

AI-based Strategic Decision Support System in Data Management and Efficiency Valuation in Fatih Municipality Service Units

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Abstract

The growing demand for services in local governments and the constraints of public resources have made the effective and efficient management of resources a critical issue. This study presents an efficiency pilot application for service centers, developed as part of an AI-assisted strategic decision support system aimed at improving data management processes and increasing service efficiency in municipal service centers.

The primary objective of the research is to compare the service center efficiency scores obtained through manual methods in 2024 with those generated through AI-assisted data analysis, and to test the accuracy and effectiveness of this approach. In this context, existing data flows were analyzed, and key issues were identified, including manual data collection, lack of standardization, insufficient integration across systems, limited analytical capacity, and the absence of spatial analysis based on geographic information systems.

Within the scope of the proposed model, GIS-based indicator dashboards, automated data integration mechanisms, and AI-based forecasting and optimization models to support investment planning and service improvement processes were designed. The pilot application covers various municipal service categories such as libraries, sports centers, cultural centers, and social service units. The findings indicate that the proposed model has the potential to increase operational efficiency, enable monitoring of citizen satisfaction, reduce manual workload and data errors, and support municipal governance through AI-assisted strategic planning practices. In this regard, the development of data-driven management approaches, the establishment of standard data infrastructures, and the use of more advanced analytical methods are of critical importance for enhancing effectiveness and efficiency in local governments.

Keywords: Artificial Intelligence, Decision Support System, Municipal Data Management, Service Efficiency, Random Forest

Introduction

The delivery of efficient public services under conditions of constrained budgets and growing urban demand is the defining governance challenge of contemporary local administration. Municipalities are responsible for providing a wide and heterogeneous array of services-from libraries, sports centers, and cultural facilities to social care and urban infrastructure-all of which must be maintained and improved while operating within finite fiscal boundaries. Public services around the world face growing demands, limited budgets, and changing populations,

making efficiency analysis more important than ever; techniques such as data envelopment analysis (DEA), stochastic frontier analysis, and machine learning offer valuable tools for improving how public services are managed (De Witte, et al., 2025). Yet in practice, most municipalities still rely on fragmented data, manual processes, and experience-based judgment to allocate budgets and plan service investments—an approach that is both analytically weak and operationally costly. For this reason, public institutions consider not only financial indicators but also performance criteria such as service quality, accessibility, and citizen satisfaction. Unlike private sector organizations, municipalities must simultaneously manage financial inputs (personnel, operating expenditures, infrastructure costs) against non-financial outputs—service reach, citizen engagement, repeat usage, and satisfaction—that cannot be reduced to a simple profit metric (Bartolacci, et al., 2025). User satisfaction with public services is one of the agreed indicators for monitoring achievement of the UN's 2030 Sustainable Development Goal 16 on building effective, accountable, and inclusive institutions at all levels (OECD, 2025). Citizen satisfaction has increasingly been conceptualized as a measurable and analytically tractable output indicator. Empirical evidence demonstrates that transparency exerts a significant positive effect on citizen satisfaction with public services (Li, et al., 2026). Municipalities worldwide are increasingly adopting artificial intelligence (AI) to address the growing complexity and demand for efficient, transparent, and citizen-centric public services. Strategic decision support systems (DSS) powered by AI are at the forefront of this transformation, enabling data-driven policy development, resource optimization, and automation of routine tasks (Szpyt and Bilski, 2025). Several AI-based techniques are used for DSS such as AN, ML, Hybrid and Ensemble Models (CNN-LSTM, GNN, hybrid ML-DL Frameworks) (Banerjee, et al., 2023; Mishra, et al., 2026; Yáñez, et al., 2025). As Szedmák, et al., (2025) mentioned, data produced by different units in municipalities is often stored in different systems, combined with insufficient data standardization and largely manual data collection processes, creates significant limitations in decision-making. This situation makes it difficult to accurately measure service efficiency and to effectively use data-driven analyses in strategic planning processes.

With the increasing prevalence of data-driven management approaches in recent years, the transition from input-oriented to output- and outcome-oriented approaches in public administration has gained momentum (Tilly, et al., 2025). This study is based on the primary results of ISTKA (Istanbul Development Agency) project. According to this project, FM aims to enhance its digital transformation, by integrating AI-driven data management and decision-support systems. The project will unify data sources, improving investment planning, service design, and decision-making efficiency. It also strengthens staff competencies in AI and analytics, ensuring sustainable adoption. Ultimately, it will boost data-driven governance, inter-agency collaboration, and citizen satisfaction, while promoting the wider use of AI in local government services across Istanbul. This study aims to compare the service center efficiency scores obtained through manual methods at Fatih Municipality in 2024 with those produced by Random Forest to test accuracy and effectiveness. The efficiency parameters of 2024 data have been defined as defined as an output of the ISTKA project. The RF results have been compared with EATWIOS (Peters and Zelewski, 2021) statistical analysis result that was generated manual. The outputs show that AI-based solutions give encouraging results.

Data and Methodology

Measuring efficiency in local government services is a complex process due to variable selection, data collection difficulties, and structural challenges in measuring public services (Balaguer-Coll et al., 2013). In the study, data based on a multi-input, multi-output structure was created to measure the efficiency of service centers. Input variables were determined as operating expenses (electricity, water, heating, and consumables) and personnel costs under

the scope of financial expenditures. In addition, the service duration of the service centers was included in the analysis as an indirect input variable. Since many output indicators in public services do not have a direct financial equivalent, user (citizen) interaction is one of the most important output indicators in efficiency analyses of public services. The 2024 data consist of 33 services in the region of Fatih.

Accordingly, in 2024 data, output variables; the number of users, the rate of reaching potential users, repeat usage, and citizen satisfaction were considered as the primary output indicators given below:

- Number of Municipal Personnel
- Number of Temporary Personnel
- Number of Facility Operations Personnel
- Total Personnel Cost
- Event/Training etc. Cost
- Rental Cost
- Number of Registrations/Users
- Number of Unique Registrations/Users
- Number of Fatih Residents
- Number of Registrations/Users
- Number of Unique Registrations/Users
- Number of Fatih Residents
- Usage Frequency (Multiple Users / Unique Users)
- Average Satisfaction
- Non-Reporting Issue Rate

Data Preprocessing and Normalization

All input variables were normalized prior to model training in order to ensure comparability across different units and scales. First, the square root transformation was applied to the raw input values to reduce skewness and stabilize variance. Following this, a Min–Max normalization approach was employed. Depending on whether the input variable had a positive or negative effect on efficiency, different normalization formulations were used. For negatively oriented inputs, the normalization was applied using the following transformation:

$$X' = 1 - \frac{X - X_{\min}}{X_{\max} - X_{\min}} \quad (1)$$

This approach ensures that all variables are scaled within a comparable range and aligned in terms of their directional impact on performance. Finally, the normalized input values were multiplied by their respective weights to compute the weighted input structure used in the model.

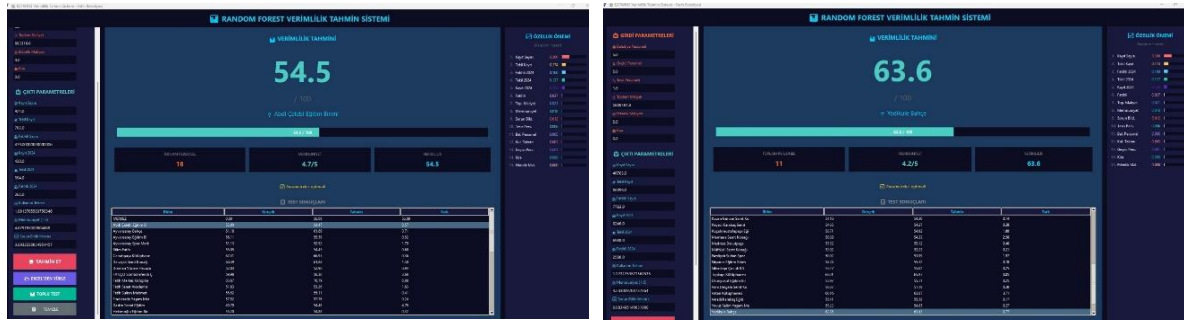
Model Overview

The AI-based prototype was developed to evaluate the performance of FB service centers using a standardized efficiency score ranging from 0 to 100 based on 2024 data.

Model Architecture

- A Random Forest model was then trained using 200 decision trees ($n_estimators = 200$), with a maximum depth of 10, minimum samples split of 5, and a minimum leaf size of 2. These hyperparameters were selected to balance model complexity and generalization performance.
- The model predicts efficiency scores by normalizing input and output variables and applying the weighted EATWIOS formula.
- Feature importance analysis identified key drivers of efficiency, confirming that satisfaction and user-related variables are the most influential factors.
- Model performance was evaluated using R^2 (coefficient of determination) and MAE (Mean Absolute Error).

The results obtained are given in Table 1 and Figure 1a and 1b.



(a) Abdi Çelebi training Centre

(b) Yedikule garden

Figure 1. Prediction results for two services.

Table 1. Results of EATWIOS Analysis and RF Predictions (%).

Name of Service	Ground truth Manual (EATWIOS analysis) %	AI-based Prediction (RF results) %	Difference %
Abdi Çelebi Education Unit	53.9	54.47	0.57
Ayvansaray Garden	61.18	61.89	0.71
Ayvansaray Education Unit	56.11	55.59	0.52
Ayvansaray Sports Center	51.13	52.92	1.79
Science Fatih	55.05	54.45	0.6
Cerrahpaşa Library	67.31	66.95	0.36
Dervişali Neighborhood Center	60.39	61.88	1.5
Draman Swimming Pool	52.03	52.96	0.93
Sumbul Efendi Children's Center	59.98	56.3	3.68
Fatih Central Library	83.67	76.79	6.88
Fatih Art Academy	51.63	53.26	1.63
Fatih Sultan Mehmet	55.52	55.11	0.41
Fındıkzade Life Center	57.52	57.76	0.24
Gastro Art Education	49.7	54.48	4.78
Hekimoğlu Education Unit	55.2	54.88	0.32
Karagümrük Life Center	54.3	54.03	0.27
Kariye Library	61.73	59.75	1.98
Kasım Günani Neighborhood Center	54.16	54.3	0.14
Keçeci Karabaş Neighborhood Center	54.65	54.27	0.38
Küçükmustafapaşa Education Unit	56.71	54.92	1.8
Marmara Neighborhood Center	56.88	54.33	2.56
Medrese Davutpaşa	55.52	55.12	0.4
Müftüali Neighborhood Center	53.02	53.23	0.21
Neslişah Sultan Sports Center	50.02	51.99	1.97
Nişanca Education Unit	54.74	55.52	0.78
Silivrikapı Children's Library	55.27	55.02	0.25
Topkapı Library	66.01	65.97	0.05
Uzunyusuf Education Unit	55.97	55.71	0.25
Vani Dergahı Neighborhood Center	56.87	57.18	0.3
Vatan Library	60.16	63.87	3.71
Veled Karabaş Education Unit	55.41	55.58	0.17
Yavuz Selim Life Center	55.23	54.85	0.37
Yedikule Garden	62.85	63.62	0.77

Results

In this study, the service center efficiency scores obtained through manual methods were compared with those produced through AI-assisted data analysis, and the accuracy and effectiveness of this approach were tested. The results show that there is generally a high level of agreement between the efficiency scores obtained through manual methods and those

produced through AI-assisted analyses. However, it was determined that AI-assisted models produce more reliable results in terms of data integrity, consistency, and analysis accuracy. Within the scope of the developed model, an AI-based prototype that evaluates the performance of service centers with a standardized efficiency score in the range of 0–100 was successfully created.

Through improvements in data integration, cleaning, and standardization processes, data quality was significantly increased and error rates in analysis processes were reduced. Additionally, a notable reduction in processing times was observed compared to manual data collection and analysis processes. Furthermore, with the developed dashboard system, efficiency scores, variable effects, and analysis results were made monitorable through user-friendly interfaces.

The IT and Strategy Departments of FB implemented Random Forest (RF) methods in this study. In this process, the input and output variable structures used for scoring the 2024 data based on the EATWIOS (Efficiency Analysis Technique with Input and Output Satisfaction) method were defined by FB teams, as presented in Table 2. The weights of the input variables were determined using the Analytic Hierarchy Process (AHP), as also shown in Table 2.

Core Formula:

$$\text{Efficiency Score} = (\text{Weighted Sum of Outputs}) / (\text{Weighted Sum of Inputs}) \quad (2)$$

Table 2. Scoring parameters and their weights.

Input Variables			Output Variables		
Variable	Description	Weight	Variable	Description	Weight
Municipal Personnel	Number of permanent staff	0.30	Registrations	Total registrations/users	0.15
Temporary Personnel	Number of contracted staff	0.15	Unique Users	Number of unique users	0.20
Facility Personnel	Facility operation staff	0.10	Fatih Residents	Usage by district residents	0.15
Total Cost	Annual personnel cost (₺)	0.35	Usage Frequency	Multiple/unique user ratio	0.10
Event Cost	Training/event expenditures	0.05	Average Satisfaction	Citizen satisfaction score (1–5)	0.25
Rent	Annual rental cost	0.05	No-Issue Reporting	Inverse complaint rate (0–1)	0.10

Conclusion

This study examined the improvement of efficiency measurement processes conducted AI-based Random Forest method and compared it with manually calculated EATWIOS method. The findings indicate that AI-based solutions show a high level of agreement with manual EATWIOS analyses and can produce faster, more consistent, and scalable results. This reveals significant potential for automating efficiency analyses in local governments and making them continuously monitorable.

In conclusion, the integration of artificial intelligence technologies into public administration enables decision-making processes to become more objective, faster, and data oriented. This transformation plays a critical role in increasing transparency, accountability, and service quality in local governments. In the future, the widespread adoption of such systems and their support with more advanced analytical methods will form the foundation of smart municipality applications.

Although the existing data structure was partially digitalized, the predominant manual nature of data collection, cleaning, and standardization processes created significant limitations in terms of data integration, standardization, and centralized access. First, weaknesses and areas requiring improvement in the existing structure were identified. It was determined that different directorates in the municipality operated data through independent systems (Excel, Oracle, ArcGIS Enterprise) and that there were deficiencies in inter-system integration. Entity-relationship (ER) diagrams and comprehensive data schemas were created within the framework of three main modules: (i) Activity and Participation Management (Project, Event, Registration, Attendance modules), (ii) Location and Revenue/Expense Management (Location, Location Revenue, Location Expense, Expense Type), (iii) Survey Management (Survey, Survey Question, Survey Answer, Survey Send Log). The automation of data management in service processes was ensured, achieving data integration and standardization. In this process, the data source, data production frequency, update period, and responsible units were defined for each input and output variable; data collection and transfer processes were systematically modeled through technical data flow diagrams.

In the next step of the project, first, data collection will be automatized, the existing large data infrastructure, open-source datasets such as House Prices, Black Friday Dataset, and Land Use will be exploited and hybrid ML+DL based models will be utilized in terms of multi-criteria decision support systems and deep learning architectures.

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