to-year changes in the volume of agricultural services and in funding. Comparing dynamic series made it possible to assess growth and decline trends in the indicators studied. The results made it possible to identify changes in the activity of agricultural service centers and to compare them with one another.

The ARIMA (Autoregressive Integrated Moving Average) econometric model was chosen to forecast the implementation indicator for scientific developments. The main reason for using it is that it allows future values to be estimated while accounting for the series' previous values and random fluctuations.

The ARIMA model is defined by three parameters:

- (p) — the order of the autoregressive component;
- (d) — the order of differencing applied to make the time series stationary;
- (q) — the order of the moving-average component.

The model is written as $ARIMA((p,d,q))$. In determining these parameters, the statistical properties of the time series, its stationarity, and its autocorrelation were taken into account.

Testing the stationarity of the time series

Before estimating the ARIMA model, the time series of the indicator for implementing scientific developments was tested for stationarity, using the Dickey–Fuller test.

The null hypothesis of the test is that the series is non-stationary; the alternative hypothesis is that it is stationary. The 5% significance level was adopted. If the (p)-value was below 0.05, there were statistical grounds to reject the null hypothesis.

The initial test results showed that the series was non-stationary. First-order differencing was therefore applied. The repeated Dickey–Fuller test gave a value of ($p = 0.0138$). On this basis, the order of differencing was set at ($d = 1$).

Selecting and estimating the ARIMA model

To determine the optimal model specification, the $ARIMA(1,1,0)$, $ARIMA(0,1,1)$, $ARIMA(1,1,1)$, and $ARIMA(2,1,0)$ variants were compared. The criteria were the statistical significance of the parameters, the error variance, the log-likelihood function, and the Akaike (AIC) and Bayesian (BIC) information criteria.

The AIC and BIC criteria serve to weigh a model's fit to the data against its complexity. All else being equal, the model with the smaller values of these criteria is preferred.

In the calculations, $ARIMA(0,1,1)$ was selected as the optimal specification because it had the lowest AIC and BIC values. Its AIC was 77.8963 and its BIC was 78.69209.

Model diagnostics and forecasting

To assess the reliability of the selected model, its residuals were tested with the portmanteau test. The main purpose of the test is to determine whether the residuals contain statistically significant autocorrelation.

The test gave ($p = 0.2464$). Because this value is above 0.05, there was not enough evidence to confirm statistically significant autocorrelation in the residuals. This supports the use of the selected model for forecasting, though it does not fully guarantee forecast accuracy.

In the final stage, forecast values of the indicator for implementing scientific developments for 2025–2030 were calculated using the ARIMA(0,1,1) model. The forecasts were used for the strategic planning of agricultural service centers and for assessing future directions of innovation activity.

All econometric calculations were carried out in Stata. The results were interpreted within the limits of the available statistical data. The short observation period for the volume of agricultural services and funding, and the limited length of the time series on the implementation of scientific developments, were taken into account when interpreting the forecasts.

3. Research Results

The Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020–2030 sets out the main targets to be achieved across its priority areas. One of them is the forecast growth in the number of farmers served by knowledge-dissemination and information and advisory centers, and in the number of farmers able to use advisory and additional services (Figures 2–3).

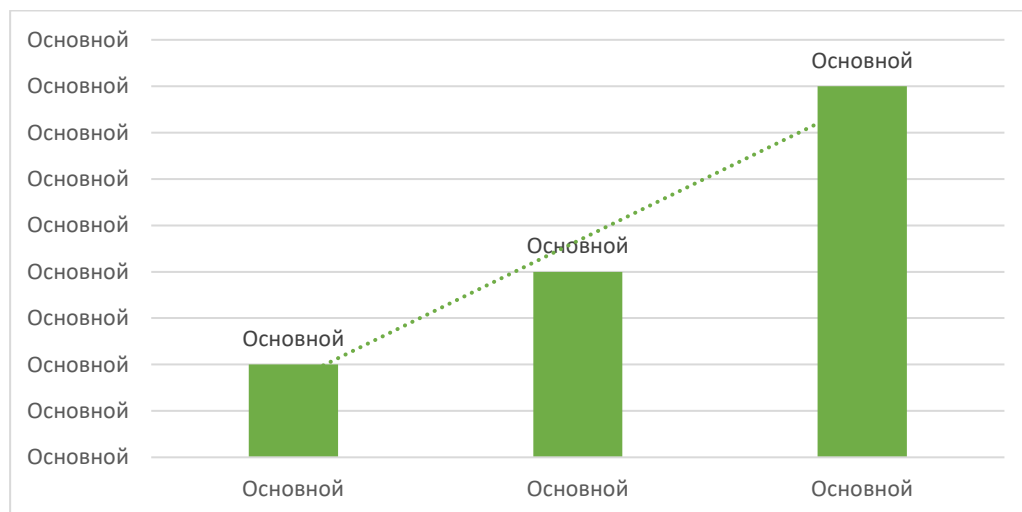


Figure 2. Growth in the number of farmers served by knowledge-dissemination and information and advisory centers.



Figure 3. Growth in the number of farmers able to use advisory and additional services.

The work carried out in the country by agricultural service centers and by research institutions is of considerable importance. For this reason, it matters for developing strategic plans to raise the efficiency of agricultural service centers.

In analyzing the time series, the ARIMA model was used to forecast future values of the number of scientific developments put into practice by institutions within the National Center for Knowledge and Innovation in Agriculture, with previous values of the series as the time-dependent variable. The ARIMA model is a statistical model for analyzing time series, defined by the structural parameters p (the autoregressive order of the series), d (the order of differencing needed to make the series stationary), and q (the order of the moving average, derived from the residuals). ARIMA (Autoregressive Integrated Moving Average) is a model of the periodic moving average of integrated autoregressive values. It is convenient for analyzing multi-year periodic data and makes it possible to forecast future changes in the factors of the autoregression on the basis of their average values in base years.

The main characteristics of the ARIMA model are as follows:

- the model calculates the dynamics of change for a future period from the past values of each economic indicator studied;
- the model is able to forecast periodic changes;
- it is convenient for technical analysis and for forecasting periodic values;
- it is convenient for calculating interrelated indicators together with their past values.

The basic formula of the ARIMA model (3.1) is as follows:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \dots + \beta_n Y_{t-n} + \epsilon_t \quad (1)$$

where:

Y = the resulting factor / dependent variable;

$t-n$ = the period count for each factor;

β = the elasticity coefficient of each factor for each period;

ϵ = standard error.

Only simple time series can be forecast with the ARIMA model. Forecasting with it has three stages:

1. Identification;
2. Estimation;
3. Forecasting.

In applying the ARIMA model, the stages above were carried out, on the basis of the analysis of time-series data for the observed period, in the following sequence (Figure 4):

1. The observed periodic data were plotted on a coordinate axis and unusual observations were identified;
2. The stationarity of the data was tested; if the data were not stationary, first differences were taken until they became stationary;
3. The full or partial autocorrelation functions (ACF/PACF) were examined;
4. Suitable ARIMA (p, d, q) models were tested;
5. The selected models were tried out, and the AIC/BIC criteria were used to identify the better model;
6. Tests were run on the residuals of the model results, and stronger models were tried;
7. Forecasts were calculated.

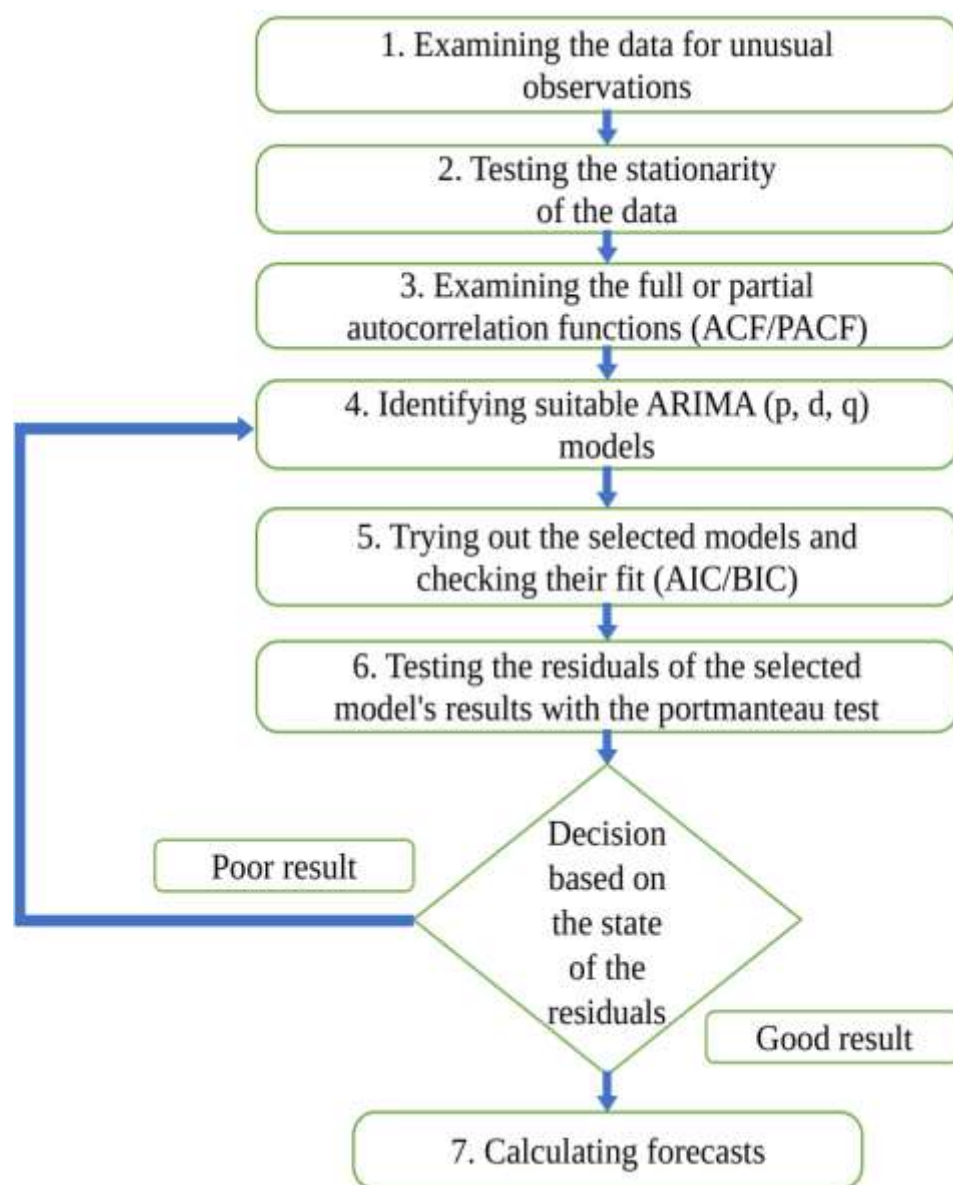


Figure 4. Sequence of forecasting with the ARIMA model.

After the data were loaded into Stata, our study began with the first stage of the ARIMA model, Identification. At this stage, the values of p , d , and q are determined. To this end, the time series is tested for stationarity; the order of integration is found and expressed as the value d . As is well known, there are three ways of testing a time series for stationarity: the graphical method, the autocorrelation method, and the test method.

In Stata, testing a time series graphically shows whether trend, randomness, and seasonality elements are present in the series.

To be fully confident of a series' stationarity, it is advisable to assess it with a formal test.

One such test is the Dickey–Fuller test. As with other methods, the Dickey–Fuller test requires the probability value $p\text{-value} < 0.05$. On the basis of the $p\text{-value}$, the following hypotheses are accepted or rejected:

H0: the time series is not stationary;

H1: the time series is stationary.

If $p\text{-value} < 0.05$, the null hypothesis is accepted and the alternative hypothesis is rejected; conversely, if $p\text{-value} > 0.05$, the alternative hypothesis is accepted and the null hypothesis is rejected. If a time series is found to be non-stationary, it can be converted into a stationary form. This requires differencing the series, which in econometrics is called an integration process. The step of the integration process at which the series is shown to be stationary gives the value d . When we test our series with the Dickey–Fuller test in Stata, the series was found to be non-stationary at the initial stage (Table 4).

According to the Dickey–Fuller results, the probability value is 0.8698, which does not satisfy the condition $p\text{-value} < 0.05$; the series therefore has to be differenced and the Dickey–Fuller test run again. When the series was tested again, we see that it had been made stationary (Table 7). According to the repeated Dickey–Fuller results, the probability value is 0.0138, which fully satisfies the condition $p\text{-value} < 0.05$; that is, the integration process stops here.

Table 4. Result of the Dickey–Fuller test

Variables	Test statistic	1% critical value	5% critical value	10% critical value	p-value	Test type
Initial test result						
Number of scientific developments put into practice	-0.605	-3.750	-3.000	-2.630	0.8698	Simple
Test result after first-order differencing						
Number of scientific developments put into practice	-3.326	-3.750	-3.000	-2.630	0.0138	Simple

Thus, the value of d required for the Identification stage of the ARIMA model is 1: $d = 1$. The meaning of the values p and q is that they indicate whether autocorrelation is present in the time series and in its residuals.

If there is no autocorrelation, $p = 0$ or $q = 0$ is adopted; if there is, its order is taken as $p = [0;1]$ or $q = [0;1]$. It should be remembered that if a series has become stationary after differencing, the values of p and q are found from that transformed series.

First, to determine whether the variables in the time series are interrelated, that is, to determine the value of q , we ran the necessary command in Stata. It showed that autocorrelation in the series is present only to a negligible degree, since all lags lie outside the confidence interval. On this basis, the value of q can be set at 0 or 1: $q = 0$ or 1. First- and second-order autocorrelation is present among the residuals, because one of the lags lies markedly outside the confidence interval and another lies slightly outside it. Accordingly, the value of p is taken as 1 or 2: $p = 1$ or 2.

Thus, once the values of p , d , and q required for the ARIMA model were determined, we write out the variants for these values as combinations, in the following order:

ARIMA = $(p, d, q) = (1, 1, 0)$

ARIMA = $(p, d, q) = (0, 1, 1)$

ARIMA = $(p, d, q) = (1, 1, 1)$

ARIMA = $(p, d, q) = (2, 1, 0)$, and so on.

In these combinations only the value of d stays fixed; the values of p and q vary within the ranges 0 to 2 and 0 to 1 respectively.

At the Estimation stage of the ARIMA model, the significance (quality) of the variants selected above is assessed against five criteria, and the best one is chosen (Table 5).

Table 5. Criteria for evaluating the models

Criteria	Normative requirements
Parameters	the conditional probability level $p < 0.05$ takes precedence
Sigma	the model with the smaller value is better
Fit (Log likelihood)	the model with the larger value is better
Akaike	the model with the smaller value is better
Bayesian	the model with the smaller value is better

From the models we constructed, using the available criteria, we selected ARIMA (1,1,0), ARIMA (0,1,1), ARIMA (1,1,1), and ARIMA (2,1,0), and examined, on the basis of the criteria above, whether the optimal variant could be chosen from among them (Table 6).

Table 6. ARIMA model results

	Variant A ARIMA (1,1,0)	Variant B ARIMA (0,1,1)	Variant C ARIMA (1,1,1)	Variant D ARIMA (2,1,0)	Preferred variant
Constant	3.674785	3.783221***	3.783457***		C
L1.ar	-0.2229939		0.0133779	-0.394579	
L1.ma		-1.000001*	-1.000012		
Sigma	8.692424***	6.215353	6.221888	6.364494***	B
Log likelihood	-39.42076	-36.94815	-36.94726	-36.52549	D
AIC	84.84153	77.8963	81.89453	81.05097	B
BIC	86.03521	78.69209	83.48611	82.64255	B

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

According to the analysis in Table 6, the AIC (Akaike information criterion) and BIC (Bayesian information criterion) results were given priority in identifying the most reliable values in the fitted model. Of the four variants, the one with the lowest value on the AIC and BIC selection criteria was accepted as the most reliable. ARIMA (0,1,1) was selected as the model that gives the most reliable values for forecasting the future number of scientific developments put into practice by institutions within the National Center for Knowledge and Innovation in Agriculture.

According to the estimation results, ARIMA (0,1,1) is optimal among the selected models, because it fully meets the requirements of all criteria.

In the final stage of the ARIMA model, Forecasting, we produce forecasts for the selected optimal ARIMA (0,1,1). Assessing any model through its residuals has become an indispensable principle of modern applied econometrics, and it matters equally when forecasting with ARIMA. For this reason, before forecasting, it is advisable to check the residuals of the selected model by several methods. Specifically, as with the IM test, Breusch–Pagan, Shapiro–Wilk, and Breusch–Godfrey tests, the portmanteau test requires that the $\text{Prob} > \chi^2$ value be greater than 0.05. In determining this value, the following hypotheses are accepted or rejected:

H0 (null hypothesis): the residuals tend toward stationarity;

H1 (alternative hypothesis): the residuals are not stationary.

Testing for stationarity with the portmanteau test gave the following result:

Portmanteau test for white noise

Portmanteau (Q) statistic = 4.1430

Prob > chi2(3) = 0.2464

From this we can see that, according to the portmanteau test, $\text{Prob} > \chi^2(3) = 0.24$, which is greater than 0.05. We therefore reject the alternative hypothesis and accept the null hypothesis, and can be fully confident that the residuals are stationary. On the basis of these checks, we can say that the selected ARIMA (0,1,1) model was positively assessed for stationarity and stability under the required conditions, and that it can be used as the optimal variant for forecasting future growth rates.

The analysis based on the ARIMA (0,1,1) model, with its significance fully tested across a series of tests, namely Dickey–Fuller, portmanteau, Breusch–Pagan, Shapiro–Wilk, and Breusch–Godfrey, confirmed that the forecast values are reliable.

The results show that, while the number of scientific developments put into practice by institutions within the National Center system stood at 62 in 2024, a significant increase is expected during 2025–2030 (Figure 5).

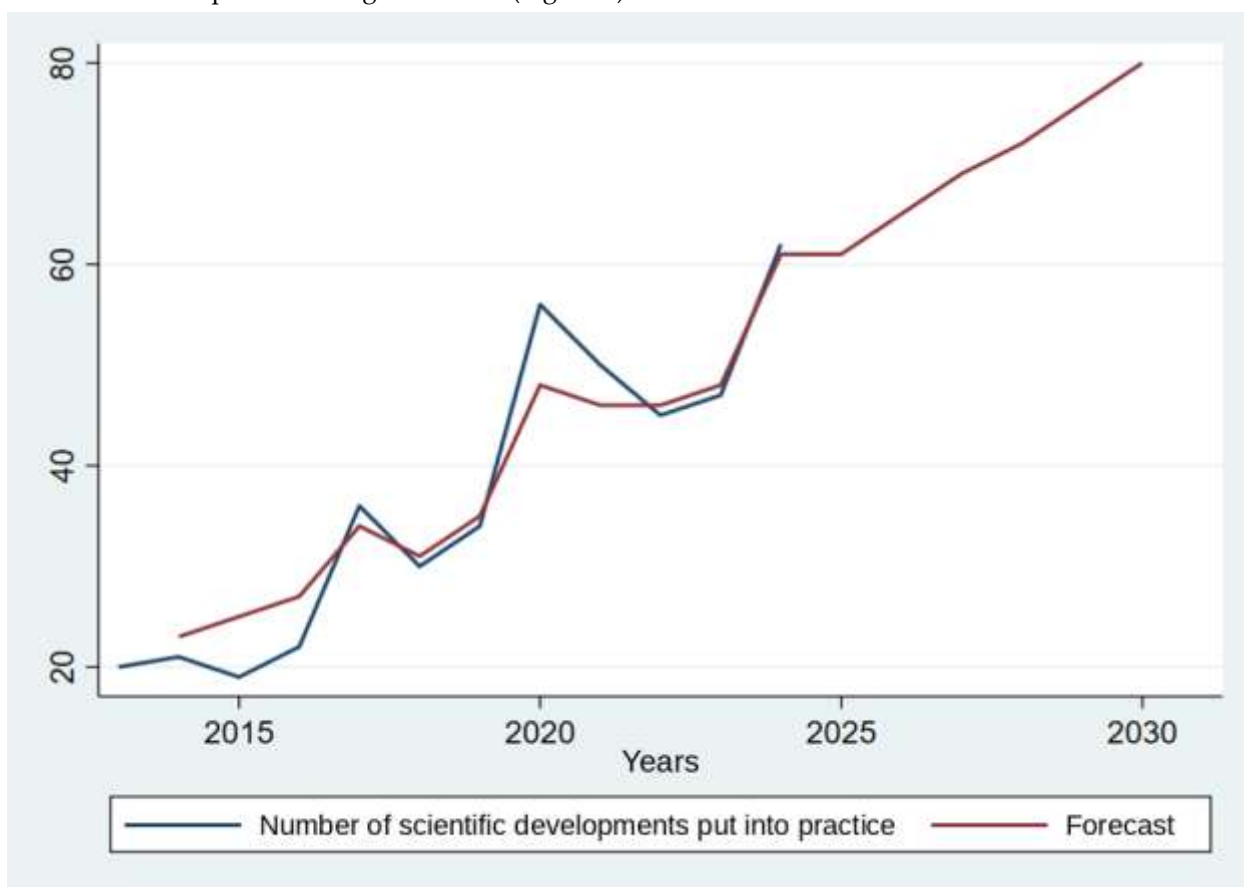


Figure 5. Forecast indicator of the number of scientific developments put into practice by institutions within the National Center for Knowledge and Innovation in Agriculture.

In particular, given that this growth is observed by 2027, the forecast results show that in 2027 the number of scientific developments put into practice will increase by 3, or 104.8%, compared with 2024. In 2030, the forecast number of scientific developments put

into practice by institutions within the National Center for Knowledge and Innovation in Agriculture is 80, an increase of 18, or 129%, over 2024, which has been scientifically substantiated.

Table 7. Dynamics of the analysis of agricultural services delivered by the National Center for Knowledge and Innovation in Agriculture in 2021–2024

№	Indicators	2021	2022	2023	2024
1	Number of services delivered by the centers	12,549	67,461	40,388	114,876
2	Funding for service delivery, thousand soums	162,621	497,305	255,884	50,977.5

Forecasts of how the number of agricultural services and the funding for delivering them are likely to change in 2025–2030 were developed on the basis of analyzing their numerical dynamics at the National Center for Knowledge and Innovation in Agriculture in 2021–2024 (Figures 3.6–3.7).

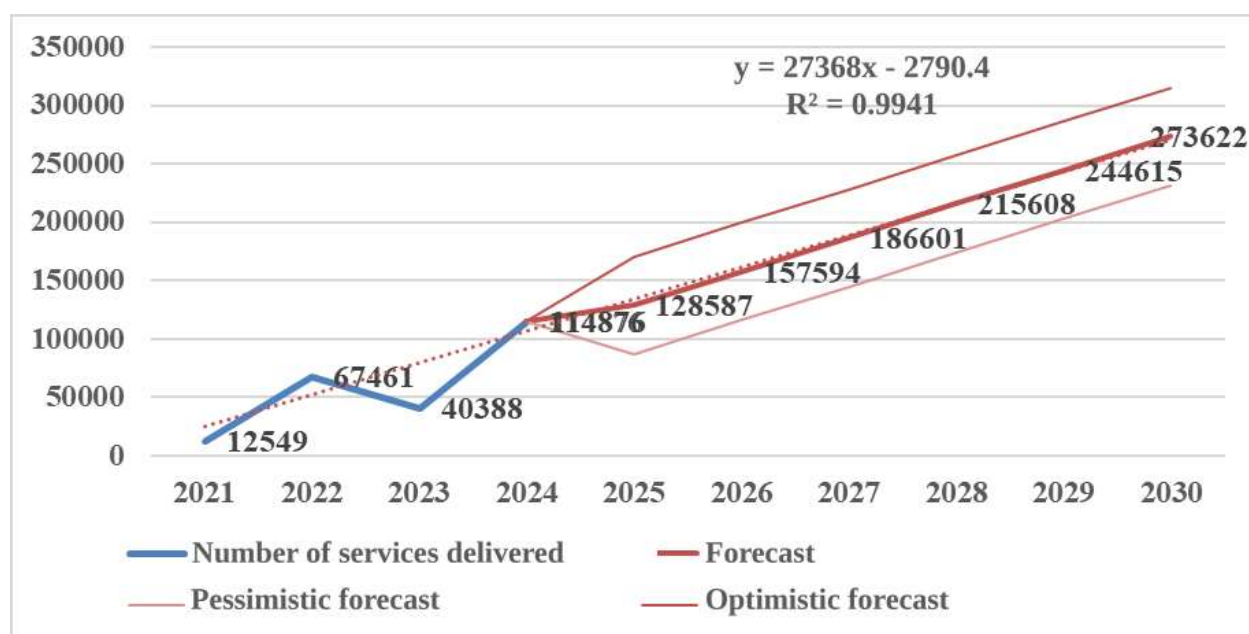


Figure 6. Dynamics of the number of services delivered within the National Center system in 2021–2024 and forecast indicators for 2025–2030.

Over these years, the number of services delivered within the National Center system both fell and rose. Specifically, the number of services delivered was 12,549 in 2021, 67,461 in 2022, and 40,388 in 2023, and reached 114,876 in 2024. On the basis of these indicators, forecasts of the change in the number of services to be delivered in 2024–2030 were developed (Figure 3.6).

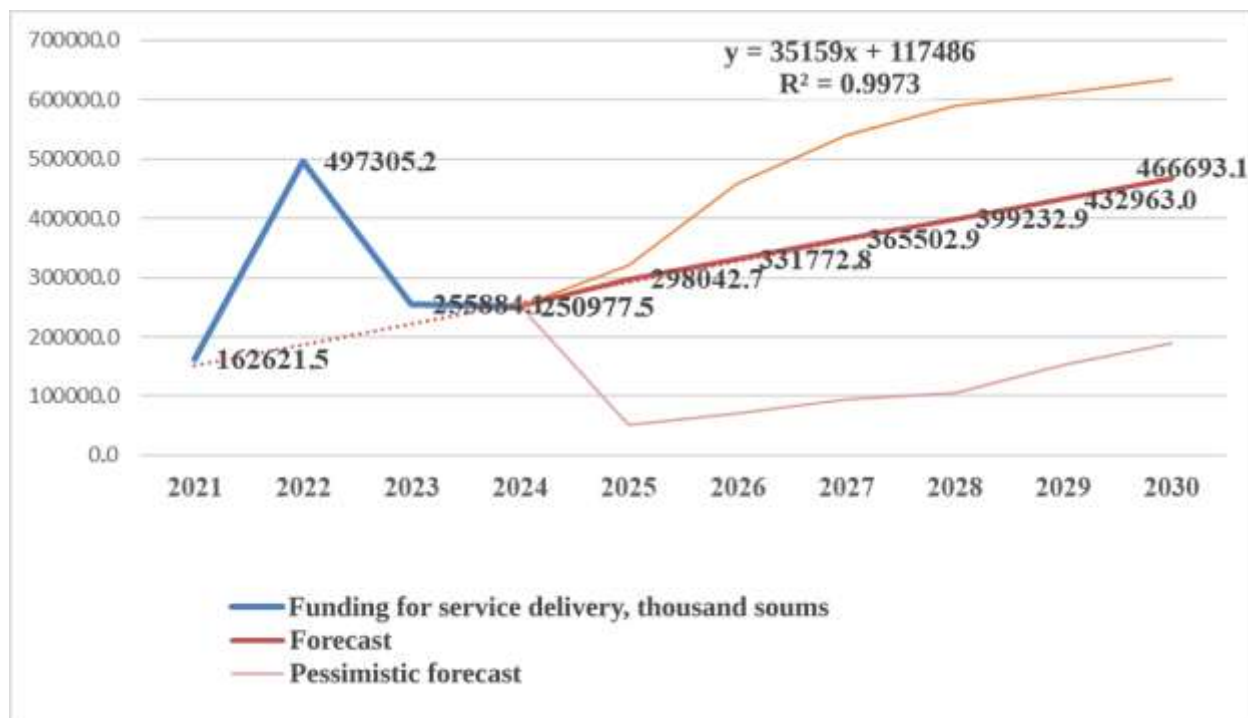


Figure 7. Dynamics of funding for service delivery within the National Center system in 2021–2024 and forecast indicators for 2025–2030 (in thousand soums).

Here we can see that the number of services delivered within the National Center system may rise by 273,622, or 138%, by 2030 compared with 2024.

Figure 3.7 shows that in 2021–2024 the volume of funding aimed at service delivery at the National Center for Knowledge and Innovation in Agriculture saw sharp rises and, conversely, sharp falls.

Funding stood at 162,621.5 thousand soums in 2021 and rose to 497,305.2 thousand soums in 2022, but by 2023 it had fallen to 255,884.1 thousand soums and by 2024 to 50,977.5 thousand soums. On the basis of these indicators, forecasts of the change in funding for the services to be delivered in 2025–2030 were developed (Figure 7). Here we can see that funding is expected to grow to 466,693.1 thousand soums by 2030, an increase of 82.3% compared with 2023.

The results of the study showed the importance of jointly analyzing the volume of services, funding, and the implementation of scientific developments in the work of agricultural service centers in Uzbekistan. The number of services delivered in 2021–2024 changed from 12,549 to 114,876, which shows that the scale of services grew but also fluctuated considerably.

Funding was 497,305.2 thousand soums in 2022 and fell to 50,977.5 thousand soums in 2024. That the number of services rose over the same period shows the need to study the relationship between the volume of services and the dynamics of financial resources more deeply. However, the available data are not sufficient to establish the reasons for these changes.

In forecasting the implementation indicator for scientific developments, the ARIMA(0,1,1) model was found optimal on the AIC (77.8963) and BIC (78.69209) criteria. The portmanteau test result (($p = 0.2464$)) showed that there is insufficient evidence of statistically significant autocorrelation in the residuals. According to the model's forecasts, the number of scientific developments is expected to rise from 62 in 2024 to 80 in 2030, that is, by about 29%.

The results show the importance of using econometric forecasting methods in planning the work of agricultural service centers, assessing the use of financial resources, and improving the process of implementing scientific developments. At the same time, the

short span of annual observations is the main limitation of the study. For this reason, future research should extend the data period and test forecast accuracy against additional criteria.

The results of the study showed the importance of jointly analyzing the volume of services, funding, and the implementation of scientific developments in evaluating the work of agricultural service centers in Uzbekistan. In 2021–2024 the number of services delivered within the system of the National Center for Knowledge and Innovation in Agriculture changed considerably. In particular, the number of services was 12,549 in 2021, 67,461 in 2022, 40,388 in 2023, and 114,876 in 2024. This dynamic shows that, alongside the overall growth in the scale of services, there is considerable year-to-year variability.

Funding indicators also changed unevenly. The volume of financial resources aimed at service delivery was 162,621.5 thousand soums in 2021 and reached 497,305.2 thousand soums in 2022. It then fell to 255,884.1 thousand soums in 2023 and to 50,977.5 thousand soums in 2024.

The fall in funding in 2024 while the number of services was rising shows the need to study the relationship between the scale of agricultural services and the dynamics of financial resources more deeply. However, the available data are not sufficient to establish the reasons for these changes or to prove the effect of funding on the efficiency of services. Future research should therefore also take into account the types of services, funding sources, cost structure, and farmers' demand.

Selecting the ARIMA(0,1,1) model for forecasting the implementation indicator for scientific developments made it possible to use the series' previous dynamics. When alternative models were compared, this specification showed the lowest AIC and BIC values. The portmanteau result ($p = 0.2464$) showed that there is insufficient evidence to confirm statistically significant autocorrelation in the residuals. This supports using the selected model for forecasting, but does not in itself guarantee high forecast accuracy.

According to the model's forecasts, the number of scientific developments put into practice is expected to rise from 62 in 2024 to 80 in 2030. This represents an increase of 18, or about 29%. The forecast shows that econometric models can be used in medium- and long-term planning of the process of implementing scientific developments. At the same time, forecast values should be interpreted not as results that will certainly be achieved, but as estimates calculated from the available data and the chosen model.

The practical significance of the results lies in improving the planning of agricultural service centers, the monitoring of the use of financial resources, and the processes by which scientific developments are applied in production. A rise in the number of services does not in itself mean that their quality or economic efficiency has improved. In future it is therefore important also to assess the number of farmers who used the services, their level of satisfaction, the economic results of the technologies adopted, and the cost per unit of service.

The main limitation of the study is the short span of annual observations. The four observations for 2021–2024 are limited for reliably modeling the long-term dynamics of the volume and funding of agricultural services. The limited length of the time series on scientific developments may also affect the stability of the forecast results. Future research is recommended to extend the data period, assess forecast errors by additional criteria, compare alternative forecasting models, and update the forecasts as new statistical data become available.

4. Methodology and Discussion

To assess development trends of agricultural service centers in Uzbekistan, to analyze the dynamics of the volume of services and their funding, and to forecast indicators of the implementation of scientific developments, this study used statistical analysis, dynamic comparison, and econometric modeling. The empirical basis consisted of statistical data on

the agricultural services delivered within the system of the National Center for Knowledge and Innovation in Agriculture in 2021–2024, on their funding, and on the scientific developments put into practice.

According to the results of the analysis, the number of agricultural services delivered was 12,549 in 2021, 67,461 in 2022, 40,388 in 2023, and 114,876 in 2024. These indicators show that, alongside an overall increase in the volume of agricultural services, there is considerable variability. Funding aimed at service delivery rose from 162,621.5 thousand soums in 2021 to 497,305.2 thousand soums in 2022, and then fell to 255,884.1 thousand soums in 2023 and 50,977.5 thousand soums in 2024. These differences in the dynamics of the number of services and of funding show the need to study the efficiency of resource use in the agricultural service system more deeply. However, the available data are not sufficient to establish the reasons for these changes or the causal relationship between the indicators.

The ARIMA (Autoregressive Integrated Moving Average) model was used to assess the future dynamics of the implementation indicator for scientific developments. First, the stationarity of the series was tested with the Dickey–Fuller test. After first-order differencing, the test's (p)-value was 0.0138, and on this basis the order of differencing was set at ($d = 1$). The ARIMA(1,1,0), ARIMA(0,1,1), ARIMA(1,1,1), and ARIMA(2,1,0) models were then compared, and ARIMA(0,1,1), which had the lowest values on the AIC and BIC information criteria, was selected as the optimal specification. The model's AIC was 77.8963 and its BIC was 78.69209.

The residuals of the selected model were checked with the portmanteau test, which gave ($p = 0.2464$). This showed that there is insufficient evidence to confirm statistically significant autocorrelation in the residuals. According to the forecasts calculated from the ARIMA(0,1,1) model, the number of scientific developments put into practice is expected to rise from 62 in 2024 to 80 in 2030. This represents an increase of 18, or about 29%.

The results show the importance of jointly considering the volume of services, financial resources, and the indicators of scientific-development implementation when planning the work of agricultural service centers. In practical terms, it is advisable to align the growth in the volume of services with funding, to adapt information and advisory services to farmers' needs, and to strengthen cooperation with research institutions. At the same time, a rise in the number of services does not in itself mean that their quality or economic efficiency has improved. In future research it is therefore necessary also to assess the number of service users, farmers' level of satisfaction, the economic results of the scientific developments implemented, and the cost per unit of service.

The main limitation of the study is the short observation period. In particular, the four annual observations for 2021–2024 limit the ability to reliably assess long-term trends in the volume and funding of agricultural services. The forecast results are also not exact values that will be achieved in the future, but estimates calculated from the available data and the chosen model. Future research is recommended to extend the data period, compare alternative forecasting models, and test forecast accuracy against additional criteria.

5. Conclusions

This study analyzed development trends of agricultural service centers in Uzbekistan and the dynamics of the volume of services and of their funding, and assessed forecast values of the implementation indicator for scientific developments for 2025–2030 on the basis of econometric modeling.

The results showed that the volume of agricultural services changed considerably in 2021–2024. The number of services delivered rose from 12,549 in 2021 to 114,876 in 2024. Over the same period, funding for service delivery followed an uneven path, standing at 497,305.2 thousand soums in 2022 and falling to 50,977.5 thousand soums in 2024. These

results show that, in evaluating the work of agricultural service centers, the dynamics of financial resources should be considered alongside the number of services.

To forecast the implementation indicator for scientific developments, alternative ARIMA models were compared, and ARIMA(0,1,1), with the lowest AIC (77.8963) and BIC (78.69209) values, was selected. The portmanteau test result ($p = 0.2464$) showed that there is insufficient evidence of statistically significant autocorrelation in the model's residuals. According to the forecasts of the selected model, the number of scientific developments put into practice is expected to rise from 62 in 2024 to 80 in 2030. This represents an increase of 18, or about 29%.

The scientific and practical significance of the study lies in justifying the use of methods that jointly analyze and forecast the volume of services, funding, and the implementation of scientific developments in evaluating the work of agricultural service centers. The results can be applied to the strategic planning of the agricultural service system, to monitoring the use of financial resources, and to improving the processes by which scientific developments are applied in production.

In practical terms, it is advisable for agricultural service centers to adapt information and advisory services to farmers' needs, to allocate financial resources according to plan, to strengthen cooperation with research institutions, and to evaluate the effectiveness of the scientific developments they implement. It is also necessary to build an expanded database covering types of services, cost structure, and indicators of farmers' use of the services, in order to study more deeply the relationship between the volume of services and funding.

The main limitation of the study is the short observation period and the limited data on some indicators. Forecast results should therefore be interpreted as estimates based on existing trends. Future research is recommended to extend the observation period, compare alternative econometric models, and assess forecast accuracy against additional statistical criteria. This will broaden the possibilities for a more soundly based evaluation of agricultural service centers and for making effective management decisions on introducing innovations in the agricultural sector.

Abbreviations

ARIMA — Autoregressive Integrated Moving Average.

AIC — Akaike Information Criterion.

BIC — Bayesian Information Criterion.

ACF — Autocorrelation Function.

PACF — Partial Autocorrelation Function.

ADF — Augmented Dickey–Fuller test.

MA — Moving Average.

Stata — Statistical Software for Data Analysis.

Acknowledgements

The authors thank the National Center for Knowledge and Innovation in Agriculture for providing the data used in the study. They also express their gratitude for the statistical data that formed the basis for analyzing development trends of agricultural services in Uzbekistan and for developing the forecast indicators.

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