

# Machine Learning Model Evaluation Report

## ### Analysis of the Model Performance:

The provided evaluation metrics (Log Loss, Precision-Recall AUC, Accuracy, and Cross-Validation Scores) give a comprehensive view of how each machine learning model performs, both **with** and **without** SMOTE (Synthetic Minority Over-sampling Technique). Below is a detailed analysis of the results:

### Log Loss Comparison (Without SMOTE)

Model	Log Loss
Linear SVM	0.887
Logistic Regression	0.824
Random Forest	0.645
K-Nearest Neighbors	1.020
XGBoost	0.658

### Log Loss Comparison (With SMOTE)

Model	Log Loss
Linear SVM	0.845
Logistic Regression	0.785
Random Forest	0.502
K-Nearest Neighbors	0.920
XGBoost	0.510

### Precision-Recall AUC Comparison (Without SMOTE)

Model	Precision-Recall AUC
Linear SVM	0.635
Logistic Regression	0.652
Random Forest	0.785
K-Nearest Neighbors	0.532
XGBoost	0.775

### Precision-Recall AUC Comparison (With SMOTE)

Model	Precision-Recall AUC
Linear SVM	0.678
Logistic Regression	0.692
Random Forest	0.850

K-Nearest Neighbors	0.601
XGBoost	0.848

#### Accuracy Comparison (Without SMOTE)

Model	Accuracy
Linear SVM	0.75
Logistic Regression	0.80
Random Forest	0.85
K-Nearest Neighbors	0.70
XGBoost	0.82

#### Accuracy Comparison (With SMOTE)

Model	Accuracy
Linear SVM	0.78
Logistic Regression	0.82
Random Forest	0.88
K-Nearest Neighbors	0.72
XGBoost	0.85

#### Cross-Validation Scores (Without SMOTE)

Model	Cross-Validation Score
Linear SVM	0.710
Logistic Regression	0.740
Random Forest	0.810
K-Nearest Neighbors	0.690
XGBoost	0.780

#### Cross-Validation Scores (With SMOTE)

Model	Cross-Validation Score
Linear SVM	0.730
Logistic Regression	0.760
Random Forest	0.850
K-Nearest Neighbors	0.710
XGBoost	0.790

#### 1. Log Loss Comparison (With and Without SMOTE):

Without SMOTE:

- Random Forest (0.645) performs the best, followed by XGBoost (0.658). Linear SVM (0.887) and KNN (1.020) struggle.

With SMOTE:

- Random Forest (0.502) and XGBoost (0.510) improve significantly. SVM and Logistic Regression improve moderately.

Conclusion: Random Forest and XGBoost handle imbalanced data better post-SMOTE.

## **2. Precision-Recall AUC Comparison (PR AUC):**

Without SMOTE:

- Random Forest (0.785) and XGBoost (0.775) perform well. KNN (0.532) is the weakest.

With SMOTE:

- Random Forest (0.850) and XGBoost (0.848) improve. Linear models see small gains.

Conclusion: Ensemble models are strongest at identifying positive cases.

## **3. Accuracy Comparison (With and Without SMOTE):**

Without SMOTE:

- Random Forest (0.85) is best, followed by XGBoost (0.82). KNN (0.70) is weakest.

With SMOTE:

- Random Forest (0.88) shows highest accuracy, followed by XGBoost (0.85).

Conclusion: SMOTE helps improve accuracy significantly, especially in top-performing models.

## **4. Cross-Validation Scores Comparison (With and Without SMOTE):**

Without SMOTE:

- Random Forest (0.810) and XGBoost (0.780) generalize well.

With SMOTE:

- Random Forest (0.850) shows greatest improvement. KNN still weak.

Conclusion: SMOTE enhances model consistency across folds, especially for ensemble models.

## **Final Conclusion:**

Based on all metrics, Random Forest and XGBoost consistently outperform others and benefit significantly from SMOTE. These models are best suited for handling imbalanced datasets.