###### INSTITUT D’ENSEIGNEMENT SUPÉRIEUR DE RUHENGERI



*Scientia et Lux*

B.P :155 Ruhengeri

Rwanda

**T** : +250 788 90 30 30

+250 788 90 30 32

**E** : :info@ines.ac.rw

**W**  : [www.ines.ac.rw](http://www.ines.rw/)

##### Accredited by Ministerial Order N° 005/2010/Mineduc of 16 June 2010

**FACULTY OF SCIENCES AND INFORMATION TECHNOLOGY**

**DEPARTMENT OF COMPUTER SCIENCE**

**OPTION SOFTWARE ENGINEERING**

**AI-BASED LOAN EVALUATION SYSTEM**

**Case Study: EQUITY BANK**

A dissertation submitted in partial fulfilment of requirements for the award of a Bachelor’s Degree of Science with honors in Computer Science, Software Engineering Option.

**By: MASONGA SHEMA Prince**

**Reg N0: 23/20861**

**Supervisor: Mrs.SHIMIRWA Aline Valeria**

**Co-Supervisor: NSENGIYUNVA Emmanuel**

**Musanze, March 2025**

# DECLARATION OF ORIGINALITY

I do hereby declare that the work presented in this dissertation is my own to the best of my knowledge. The same work has never been submitted to any other University or Institution. I, therefore declare that this work is my own for the partial fulfilment of the award of a Bachelor’s degree of Science in Computer Science with honors in Software Engineering at INES-Ruhengeri.

Candidate’s name: MASONGA SHEMA Prince

Candidate’s signature: ………………………………………………….

Submission’s date: ………………………………………………………

# APPROVAL

# DEDICATION

To my parents, Family, Friends, Brothers, Sisters, Lecturers, INES staff, ……….

# ACKNOWLODGEMENTS

## ABSTRACT.

This study proposes an AI-Based loan evaluation system for Equity bank that incorporates with Artificial Intelligence (AI) and Optical Character Recognition (OCR) with manual data insertion where necessary to automate the processing of loans, make it more accurate, and enable more equitable lending decisions, addressing delays and biases in traditional methods. To achieve this, the study adopts an agile approach to research. The study gathered data from surveys and interviews of the banking clients and experts, and from past loan approval data to determine the performance of the AI model. The study targets the banked individuals and businesses applying for loans in Equity bank.

The study employs Machine learning algorithms, statistical tests, and qualitative examination to assess how well the AI-Based system performs compared to the traditional methods. The expected outcome is a system that reduces processing time for lending, improved risk analysis, increases transparency, and wider lending approvals. By improving efficiency and complementing Rwandan’s digital banking revolution, this study provides scalable and futuristic solutions for banks to automate their lending processes while ensuring adherence to industry standards.

Table of Contents

[DECLARATION OF ORIGINALITY ii](#_Toc198338820)

[APPROVAL ii](#_Toc198338821)

[DEDICATION ii](#_Toc198338822)

[ACKNOWLODGEMENTS ii](#_Toc198338823)

[ABSTRACT. iii](#_Toc198338824)

[CHAPTER 1: GENERAL INTRODUCTION 1](#_Toc198338825)

[1.1 Background of the study 1](#_Toc198338826)

[1.2 Problem Statement 2](#_Toc198338827)

[1.3 Objectives of the study 3](#_Toc198338828)

[1.3.1 General Objective 3](#_Toc198338829)

[1.3.2 Specific Objectives 3](#_Toc198338830)

[1.4 Research Questions 4](#_Toc198338831)

[1.5 Choice of the study 5](#_Toc198338832)

[1.6 Significance of the study 6](#_Toc198338833)

[1.7 Delimitation of the study 6](#_Toc198338834)

[1.8 Research Methodology 7](#_Toc198338835)

[1.9 Organization of the study 8](#_Toc198338836)

[CHAPTER 2: LITERATURE REVIEW 9](#_Toc198338837)

[2.1. Introduction 9](#_Toc198338838)

[2.2. Related Studies 9](#_Toc198338839)

[2.3. Design and Implementation of AI-Based Evaluation System 10](#_Toc198338840)

[2.4. Theoretical Framework 11](#_Toc198338841)

[2.5. Conceptual Framework 12](#_Toc198338842)

[2.6. Key Concept Definitions 13](#_Toc198338843)

[2.6.1 Artificial Intelligence (AI) 13](#_Toc198338844)

[2.6.2 Machine Learning (ML) 13](#_Toc198338845)

[2.6.3 K-Nearest Neighbors (KNN) 13](#_Toc198338846)

[2.6.4 Support Vector Machine (SVM) 14](#_Toc198338847)

[2.6.5 Random Forest (RF) 14](#_Toc198338848)

[2.6.6 Optical Character Recognition (OCR) 14](#_Toc198338849)

[2.6.7 Credit Scoring 14](#_Toc198338850)

[2.6.8 Agile Methodology 14](#_Toc198338851)

[2.6.9 Python 15](#_Toc198338852)

[2.6.10 Django 15](#_Toc198338853)

[2.6.11 HTML & CSS 15](#_Toc198338854)

[2.6.12 JavaScript 15](#_Toc198338855)

[2.6.13 Web Application 15](#_Toc198338856)

[2.6.14 Database Management System (DBMS) 16](#_Toc198338857)

[2.6.15 PostgreSQL 16](#_Toc198338858)

[2.6.16 Dataset 16](#_Toc198338859)

[2.6.17 Data Analysis 16](#_Toc198338860)

[2.6.18 Model Interpretability 16](#_Toc198338861)

[2.6.19 Risk Classification 17](#_Toc198338862)

[2.6.20 Loan Evaluation System 17](#_Toc198338863)

[CHAPTER 3: RESEARCH METHODODLY 18](#_Toc198338864)

[3.1 Introduction 18](#_Toc198338865)

[3.3.1 Case study 18](#_Toc198338866)

[3.2 System Development Methodology 19](#_Toc198338867)

[19](#_Toc198338868)

[3.3.1 Requirements gathering and Planning 20](#_Toc198338869)

[3.3.2 System Design 21](#_Toc198338870)

[3.3.3 Development and Implementation 22](#_Toc198338871)

[3.3.4 Testing 23](#_Toc198338872)

[3.3.5 Deployment 23](#_Toc198338873)

[3.3.6 Review 24](#_Toc198338874)

[References 25](#_Toc198338875)

# CHAPTER 1: GENERAL INTRODUCTION

* 1. Background of the study.

In today’ world is changing how we do things making them faster, easily and more efficient. One the area where technology is coming up with a big difference is in banking sector. Having fast, fair and accurate loan approval systems is very important for helping people and businesses grow financially. In Rwanda, as digital technology continues to improve there is a growing need for banks to modernize the way they process loan applications. Many banks in Rwanda, including Equity bank still use traditional methods like manual checking of documents and basic credit scoring to decide who are allowed to get loan or not, these methods are often slow, can contain mistakes, and sometimes are unfair due to human bias.

According to (Arya.ai, (2023)), using automated system in loan processing helps bank work faster, follow the rules better, and give customers a better experience. New technologies like Artificial Intelligence (AI) and Optical Character Recognition (OCR) can help banks automatically read and understand financial documents. This means loan decision can be made more quickly and without mistakes. Equity Bank, one of the biggest banks in Rwanda, serves May types of customers. The bank gives out many loans, including small business loans for people living abroad. However, most of these loans are still approved using old manual systems (Rwanda, (n.d.-a); Rwanda., (n.d.-b).). Also Equity bank is one of the banks offering wide range of banking services including loans, savings, digital banking and business financing. As more customers want faster and more reliable loan services.

This study explores the implementation of an AI-Based Loan Evaluation system at Equity Bank aims to develop a user friendly web-based as solution help Equity Bank to evaluate loan applications more efficient. This system will collect financial information from documents using OCR and also allow users to enter data manually. Traditionally this process has relied on manual credit assessment, where human analysts review financial documents, credit histories, and other relevant data, which often lead inefficiencies, extended processing times and bias, but with the growth in Artificial intelligence (AI) and Machine learning (ML) banks and financial are adopting AI-based evaluation system to increase accuracy, fairness and timeliness to make quicker decision. Most importantly, the system will improve customer experience and support Rwandan’s Artificial intelligence policy encourage the development of AI solutions to improve financial services.(Innovation, 2023; A. t. F. Rwanda, 2024)

## Problem Statement

Many banks In Rwanda, including equity still use old and slow procedures in identifying if a person is eligible for a loan they use a lot a paperwork and manual processes which is slow is slow and can lead to mistakes. Sometimes people the people checking the loan application could be biased unconsciously, so it becomes Harder some applicants to get loans. Though there are new technologies like Artificial intelligence (AI) and Optical Character Recognition (OCR), many banks in Rwanda, including Equity bank, are not using them; this makes a loan process slow and less accurate.

Some banks in Rwanda , like Bank of Africa(BOA) and bank of Kigali have started using AI for faster and more fair loan decision making(Storyteller, 2024a), (Storyteller, 2024b). But still equity and others continue to rely on traditional methods of checking loans, which can be slow and unfair. That is why a new system based on AI and OCR is needed to enable the loan process to be quicker more precise, and fairer to everyone(MoneyPhone, 2021). This project aims to create AI-based evaluation system that would assist in enhancing the loan evaluation process in banks like equity bank. It will utilize AI and OCR in automatically reading documents, verifying loan applications more quickly and minimizing errors. It will also help make sure that everyone is treated fairly when applying for loans. This matches the idea of Rwanda’s National artificial intelligence policy(Writer, 2023). This system will allow equity bank to enhance it loan processing system to make it quicker and more efficient for all clients.

* 1. Objectives of the study

### General Objective

The main goal of this study is to develop an AI-Based Loan Evaluation System that enhances the efficiency, accuracy, and transparency of loan approvals for all loan applicants in Rwanda through machine learning and Optical Character Recognition (OCR).

### Specific Objectives

1. Create and deploy an AI model that automates loan evaluation and determine risk.
2. Apply Optical Character Recognition (OCR) to extract financial information from errors of manual data entry.
3. Create an automated loan evaluation system that reduces the approval time by using Machine learning algorithms for real-time analysis.
4. Implement fraud detection features to identify inconsistencies in customer documents and financial records, offering secure and reliable loan evaluation.
5. Use AI for making customized loan programs to the clients according to his/her financial standing and repayment capability.
6. Create a user-friendly web interface with Django, ensuring accessibility for large number of both applicants and administrators.

## Research Questions

Thinking about research questions help to ensure the research stays in relevant, structured and aligned with its objectives. The main research question is about how can an AI-Based Loan Evaluation System enhance the loan at equity bank in terms of accuracy, speed, and transparency? Here the following are some specific questions:

1. What are the existing challenges in Equity Bank traditional loan assessment process?
2. In what way does Optical Character Recognition (OCR) integration with manual data entry boost loan application data collection and analysis for Equity Bank?
3. Which machine learning algorithms are most effective in evaluating loan eligibility based on Equity Bank’s financial data?
4. To extent does the implementation of AI-Based loan evaluation system reduce human bias and error in Equity Bank’s loan decision making?
5. How does the adoption of AI-Based Systems align with current Rwandan banking regulations and data protection lows at Equity Bank?
6. What operational and technical factors affect the successful implementation of AI-Based systems in Equity Bank?

## Choice of the study

The study was conducted since Equity Bank, as well as most other banks in Rwanda, relies on traditional credit scoring techniques and manual document checks to asses loan applications. These Methods are often slow, prone to errors and influenced by human biases, leading to inefficiencies in loan approvals. As the banking sector grows and becoming more advanced and more e-based, the need for an advanced and automated loan assessment system that is able to speed up application faster, more accurately, and fairly. The existing manual approach increases the risk of biases, delays, and operational inefficiencies that can negatively impact both the bank and its clients.

To address these issues, this study investigates the use of AI-Based Loan Evaluation System in equity bank, though the integration of Optical character recognition (OCR) and manual data insertion to automate financial data extraction and improve credit decision-making. The system will not only reduce loan processing time but also increase accuracy, transparency and fairness in lending decisions. By adopting AI-based assessment models, Equity bank can improve financial regulations compliance, minimize human errors and improve more efficient, customer lending experience. Ultimately, this research aligns with Rwanda’s digital transformation goals and aims to modernize Equity Bank’s loan evaluation process, making it more scalable. (Fabri​, October 14, 2024; Shah, 2024)

## Significance of the study

This study is relevant to equity Bank as it will facilitate loan approvals to be quick, accurate, and fair by using artificial intelligence (AI) and Optical Character Recognition (OCR) to automate financial data processing. This will help the bank reduce operational costs, minimize errors and comply with banking laws while improving customer care and service. Loan applicants benefit from faster and more transparent approval process ensuring fair decision making with less bias.

Policymakers and regulators can use the findings to create improved regulations for financial institutions and guidelines for adopting AI adoption in financial services, promoting financial inclusion in Rwanda. By modernizing loan analysis at Equity Bank, this study assists in aligning the country’s digital transformation vision, making banking faster and more accessible.

## Delimitation of the study

This study focuses on the use an AI-Based loan evaluation system by equity bank and its impact on loan processing efficiency, accuracy, and fairness. The data collection is limited ensuring a robust dataset for training and testing AI models. Results are restricted to this timeframe. The research does not include unbanked individuals or informal lending system. The study is designed for testing and developing AI-Based prediction models for eligibility in loan evaluation systems compared to their implementation within a complete current banking system or examining long-term impacts on financial incorporation and credit availability.

Due to the integration of the system with optical character recognition (OCR) and Manual data insertion, human error in data input can influence AI-Based predictions. This underlines the need for strict data verification, regulatory compliance and continuous system improvements to enhance the system’s reliability in real-world application. The findings are based on current banking regulations and AI development in Rwanda especially in Equity Bank meaning results may develop new technologies and policies emerge.

## Research Methodology

Methodology in software engineering refers to a structured approach to software development that involves a set of different guidelines, techniques, and tools to be used throughout the SDLC. We applied the agile methodology in this study which is the iterative and incremental approach to project management that promotes continuous feedback and rapid response to changes to meet user requirements(Alliance, 2024). Data collection includes both primary and secondary sources, primary data collected through surveys and interview with equity bank and loan applicants to compare their experience with traditional and AI-based loan evaluation methods. Secondary data obtained from different reports, financial records of equity bank and existing literature on AI adoption in financial services to gather requirements and identify problems within the existing system.(Direct; PLC, 2023)

In the designing phase, UML diagrams were created to define system architecture, database schema and user interface layouts. The system was developed using, using python and TensorFlow for AI-based credit assessment, Django for the backend and PostgreSQL for database storage. To ensure system functionality, the system was tested at each iteration, evaluating accuracy, efficiency and bias reduction in AI-Based loan evaluation processes. The agile methodology ensured that the system developed based on continuous feedback from users, improving its functionality to meet specific requirements of equity bank and ensuring compliance with Rwandan banking regulations. (G. o. Rwanda, 2024; N. B. o. Rwanda, 2024)

## Organization of the study

This study is divided into five main chapters. Chapter one presents a general introduction, including the background, problem statement, research questions, research hypothesis, choice of the study, significance, delimitation, and methodology.

Chapter two presents a comprehensive review of existing literature on AI-Based loan evaluation system, traditional credit scoring models, and financial technology innovations.

Chapter three is about the research design, data collection processes, data analysis processes used in the study, detailing the structure approach, development tools and techniques for AI-Based loan evaluation system. Giving idea and work on how we should prepare our environment for the development and implementation of the system.

Chapter four focuses on design and implementation of the system, step by step on how we implement the project and how the system is working with the design of different diagrams allowing us to know and understand better on how the system is functioning.

Chapter five concludes, summarizes the study results and provides recommendations for future improvements and further studies in AI-Based loan evaluation system.

# CHAPTER 2: LITERATURE REVIEW

## Introduction

This Literature review chapter describes the methodology and approach followed in designing and development of the AI-Based Loan Evaluation System. It provides a general overview of the system architecture, technologies applied, data flow, and how all the components in the system interacts to achieve the main objectives of the project.

The system employs Optical Character Recognition (OCR) in order to capture financial information from uploaded financial documents and combines it with manually entered data. The extracted data is analyzed using predefined rules and Machine Learning (ML) trained models on historical loan approval data to determine an applicant’s eligibility. The chapter begins with the system architecture overall and then the detailed descriptions of the main modules and technologies used are provided. It also shows how the data are processed and analyzed for making intelligent decisions so that the loan evaluation process is made quicker, more objective and user-friendly.

## Related Studies

In Rwanda, several banks have made notable progress in adopting artificial intelligence (AI) to enhance their loan evaluation processes. For instance, Based on (Cash\_Platform, 2023b), Bank of Africa Rwanda implemented AI technologies, particularly chatbots and virtual assistants, detecting and mitigating financial fraud and leverages AI-powered credit scoring models that utilize customer transaction history and behavioral data to improve creditworthiness assessments to its customers. Similarly, **Bank of Kigali** has partnered with **Veefin Solutions,** an Indian digital lending company, to implement comprehensive AI-driven loan processing systems. These include automated digital underwriting and loan management platforms designed to improve turnaround time, transparency, and operational efficiency in credit services(Newswire, 2024). Despite these advancements, gaps remain in areas such as data privacy protection, fairness in algorithmic decision-making, and the full integration of predictive AI models into core lending operations.

In contrast, Equity Bank Rwanda, while having integrated AI in areas such as customer support through chatbots and fraud detection using machine learning models, has not yet adopted AI-driven systems for evaluating loan applications(Cash\_Platform, 2023b). This creates a strategic opportunity to introduce an AI-based loan eligibility evaluation system that leverages both Machine Learning and Optical Character Recognition (OCR) technologies. The proposed system would enable faster, more accurate and more equitable loan decisions by automating the analysis of financial documents and credit-related data. Moreover, such a solution would directly support Equity Bank’s ongoing digital innovation efforts and contribute to Rwanda’s broader goal of fostering financial inclusion through technology.

## Design and Implementation of AI-Based Evaluation System

The design of the AI-Based Loan Evaluation System is guided by the need to enhance speed, accuracy, and fairness in processing loan applications at Equity Bank Rwanda. The system is composed of several integrated modules, including a user interface, document processing module (using Optical Character Recognition), a database for storing applicant information, and a backend powered by machine learning models for decision-making.

During the design phase, UML diagrams were developed to outline system architecture and data flow, ensuring clear interaction between system components. The frontend is designed using HTML, CSS, and JavaScript for user-friendly interaction, allowing applicants and administrators to upload financial documents, input personal data, and track application status. The backend is developed using Python and Django, enabling strong server-side logic and model integration. For AI functionality, TensorFlow is used to train and run machine learning algorithms that analyze applicant data and assess risk levels based on predefined patterns from historical loan approvals. The database layer is handled by PostgreSQL, supporting secure storage and retrieval of structured data.

The system accepts financial documents such as payslips and bank statements, which are processed using Optical Character Recognition (OCR) technology (Tesseract engine). The extracted text is validated against manually entered data to ensure consistency. This hybrid method ensures flexibility and reduces dependency on document quality alone.

Once the data is cleaned and validated, the machine learning model classifies applicants into risk categories based on factors like income, credit history, repayment capacity, and debt ratio. The results are presented through a web-based dashboard for the loan officer to review, along with a recommendation generated by the AI engine.

This approach not only automates routine tasks but also enhances decision accuracy and reduces human bias. The modular design ensures the system can be updated or scaled to other financial institutions in Rwanda as AI adoption grows across the sector.

## Theoretical Framework

The theoretical framework guiding this study is rooted in key concepts from machine learning (ML), particularly focusing on model interpretability, feature selection, and algorithm choice. In the domain of loan evaluation, selecting the most relevant features such as income, credit history, employment status, existing debt, and repayment behavior is critical to building accurate and fair AI models. Feature selection helps reduce noise, improve model performance, and ensure transparency in how decisions are made, especially when dealing with sensitive financial data(Elisseeff, 2003).

Model interpretability is also a fundamental part of the theoretical framework. In the financial sector, decisions such as loan approvals must be explainable not only to internal stakeholders like credit officers but also to regulators and customers. Therefore, the AI models used in this project are selected with their explain ability in mind. Decision Tree-based models and Random Forests (RF), for instance, are favored for their ability to show how input variables contribute to outcomes. This helps build trust and accountability in automated credit decisions (Rudin, 2019a; Zhang, 2020).

The framework also considers the suitability of different ML algorithms for classification tasks related to loan eligibility. For this study, algorithms such as K-Nearest Neighbors (KNN), Support Vector Machines (SVM), and Random Forests (RF) are explored. Each has strengths depending on data complexity and classification requirements. KNN is simple and effective for small datasets, SVM performs well with high-dimensional data, while RF is powerful for handling imbalanced datasets and avoiding overfitting(Zhang, 2020). These algorithms will be trained using historical loan data to predict applicant risk levels, ensuring the system balances accuracy, fairness, and speed.

## Conceptual Framework

The conceptual framework of this study outlines the key components and flow of data within the AI-Based Loan Evaluation System, highlighting the interaction between input data, data processing mechanisms, and the final decision-making output. The framework serves as a roadmap for how the proposed system will operate to enhance the efficiency, accuracy, and fairness of loan approvals at Equity Bank Rwanda.

At the input stage, the system receives data from two main sources, Uploaded documents such as payslips, tax returns, and bank statements processed using Optical Character Recognition (OCR), manually entered data such as name, national ID, declared income, and employment details filled in through the system’s user interface. This data is then passed to the processing unit, where OCR technology (Tesseract) extracts and digitizes financial information from the uploaded documents.

The cleaned and validated data is then sent to a trained Machine Learning model (Random Forest, KNN, or SVM), which evaluates the loan applicant’s creditworthiness based on key financial features (e.g., income, credit score, debt-to-income ratio, repayment history). The output is a risk classification and a loan approval recommendation generated by the AI engine. This decision is accompanied by an explanation based on model interpretability techniques to ensure transparency for loan officers. The loan officers can then review the result, approve or reject the application, or request additional information.

## Key Concept Definitions

This section defines important terms and concepts used throughout the study to ensure a clear and consistent understanding of the technical and operational elements involved in designing and implementing the AI-Based Loan Evaluation System.

## Artificial Intelligence (AI)

AI refers to the capability of machines and computer systems to perform tasks that typically require human intelligence. In this study, AI is applied to evaluate loan applications, automate decision-making, and improve accuracy and fairness in credit assessment.

## Machine Learning (ML)

ML is a subfield of AI focused on developing algorithms that can learn patterns from data and make decisions without being explicitly programmed. It includes techniques like supervised learning and is used in this project to predict loan eligibility.

## K-Nearest Neighbors (KNN)

KNN is a simple supervised learning algorithm used for classification. It predicts outcomes based on the majority class of the K most similar data points. It is used in this project for grouping loan applicants based on financial behavior(Nureni & Adekola, 2022).

## Support Vector Machine (SVM)

SVM is a supervised ML algorithm that identifies the best hyperplane to separate classes of data. It is useful for high-dimensional financial data and ensures robust classification of loan applicants.

## Random Forest (RF)

Random Forest is an ensemble learning method that builds multiple decision trees and outputs the majority vote. It improves predictive performance and reduces overfitting, making it suitable for financial risk

## Optical Character Recognition (OCR)

OCR is a technology that converts scanned images or documents into editable, machine-readable text. In this study, it extracts key financial details from loan applicants’ uploaded documents like payslips and statements.

## Credit Scoring

Credit scoring is a system that evaluates a borrower's likelihood of repaying a loan based on financial and personal data. In this project, AI enhances traditional scoring by analyzing more variables and reducing bias.

## Agile Methodology

Agile Methodology is a flexible, iterative software development approach that encourages continuous improvement and collaboration. Agile methodology is used in this project to allow for feedback-driven development of the AI system.

## Python

Python is a widely-used programming language in AI development. It provides powerful libraries such as Scikit-learn, TensorFlow, and Pandas used in building the machine learning models in this project.

## Django

Django is a high-level Python web framework that simplifies backend development. It was used to build the web-based interface of the loan evaluation system, handling business logic and database communication.

## HTML & CSS

HTML (HyperText Markup Language) structures web pages, while CSS (Cascading Style Sheets) is used for styling. These were used to design the user interface for applicants and loan officers.

## JavaScript

JavaScript is a client-side scripting language used to create interactive features in web applications. It enhances user experience and is used in the front-end of the loan evaluation system.

## Web Application

A web application is software that runs in a browser and performs functions similar to desktop software. This project is deployed as a web application to make it accessible to both loan officers and applicants online.

## Database Management System (DBMS)

A DBMS is software that stores, organizes, and retrieves data. It allows users and programs to interact with databases securely and efficiently. PostgreSQL was used in this project as the main DBMS.

## PostgreSQL

PostgreSQL is an open-source relational database system known for its performance and reliability. It is used to store all user data, application records, and loan decision results.

## Dataset

A dataset is a collection of data used for training and testing ML models. In this study, historical loan data containing applicant features and approval outcomes is used to train the predictive models.

## Data Analysis

Data analysis involves examining and interpreting data to discover useful insights. It includes techniques such as cleaning, transformation, and visualization to guide model development and system evaluation.

## Model Interpretability

Model interpretability refers to the ability to explain how an ML model arrives at its decision. It is important in financial systems to ensure fairness, transparency, and compliance with regulations (Ahmad et al., 2024).

## Risk Classification

Risk classification is the process of grouping applicants into categories such as low, medium, or high risk based on predictive analytics. This helps banks manage credit risk more effectively.

## ****Loan Evaluation System****

Used by financial institutions to analyze and determine whether an applicant qualifies for a loan. The AI-based version improves accuracy, speed, and fairness in comparison to traditional manual evaluation methods.

# CHAPTER 3: RESEARCH METHODODLY

## Introduction

This Research methodology chapter presents the research methodology used in the design and implementation of the AI-Based Loan Evaluation System for Equity Bank. It gives further information on research design, tools and technologies used, target population, data collection methods, system development approach, and analysis techniques. The goal is to ensure the study is systematic, reliable, and meets the intended objectives.

## Case study

The study was conducted at Equity Bank Rwanda, with a specific focus on the Musanze Branch. Equity Bank is a major financial institution in Rwanda, serving a wide range of clients including individuals, small businesses, and large corporations. Despite having a digital presence and offering online services, the bank still relies heavily on traditional manual processes for loan evaluation. These processes often involve human-based reviews of submitted documents such as payslips and bank statements, manual data entry, and subjective credit assessments, which contribute to slow turnaround times and inconsistencies in decision-making. The manual handling of loan evaluations also increases the risk of errors, fraud, and bias, making the process both inefficient and potentially unfair.

During preliminary investigations, interviews with bank staff revealed several operational challenges, including time-consuming document verification, repetitive data input tasks, and delays in client communication. Customers also expressed concerns over transparency and the lack of a clear, trackable loan application process. These challenges pointed to the need for an intelligent system that could automate and improve the accuracy of loan evaluations. Therefore, this case study aims to design and implement an AI-Based Loan Evaluation System that integrates Optical Character Recognition (OCR) and Machine Learning (ML) technologies to automate credit scoring and reduce reliance on manual operations, aligning with Rwanda’s digital transformation agenda.

## System Development Methodology

To develop the proposed system effectively, the research adopted the Agile system development methodology. Agile was selected because of its flexibility and iterative nature, which makes it ideal for projects that require frequent changes based on feedback. In the context of this research, Agile allowed the team to continuously engage with bank staff, revise features based on their feedback, and improve the solution in small, manageable increments. The Agile process involved several development phases, each contributing to the realization of the final system. The methodology ensured regular testing, documentation, and adaptability to new challenges as the system evolved.

## 

Figure 1: Steps in Agile SDLC Steps in Agile SDLC

## Requirements gathering and Planning

In the first phase, the research team conducted an in-depth analysis of the existing loan processing workflow at Equity Bank Musanze Branch. The objective was to understand how loan applications were currently being handled, identify pain points, and define what a successful AI-based system should address. This was done through direct observation of the loan approval process and informal interviews with both the bank’s credit officers and several customers who had recently applied for loans. The feedback collected helped the team to pinpoint key issues such as delays in approvals, repeated rejections due to missing information, and the inefficiency of manual document review.

After understanding these challenges, functional and non-functional requirements were documented. Functional requirements included features such as secure login for bank staff, form submission for applicants, document upload capabilities, OCR integration for automatic data extraction, and an AI-driven evaluation engine. Non-functional requirements such as system security, user-friendly interface, and fast response time were also defined. A development roadmap was created, and the scope of the system was clearly outlined, forming the basis for the system’s architecture and workflow design in the next phase.

## System Design

With the requirements in place, the next phase focused on designing the system structure and architecture. The system was designed with three primary user roles in mind: applicants, bank loan officers, and administrators. UML diagrams such as use case diagrams, class diagrams, and sequence diagrams were created to visually represent the system’s behavior and data flow. The architecture was designed to be modular and scalable, allowing new features to be added in the future without disrupting existing functionalities.

Security was a major concern in this phase. The system was planned with features such as hashed passwords, session-based authentication, and role-based access control to ensure only authorized personnel could access sensitive information. For the frontend, HTML, CSS, and Bootstrap were used to create clean and responsive user interfaces. On the backend, Django was selected as the primary web framework due to its robustness and support for Python-based machine learning libraries. PostgreSQL was chosen as the database system because of its stability and ability to handle large datasets efficiently.

## Development and Implementation

This phase involved the actual building of the system components based on the design specifications. The frontend was developed first, with user interfaces allowing applicants to register, log in, fill out loan request forms, and upload supporting documents. Bank staff interfaces were developed to review application statuses, access extracted data, and view AI-generated loan approval suggestions. Django was used to manage the server-side logic and database interactions. The Optical Character Recognition component was implemented using Tesseract OCR through the pytesseract Python library. It was integrated into the backend so that uploaded documents like payslips and bank statements could be automatically converted to text for analysis.

The core AI model was developed using scikit-learn, a Python library for machine learning. Historical data obtained from the bank was used to train classification models that could predict whether a loan should be approved or not based on various applicant features such as income, employment status, and past credit history. The model was tested and validated using standard metrics to ensure its reliability. Integration between OCR, the AI engine, and the Django backend was finalized in this phase.

## Testing

Once development was complete, the system underwent a rigorous testing phase. Unit tests were written for backend functions to verify that each part of the application worked as expected. Frontend testing was carried out manually to ensure that forms were submitting correctly, data was being captured accurately, and user navigation was smooth. Integration testing was performed to verify that the OCR, AI, and database modules worked together seamlessly.

To ensure security, role-based access control was tested to confirm that only authorized users could access certain pages. Various edge cases were tested, such as uploading incomplete documents, missing required fields, and invalid login attempts. The model’s loan prediction output was compared with past decisions to measure accuracy and bias. Feedback from Equity Bank staff during user testing helped the team identify usability issues, which were fixed before the system moved into deployment.

## Deployment

After successful testing, the system was deployed for real-world use. The initial deployment was done locally to allow a group of selected users to try the system and provide final feedback. Once stable, the system was configured for production deployment using Gunicorn and Nginx on a secure Linux server. Data protection measures were enforced, including secure file uploads and HTTPS encryption.

The deployed system immediately demonstrated improvements in processing speed and decision accuracy. Loan officers reported a significant reduction in the time required to evaluate applications, while customers appreciated the transparency and speed of responses. This deployment phase validated the effectiveness of the AI-Based Loan Evaluation System and confirmed its potential to transform how Equity Bank processes loan applications.

## Review

Following the deployment of the AI-Based Loan Evaluation System, a review phase was conducted to evaluate its performance, usability, and overall effectiveness. During this phase, feedback was collected from Equity Bank staff who had interacted with the system, including loan officers, IT personnel, and management. The review involved analyzing user satisfaction, accuracy of loan predictions, and system response time. Participants noted improved speed in processing applications, reduced paperwork, and better visibility into the loan evaluation process. Additionally, this phase helped identify areas for improvement, such as expanding the training dataset for the AI model and enhancing mobile responsiveness of the user interface. The review findings informed minor updates that were implemented immediately and provided insights for future iterations. This phase ensured the project remained aligned with user expectations and business goals, which is a core principle of the Agile methodology.

# References

*The Future of Banking in Rwanda: AI Strategies and Innovations at Bank of Kigali*. (2024, August 29). Retrieved from Cash Platform: https://www.cash-platform.com/the-future-of-banking-in-rwanda-ai-strategies-and-innovations-at-bank-of-kigali/

(Equity Bank Rwanda, n.-a., & ). (2023). *Micro Loans Credit Analyst.* Retrieved from Equity Group Holdings.

(n.d.-a), E. B. (n.d.). *Micro Loans Credit Analyst.* Retrieved from Equity Group Holdings.

Alliance, A. ( 2024). What is Agile? *Agile Alliance*.

Arya.ai. ((2023)). *Loan origination automation: Intelligent workflows for modern banking.* Retrieved from Arya.ai: https://arya.ai/blog/loan-origination-automation

Cash\_Platform. (2023b). Bank of Africa Rwanda: Pioneering AI Solutions for Sustainable and Inclusive Banking. *Cash Platform*.

Direct, S. (n.d.). *Science Direct*. Retrieved from Science Direct: https://www.sciencedirect.com/science/article/pii/S097038962400048X

Elisseeff, G. &. (2003). An introduction to variable and feature selection. *Journal of Machine Learning Research*.

Equity Bank Rwanda, (.-b. (n.d.). *Micro Loans Credit Analyst.* Retrieved from Equity Group Holdings.

Fabri​, J. (October 14, 2024). "Rwanda: The Promise of Artificial Intelligence in African Financial Services"​. *The New Times (Kigali)*.

Innovation, M. o. (2023). *National Artificial Intelligence Policy.* Retrieved from Government of Rwanda.: https://www.minict.gov.rw/index.php?eID=dumpFile&f=67550&t=f&token=6195a53203e197efa47592f40ff4aaf24579640e

Kleinberg, J. L. (2020). AI Can Make Bank Loans More Fair. *Sian Townson*.

MoneyPhone. (2021). *Equity Bank and MoneyPhone bring low-interest digital loans to Rwandan farmers*. Retrieved from MoneyPhone: https://www.money-phone.com/post/equity-bank-and-moneyphone-bring-low-interest-digital-loans-to-rwandan-farmers

Newswire, P. (2024). Veefin solutions. *Veefin solutions*.

PLC, E. G. (2023, december 31). *Equity Group Holdings PLC*. Retrieved from Equity Group Holdings PLC: https://equitygroupholdings.com/equity-group-holdings-plc-audited-financial-statements-for-the-year-ended-31st-december-2023/

Rudin, C. (2019a). Nature Machine Intelligence, 1(5), 206–215.

Runsewe, O. O. (2024). *End-to-End systems development in agile environments: Best practices and case studies from the financial sector.* Chicago: International Journal of Engineering Research and Development, 20(08), 522-529.

Rwanda, A. t. (2024). *Rwanda National FinTech Strategy (2024–2029).* Retrieved from https://afr.rw/downloads/rwanda-national-fintech-strategy-2024-2029

Rwanda, E. B. ((n.d.-a)). *https://equitygroupholdings.com/rw/uploads/Micro-Loans-Credit-Analyst.pdf.* Retrieved from https://equitygroupholdings.com/rw/uploads/Micro-Loans-Credit-Analyst.pdf.

Rwanda, G. o. (2024). *Law No. 044/2024 of 30/05/2024 Governing Banks.* Kigali: National Bank of Rwanda.

Rwanda, N. B. (2024). *Rights and Obligations of the Financial Service Consumers in Rwanda.* Kigali: National Bank of Rwanda.

Rwanda., E. B. ( (n.d.-b).). *Diaspora mortgage loan.* Retrieved from https://equitygroupholdings.com/rw/borrow/diaspora-mortgage-loan

Shah, M. (2024, November 4). *The Role of AI in Automating Loan Origination​.* Retrieved from Arya.ai Blog​: https://arya.ai/blog/loan-origination-automation

Storyteller, A. (2024). *Bank of Africa Rwanda: Pioneering AI solutions for sustainable and inclusive banking*. Retrieved from Cash Platform: https://www.cash-platform.com/bank-of-africa-rwanda-pioneering-ai-solutions-for-sustainable-and-inclusive-banking/

Storyteller, A. (2024, August 29). *The Future of Banking in Rwanda*. Retrieved from Cash Platform: https://www.cash-platform.com/the-future-of-banking-in-rwanda-ai-strategies-and-innovations-at-bank-of-kigali/

Writer, G. (2023, December 20). Retrieved from ICTwork: https://www.ictworks.org/national-artificial-intelligence-policy-rwanda/

Zhang, Z. Z. (2020). A comprehensive review on machine learning algorithms for credit scoring. *IEEE Access, 8, 150673–150701.*