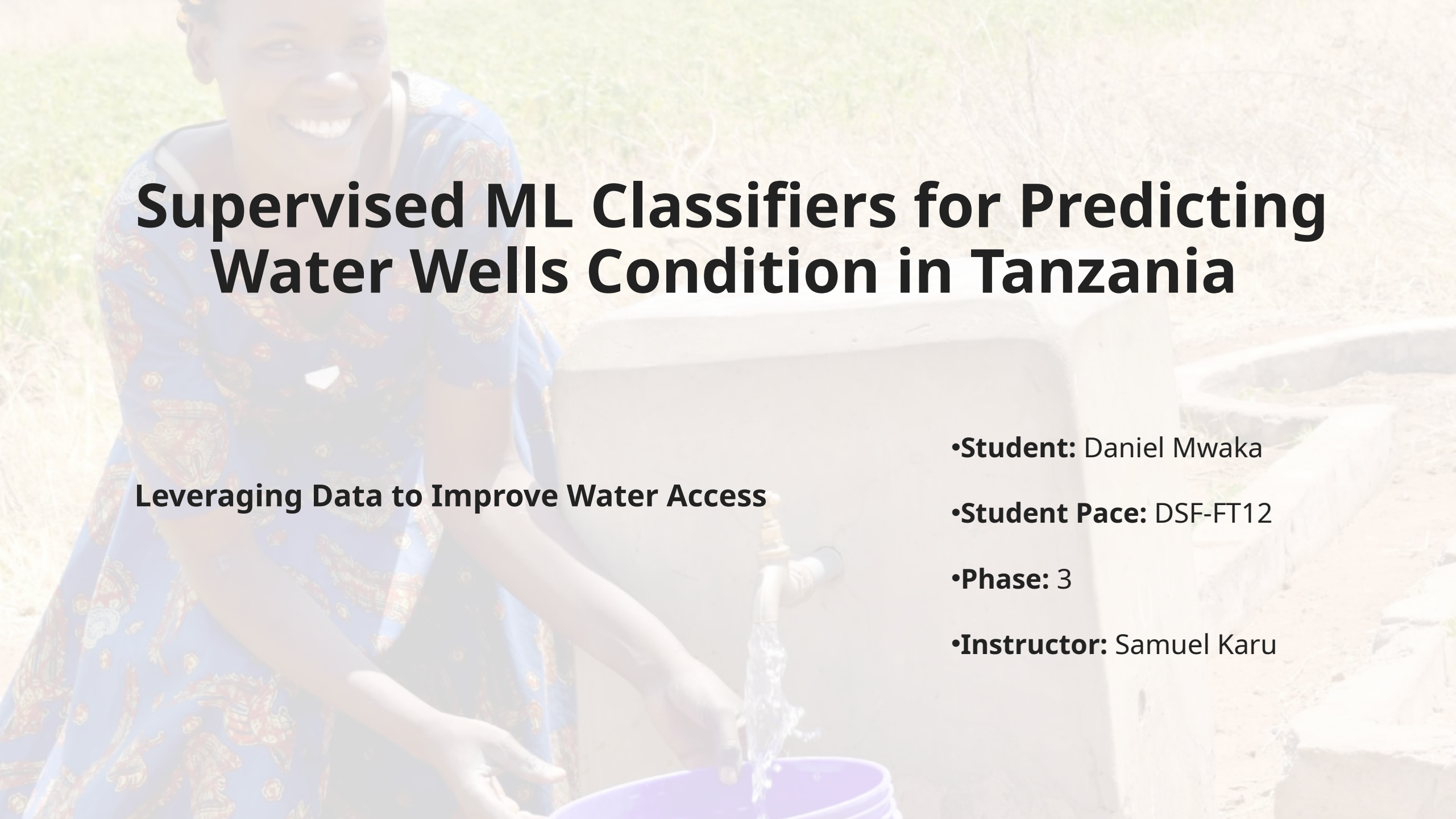

# Supervised ML Classifiers for Predicting Water Wells Condition in Tanzania

**Leveraging Data to Improve Water Access**


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- **Student Pace:** DSF-FT12
- **Phase:** 3
- **Instructor:** Samuel Karu

# Problem Statement

- Access to clean water is a critical challenge in Tanzania.
- Many established water points are in disrepair or non-functional, impacting millions leading to water scarcity.
- The lack of an effective, data-driven framework for predicting a well's functional status is a leverageable improvement area.
- **The Goal:** To recommend an evidence-based supervised ML classification model for predicting the functional condition of water wells in Tanzania.

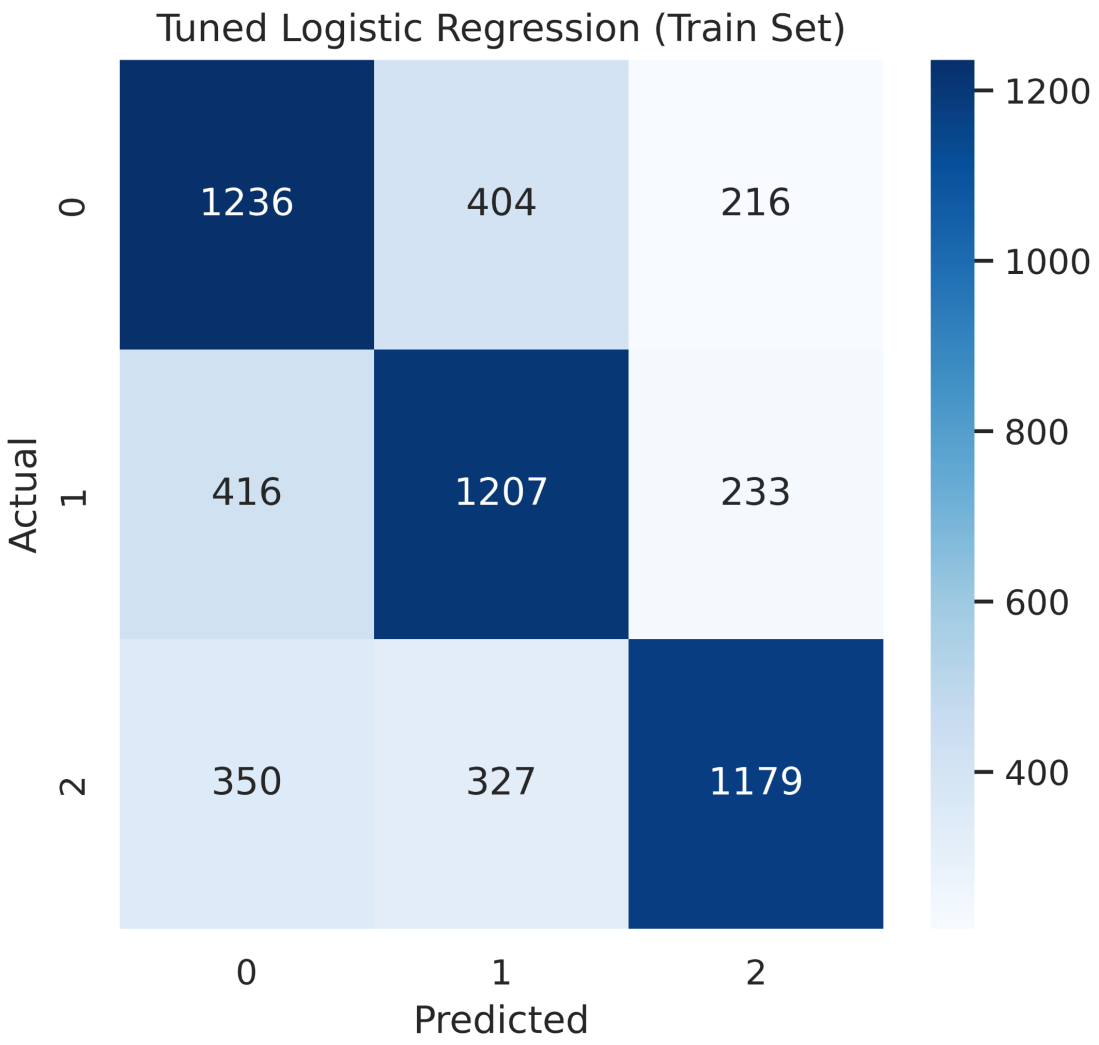

# Business Understanding

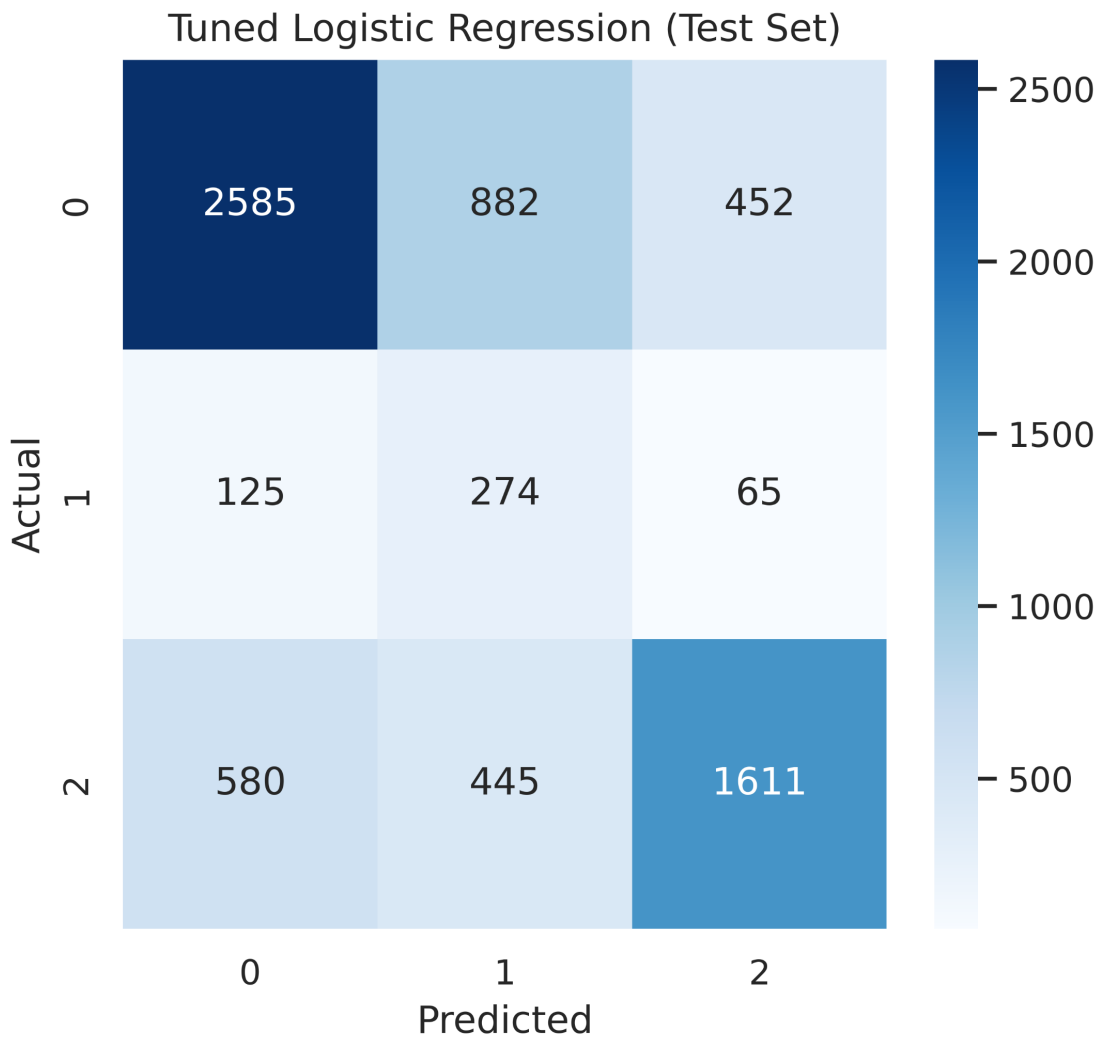
- **Business Problem:** Predicting the condition of water wells can enable stakeholders to prioritize maintenance, and allocate resources efficiently to support water security.
- **Core Question:** Can the operational status of water-wells be accurately predicted using available data and machine learning models?
- **Project Scope:**
  - Examine features related to a Water-well's function to identify potential predictor variables.
  - Build multiple classifiers, tune them, evaluate, and compare their respective prediction performance (***Accuracy, F1-score***, and ***ROC-AUC***) to determine the best fit model.
  - Verify the reliability of the best-fit model by deploying it to predict the target variable for a previously unseen dataset.
  - Deduce feasible business recommendations and viable next steps.

# Data Understanding

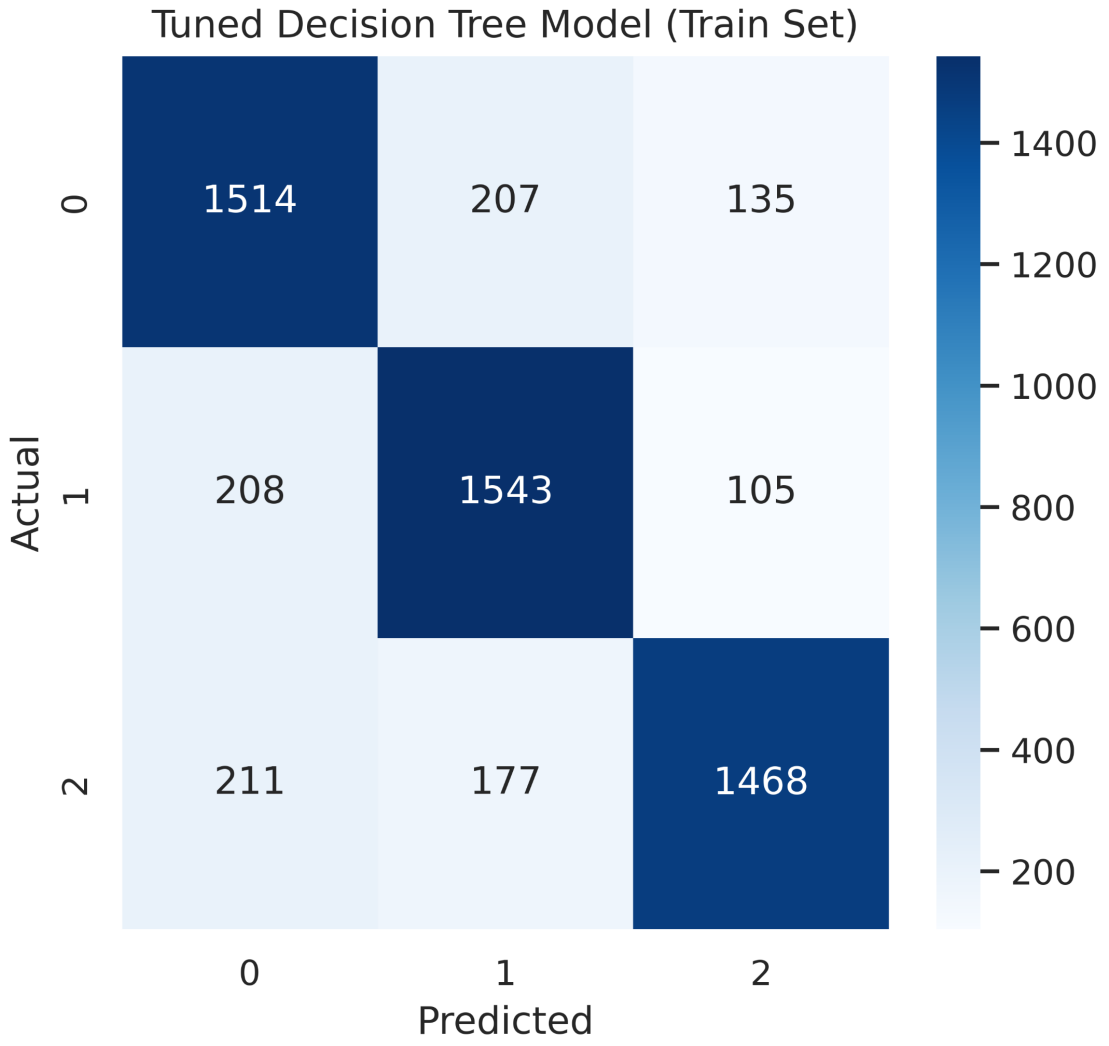
- **Dataset Source:** Kaggle competition dataset on Tanzanian Water Wells from https://www.drivendata.org/competitions/7/pump-it-up-data-mining-the-water-table/data/
- **Datasets:**
  - Trainingset.csv (40 columns and 59400 entries).
  - trainingsetlabels.csv (2 columns and 59400 entries).
  - Testdata.csv (40 columns and 14850 entries).
- **Target Variable:** Water-well Status (Functional, Function needs repair, or non-functional).
- **Selected Predictor Features:** gps height, population, well age, basin, region, permit, extraction type, management group, payment type, water quality, water quantity, source type, and water-point type.

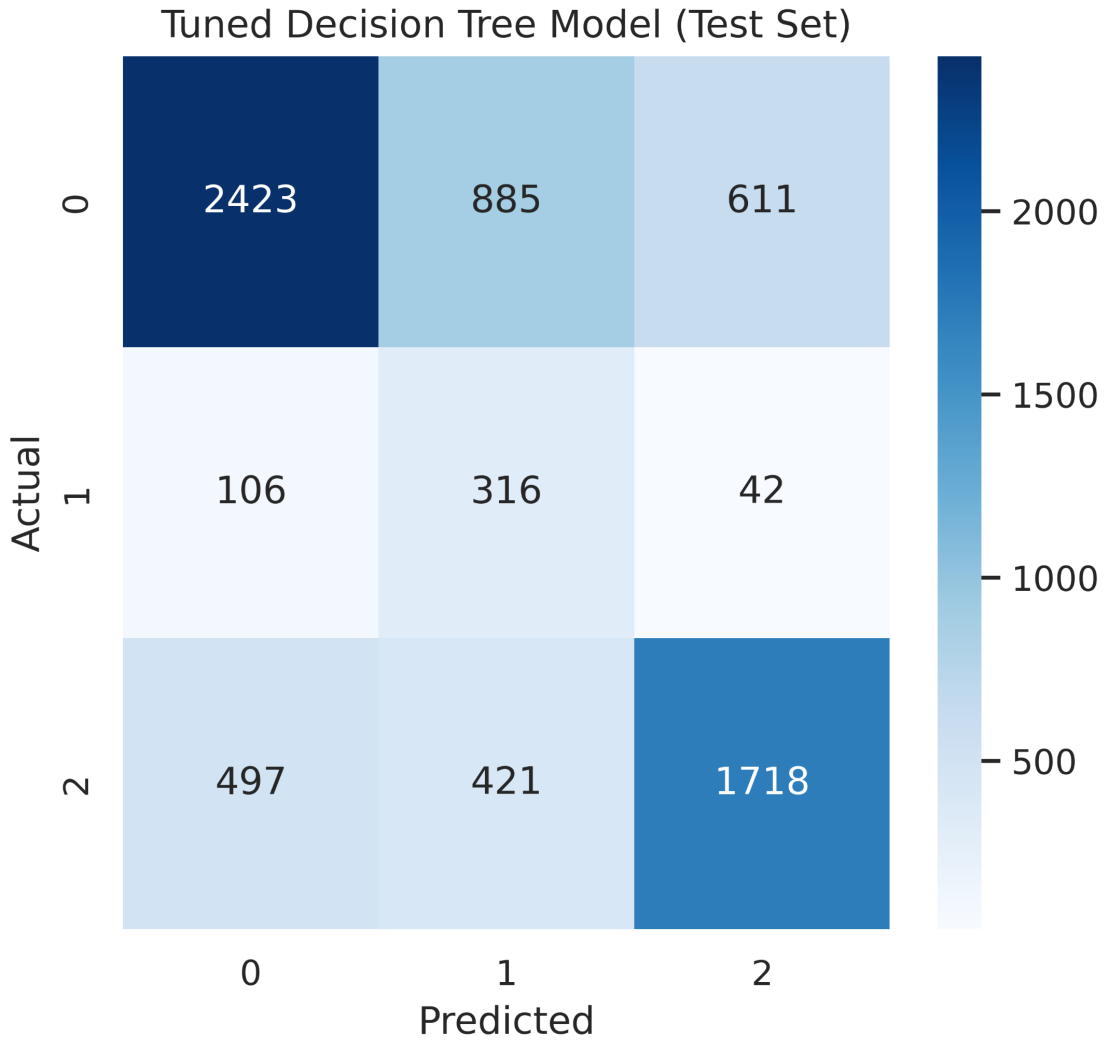
# Model Evaluation: Logistic Regression Model



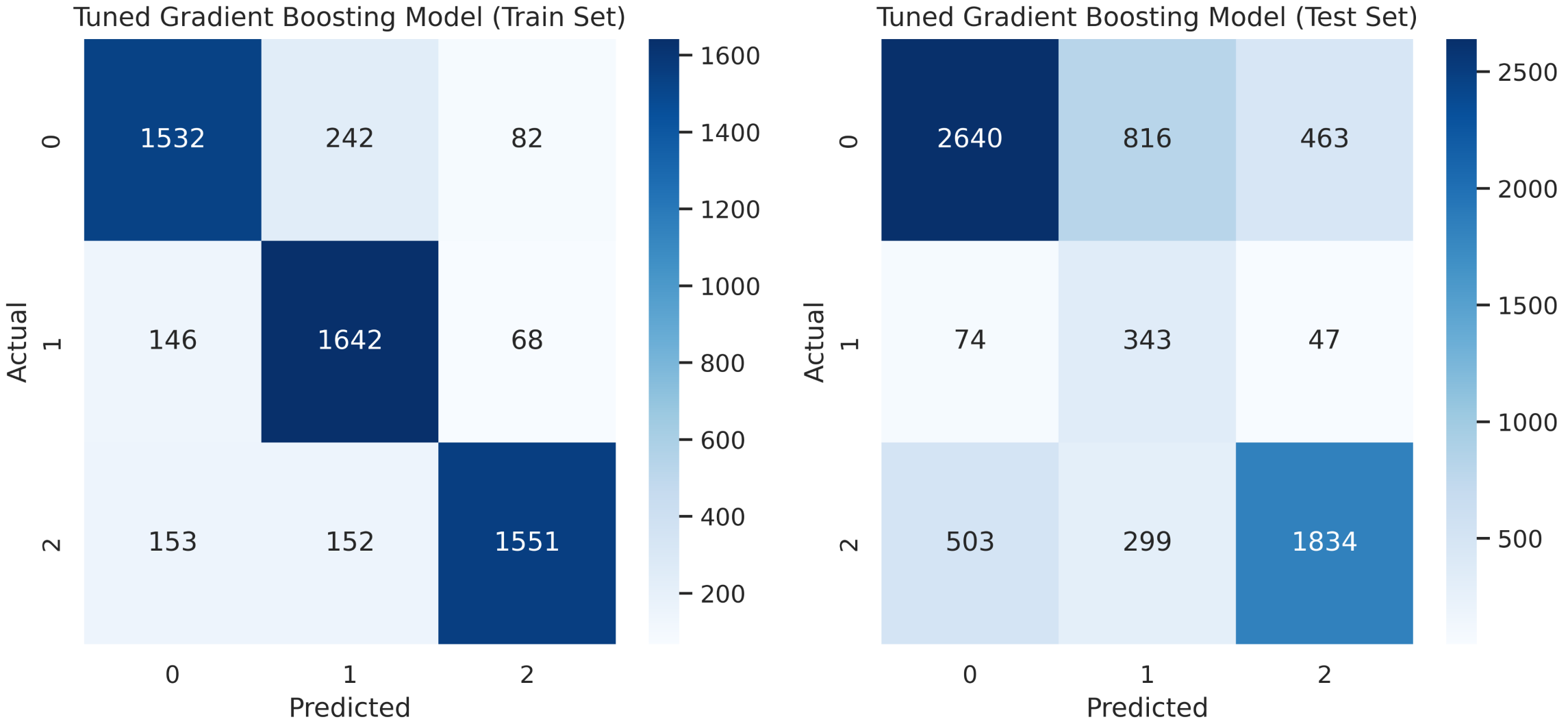



# Model Evaluation: Decision Tree Classifier



# Model Evaluation: Gradient Boosting Classifier



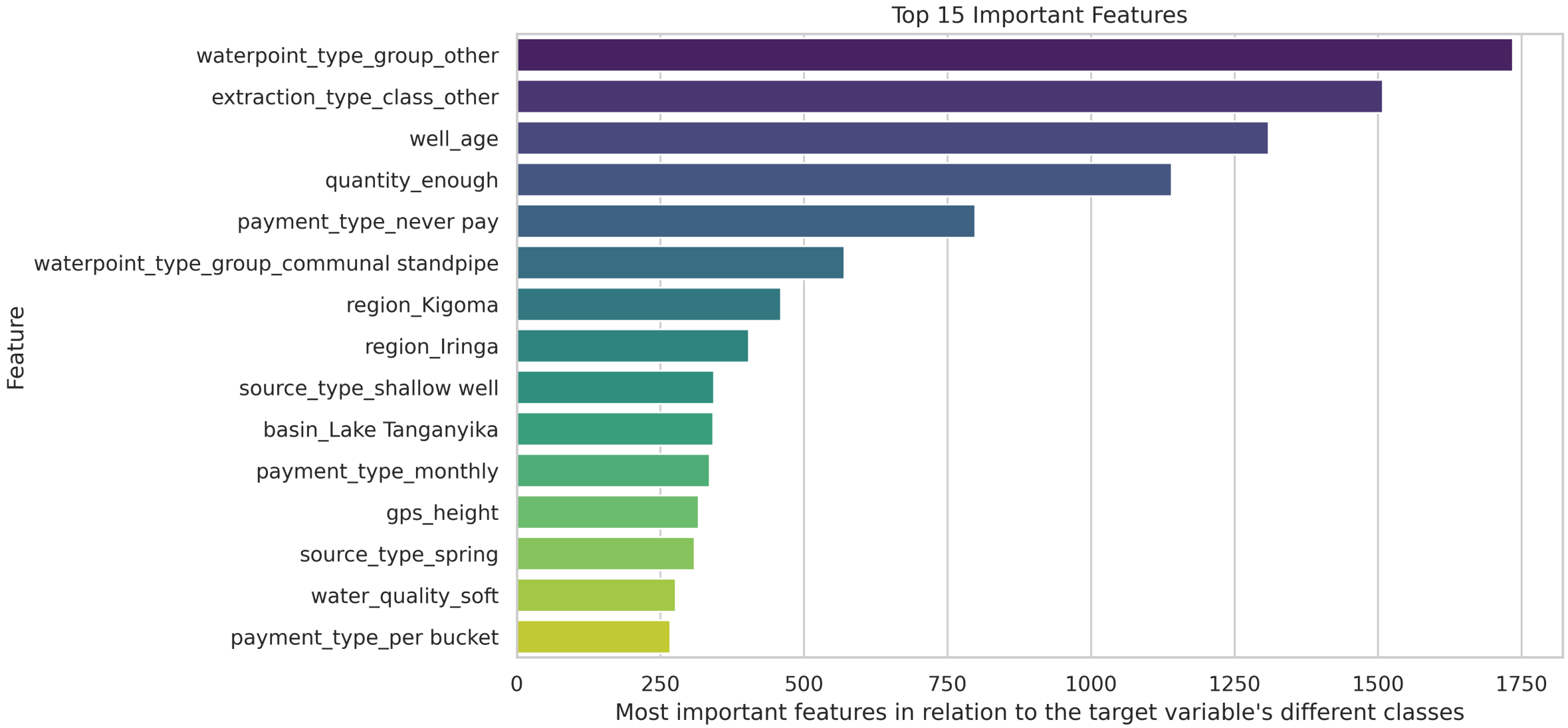
# Model Performance Comparison

| | Model | Train Accuracy | Test Accuracy | Train F1-score | Test F1-score | Train ROC-AUC | Test ROC-AUC |
|---|---|---|---|---|---|---|---|
| **0** | Logistic Regression (Untuned) | 0.649605 | 0.640120 | 0.650390 | 0.674233 | 0.831460 | 0.816319 |
| **1** | Logistic Regression (Tuned) | 0.650144 | 0.636700 | 0.650930 | 0.671800 | 0.832009 | 0.816467 |
| **2** | Decision Tree (Untuned) | 0.999461 | 0.625445 | 0.999461 | 0.657666 | 1.000000 | 0.731613 |
| **3** | Decision Tree (Tuned) | 0.812680 | 0.634991 | 0.812901 | 0.667340 | 0.953505 | 0.801969 |
| **4** | Gradient Boosting (Untuned) | 0.720366 | 0.668329 | 0.721155 | 0.698047 | 0.879053 | 0.843328 |
| **5** | Gradient Boosting (Tuned) | 0.817529 | 0.684001 | 0.817773 | 0.710658 | 0.944834 | 0.863916 |

# Selected Model for Deployment

- The ***tuned Gradient Boosting Classifier*** is selected for deployment.
- Reasons for Selection:
  - Consistently delivered superior predictive performance (***highest ROC-AUC***).
  - Balanced precision and recall across all classes (***highest F1-score***).
  - Demonstrated strong generalization to unseen data (***highest ROC-AUC***).
  - Small gap between train and test performance metrics indicates robustness and minimal overfitting.
- This model is the most reliable, effective, and best-choice for predicting the status of water wells in Tanzania.

# Feature Importance Insights



# Business Recommendations

- **Prioritize Maintenance:** Use model predictions to identify high-risk wells and allocate maintenance resources efficiently.
- **Improve Data Collection:** Enhance data quality, particularly for key features influencing well condition, such as management, payment types, and environmental factors.
- **Stakeholder Engagement:** Share insights with local authorities and NGOs to inform decision-making, schedule maintenance routines, and find patterns on factors impacting long-term functionality.
- **Inform New Infrastructure:** Use insights on factors contributing to failure to inform the design and construction frameworks for new groundwater projects.

# Next Steps

- **Model Deployment:** Integrate the Tuned Gradient Boosting Classifier into a user-friendly dashboard for real-time predictions.
- **Integration into Planning:** Use model predictions to optimize maintenance schedules and target interventions.
- **Pilot Targeted Interventions:** Use the model to pilot interventions in high-risk areas/well types and measure the impact.
- **Feature Expansion:** Incorporate additional data sources (e.g., weather, usage patterns) to enhance model accuracy and update the mode regularly with new data to maintain performance and relevance.