Enhancing Trust and Traceability in Supply Chains through Blockchain and Machine Learning

Project report submitted for the requirement for the degree of

Bachelor of Technology

by

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Abstract

Traditional supply chain models in the agricultural and food sectors frequently struggle with issues of lack of transparency, interoperability, and traceability, resulting in erroneous reporting and problems with quality assurance. The management and optimization of supply chains, however, have the potential to revolutionize with the introduction of disruptive technologies like blockchain and machine learning (ML).In this regard, the proposed project "Enhancing Trust and Traceability in Supply Chains through Blockchain and Machine Learning" offers an all-encompassing solution that makes use of the immutability and transparency of blockchain technology as well as the analytical power of ML algorithms to enhance traceability, transparency, and sustainability in the agriculture and food supply chains. The project seeks to monitor a product's complete life cycle, from production and harvesting to processing, packaging, and distribution. utilizing a decentralized and secure blockchain network, more especially Hyperledger Fabric, for storage and delivery. This makes it possible to track and document each transaction and activity in the supply chain effectively, removing middlemen and streamlining the procedure for reduced costs and increased efficiency.

The project also seeks to advance sustainable agriculture and food supply chain practices. Customers can make informed decisions by receiving clear information regarding farming practices. Customers can choose products that suit their interests for those that are socially and environmentally responsible.

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Introduction

1.1 Overview

The supply chains for the agriculture and food industries are complicated since they involve several stakeholders, processes, and transactions. These traditional supply chain models usually run into issues with quality verification, delays, and inefficiencies, as well as a lack of transparency, interoperability, and traceability that can lead to inaccurate reports. The use of disruptive technologies like blockchain and machine learning (ML) to improve and change the management of agriculture and food supply chains has gained popularity in recent years. A secure, decentralized platform for tracking and recording each transaction and activity along the supply chain can be provided by blockchain technology, which is recognized for its immutability, transparency, and security. Blockchain reduces the need for intermediaries, and accelerates the process, using a distributed ledger ensures that captured is open and impervious to manipulation. On the other hand, machine learning algorithms can go through the vast amount of data saved on the blockchain to provide intelligent analysis and forecasts that will improve supply chains. Agriculture and food supply chains may now be more transparent, traceable, sustainable, and effective than ever thanks to blockchain technology and machine learning.

We propose " Enhancing Trust and Traceability in Supply Chains through Blockchain and Machine Learning," a comprehensive strategy for reshaping the food and agriculture supply chains utilizing blockchain technology and machine learning. The objective of this strategy is to maximize the advantages of both technologies to improve efficiency, sustainability, and transparency in the agriculture and food sectors. We will examine the main advantages of using blockchain technology and machine learning in the food and agricultural supply chains, as well as how they might help solve some of the problems that traditional supply chains have. The transparency that blockchain technology offers is one of its main advantages. Customers have access to specifics about the complete process a product has undergone, including information about the seeds' place of origin and the fertilizers used. This encourages food safety and quality by giving consumers the power to make knowledgeable decisions about the products they buy. Additionally, farmers and food producers can use the data gathered on the blockchain to enhance their procedures and increase efficiency, resulting in greater product quality and higher yields. The project includes ML algorithms at different points along the supply chain process in addition to transparency. Large-scale blockchain data may be analyzed by ML algorithms, which can then produce insightful forecasts and predictions that can be used to optimize supply chain operations. To better irrigation, fertilization, and pest management, for instance, ML algorithms may analyze weather data, soil conditions, and crop health information. This results in increased crop yields and sustainable farming techniques. To identify potential quality problems and implement preventive actions, ML algorithms can also analyze data on product quality, and transportation routes. This ensures that only high-quality products are delivered to the final consumers.

The suggested method includes machine learning algorithms at multiple points along the supply chain process in addition to transparency. The massive amounts of data stored on the blockchain may be analyzed by machine learning algorithms to produce insightful forecasts and recommendations for improving supply chain operations. To better irrigation, fertilization, and pest management, for instance, machine learning algorithms may analyze weather data, soil conditions, and crop health information. This results in increased agricultural yields and sustainable farming techniques. To identify potential quality problems and implement preventive actions, ML algorithms can also analyze data on product quality, and transportation routes. This ensures that only high-quality products are delivered to the final consumers.

Customers can make decisions that are in line with their preferences for ecologically sustainable and socially responsible products by being given transparent information about farming practices. To make sure that the items match the specified sustainability requirements, the proposed approach can also aid in monitoring and verifying sustainability certificates. The proposed strategy influences numerous parties involved in the agriculture and food supply chains. Increased transparency, traceability, and access to useful data can help farmers improve their farming methods and boost yields. By being open and honest about their products, food producers may streamline their operations, guarantee the quality of their goods, and increase consumer trust. Utilizing transparent and effective supply chain management technology, importers and retailers may improve customer satisfaction while reducing expenses.

Customers can choose products that fit their tastes for quality, sustainability, and social responsibility by making informed judgments about what they buy. In addition, regulatory agencies and certifying bodies can profit from blockchain's transparency and immutability, which can help with compliance monitoring and certification verification.

Nevertheless, despite the potential advantages, using blockchain and machine learning in the agriculture and food supply chains has its share of difficulties. These difficulties include technical hurdles, such as blockchain's scalability and interoperability problems, as well as issues with data privacy and security. As numerous stakeholders with varying degrees of technological readiness and knowledge are involved in the agriculture and food supply chains, there are additional difficulties with adoption and integration. Our suggested strategy includes a broad framework that integrates blockchain and machine learning technologies, data governance and privacy measures, interoperability standards, and stakeholder engagement tactics to address these issues. We will give a thorough analysis of each element and explain how it affects the overall transformation of the food and agricultural supply chains. In conclusion, by improving transparency, sustainability, and efficiency, the combined use of blockchain with machine learning has the potential to transform agriculture and food supply chains. Our proposed approach strategy intends to take advantage of these technologies advantages to address the problems with conventional supply chains and develop a more open, sustainable, and effective system.

1.2 Problem Statement

Multiple parties in supply chains participate in complicated networks with a variety of interests, roles, and responsibilities. The current supply chain system's lack of transparency and traceability frequently leads to problems including mislabeling, contamination, and fraud, raising customer concerns and posing dangers to food safety. Additionally, while handling, storage, or transit, goods frequently become ruined, wasted, or destroyed, costing supply chain participants a lot of money. The integrity of supply chain data is compromised by existing systems that rely on centralized databases and paper-based records because they are open to data manipulation, theft, and unauthorized access.

Given the variation in product quality and the possibility of fraudulent actions, standard techniques of quality prediction and fraud detection may also be inefficient and inaccurate. It can be difficult to coordinate and manage interactions among stakeholders, which can lead to delays, disagreements, and inefficiencies in the supply chain operation.

1.3 Need of the Study

There are various advantages to implementing a blockchain-based supply chain in agricultural products. Transparency is provided by allowing stakeholders to track and verify each step of the supply chain. Traceability is also enabled by technology, ensuring the authenticity and quality of items while adhering to rules. By promptly identifying and recalling contaminated products, blockchain improves food safety. It promotes quality assurance by documenting cultivation and storage practices. Furthermore, blockchain streamlines processes lowers costs, and improves access to funding. Overall, it results in a more reliable and resilient ecosystem for agricultural goods.

Chapter 2

Literature Review

2.1 Introduction

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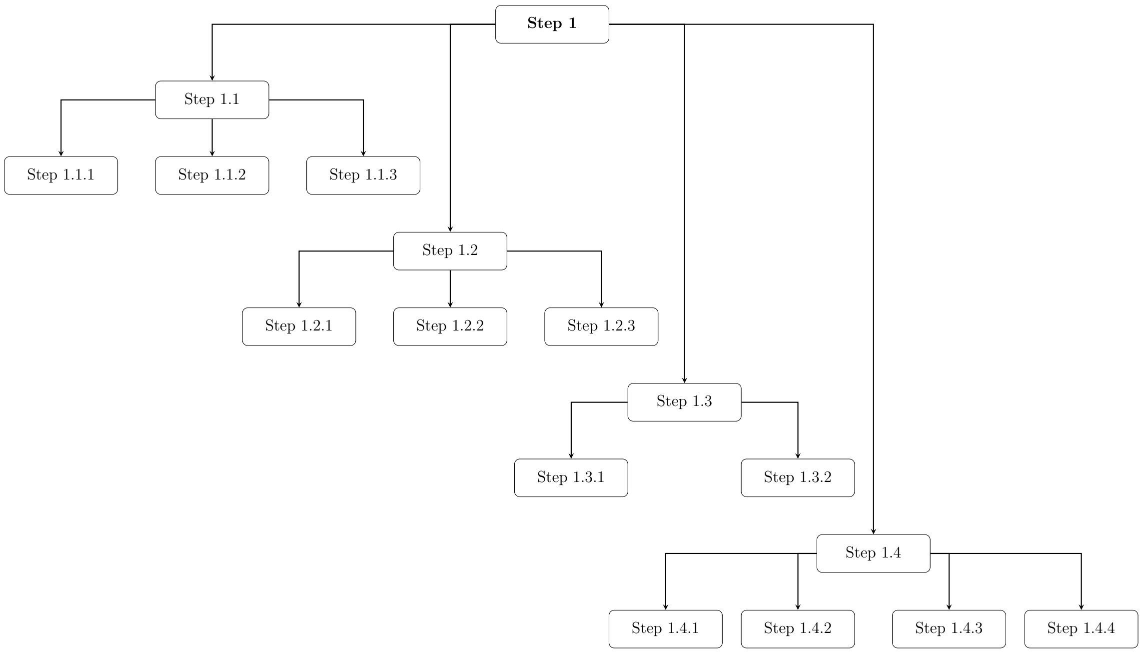

FIGURE 2.1: Factors influencing ....

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Table 2.1: Studies related to ......

Authors and Country	Population	Study Type	Sample Size	Variable used	Model/ method used
Author 1, India	Young pedestrians	O	1033	Var 1, Var 2, Var 3, Var 4, Var 5, Var 6, and Var 7	EDA
Author 2, Australia	6th grade students	Q	405	Var 1, Var 2, Var 3, Var 4, Var 5, Var 6, and Var 7	Regression

Note: E: Experimental, O: Observational survey, Q: Questionnaire survey, R: Review, V: Video graphic survey. EDA: Exploratory Data Analysis

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Speeding is a well-documented cause of crashes involving pedestrians, particularly children. To decrease the number of collisions involving school-going children, speed limits have been implemented in school zones worldwide since the 90s. However, despite these efforts, the number of fatal crashes caused by speeding has risen and continues to do so. This suggests that current strategies and campaigns are not effectively communicating the dangers of speeding to drivers. Additionally, there is a lack of data on the daily occurrences of speeding in these zones, except for enforcement efforts carried out by law enforcement. Moreover, variations in school zone treatments across different countries do not fully explain why drivers choose to speed in these areas.

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2.2.3 SubFactors

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FIGURE 2.2: Plot with a single image (Image by pencil parker from Pixabay)

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2.3 Research Gaps from the Literature Review

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Chapter 3

Feasibility Study

3.1 Introduction

We conducted a feasibility study to assess the viability and potential benefits of implementing a blockchain-based supply chain management system. Our goal was to determine whether adopting blockchain technology is feasible and advantageous for our supply chain management process. We evaluated various aspects, including technical, economic, operational, and organizational factors, to make an informed decision.

3.1.1 Technical Feasibility

We evaluated the technical capabilities and requirements of implementing a blockchain solution in our existing supply chain infrastructure. We assessed the compatibility of the blockchain technology with our current IT systems and software. We also considered the scalability, security, and performance aspects of the blockchain network to ensure it can handle our supply chain transactions.

3.1.2 Economic Feasibility

We conducted a comprehensive cost-benefit analysis to determine the financial viability of implementing a blockchain-based supply chain management system. We assessed the initial setup costs, including hardware, software, and infrastructure requirements. Additionally, we analyzed the potential cost savings and efficiency gains that could be achieved through enhanced transparency, traceability, and reduced intermediaries in our supply chain process. Based on this analysis, we determined the return on investment (ROI) and payback period for implementing the blockchain solution.

3.1.3 Operational Feasibility

We assessed the impact of implementing a blockchain system on our day-to-day supply chain operations. We identified the potential operational benefits, such as real-time tracking, improved inventory management, and streamlined logistics. We also considered the training and skill requirements for our employees to adapt to the new technology and ensure a smooth adoption and implementation process. Throughout this assessment, we analyzed any potential disruptions or challenges that may arise during the transition phase and developed strategies to mitigate risks.

3.2 Conclusion

Based on our feasibility study, we concluded that implementing a blockchain-based supply chain management system is feasible and beneficial for a organization. The study provided valuable insights into the technical, economic, operational, and organizational aspects, enabling us to make informed decisions and plan for the adoption of blockchain technology in our supply chain management processes.

Chapter 4

Methodology

4.1 Methodology

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4.3 Scope for Future Work

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Chapter 5

System Design and Architecture

5.1 Introduction

The system design and architecture are of utmost importance when it comes to the implementation of a supply chain management system using blockchain technology. A well-designed system ensures the efficient and secure management of the supply chain, leveraging the unique capabilities offered by blockchain. To effectively design the system architecture for a blockchain-based supply chain management system, several key aspects need to be considered. These include:

5.1.1 Hyperledger Fabric

The Fabric network comprises three organizations (Manufacturer, Middle Men, and Consumer) with five peers, one orderer, and one channel. Each organization has its own Fabric CA for managing digital certificates. The network uses Fabric CA as the Certificate Authority for secure authentication and authorization. The peers maintain a copy of the shared ledger and execute chaincode for smart contracts. The Orderer validates and orders transactions, ensuring consistency. The Fabric network with Fabric CA provides a secure, transparent, and efficient solution for managing the operations.

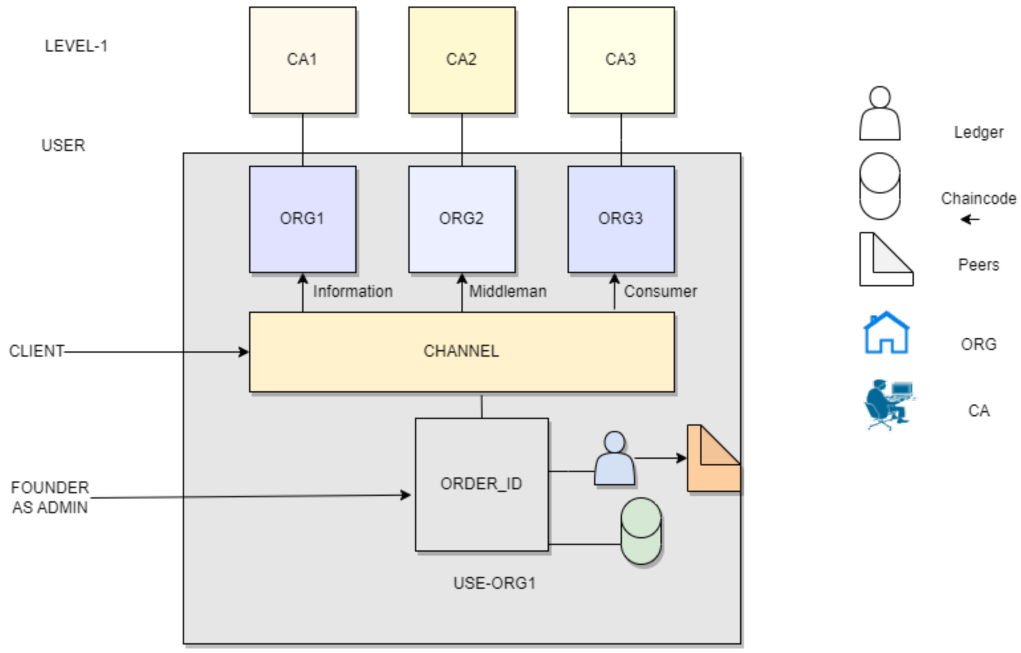


FIGURE 5.1: Hyperledger Fabric network Architecture

The Fabric network comprises three organizations (Manufacturer, Middle Men, and Consumer) with five peers, one orderer, and one channel. Each organization has its own Fabric CA for managing digital certificates. The network uses Fabric CA as the Certificate Authority for secure authentication and authorization. The peers maintain a copy of the shared ledger and execute chain code for smart contracts. The Orderer validates and orders transactions, ensuring consistency. The Fabric network with Fabric CA provides a secure, transparent, and efficient solution for managing operations.

- Admin: all the organization.
- Manufacturer: Org1.

- Middleman: Org2.
- Consumer: Org3.

5.1.2 Membership and Access Control

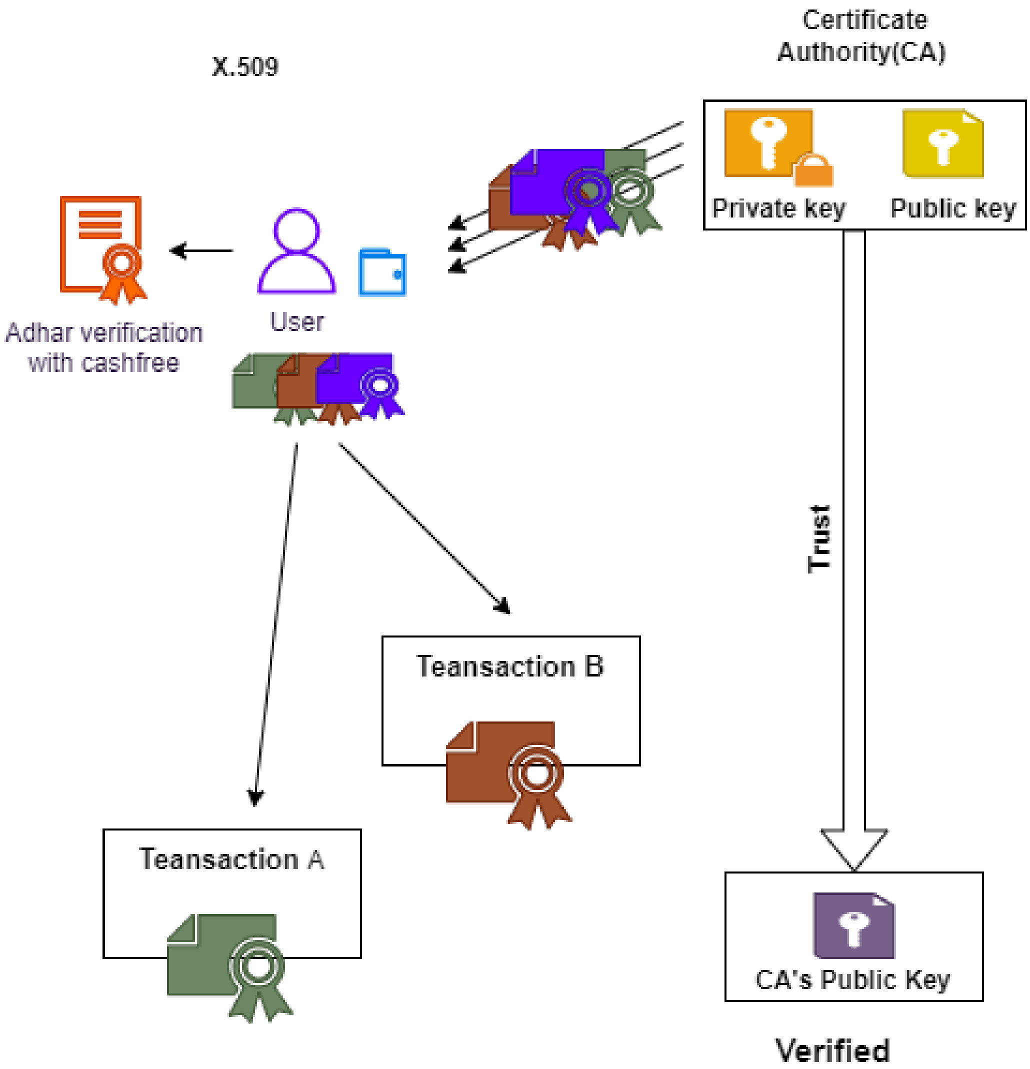


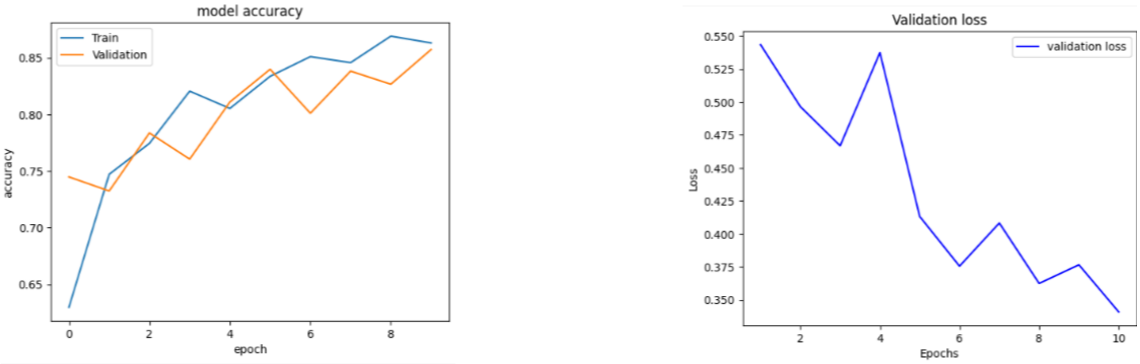
FIGURE 5.2: X.509 Identity Management

5.2 shows that there is a CA that issues a certificate to the user, and this X.059 certificate has multiple attributes whenever the user performs a transaction, it signs using this certificate and also checks for Aadhar verification status. Any other entity in the system that can view these transactions will be able to see their attributes, thereby knowing that the transaction was performed by the particular user to ensure trustworthy of each user in the network.

5.1.3 Machine Learning

The developed solution presents a machine learning (ML) model for detecting the freshness of fruits using a Convolutional Neural Network (CNN) algorithm. The model is trained using TensorFlow, an open-source library for deep learning and machine learning tasks, and is supported by other libraries such as NumPy, Pandas, and Matplotlib for data handling, data cleaning, and visualization. The dataset used for training the model is imported, and its length is verified to be 10901. The model is trained with a sequential model using different layers, including convolutional, activation, dropout, max pooling, flattening, and dense, each serving a specific function in the training process. Keras, a popular library for building neural networks, is used to create the final layers of the CNN model.

The model is compiled with the Adamax optimizer, a commonly used optimizer in ML models. During training, the data is traversed multiple times using epochs, with an epoch value of 30 in this case. A validation-data of validation-generator with verbose 1 used and a batch size of 15 is used in the model training process. The proposed approach combines various libraries, algorithms, and tools to develop an ML model for detecting the freshness of fruits based on their condition, which can be beneficial in tracking the quality of products in supply chains. The solution contributes to the expanding body of literature on blockchain applications by providing an effective, dependable, secure, and decentralized trace and track solution using ML and blockchain technologies.



(A) Model Accurecy

(B) Validation loss

FIGURE 5.3: Main caption

5.3 (a) shows the training accuracy and Validation accucy.Train graph shows the overall model's Training accuracy and validation accuracy shows the Subset of the training data .It is seen that with each epoch Model is giving more accuracy also validation accuracy too. Validation accuracy is calculated by using subset of the whole Training dataset.The final accuracy of the Model is found to be 88.5%. 5.3 (b) shows the output result that our model provides.It can be seen That our model is providing us the correct output.For a rotten Fruit it predicts the fruit as rotten and for a fresh it predicts as fresh.

Chapter 6

Implementation

6.1 Implementation

This chapter describes the Implementation based on the study conducted by **Last Name et al.** on the topic **"Article Title Article Title Article Title Article Title Article Title Article Title"** which was published in ...... journal (Volume xx, number x).

Last Name. First Name, Last Name. First Name, "Article Title Article Title Article Title Article Title, vol. xx, no. xx, pp. xxx–xxx, 2022.

6.1.1 Brief Outline of the study

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6.2 Problem Statement

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6.3 Objective of the Study

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6.4 Methodology

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6.4.1 Study Location Selection

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(A) Plot1 with a single image (Image by pencil parker from Pixabay)

(B) Plot2 with a single image (Image by pencil parker from Pixabay)

FIGURE 6.1: Main caption

6.4.2 Data Collection Strategy

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6.4.3 Data Extraction and Coding

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6.4.4 Methodology Adopted for the Analysis

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6.5 Study Observations

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- Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat.
- Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicular hendrerit sem.
- Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicular hendrerit sem.

6.6 Study Limitations

Sed commodo posuere pede. Mauris ut est. Ut quis purus. Sed ac odio. Sed vehicula hendrerit sem. Duis non odio. Morbi ut dui. Sed accumsan risus eget odio. In hac habitasse platea dictumst. Pellentesque non elit. Fusce sed justo eu urna porta tincidunt. Mauris felis odio, sollicitudin sed, volutpat a, ornare ac, erat. Morbi quis dolor. Donec pellentesque, erat ac sagittis semper, nunc dui lobortis purus, quis congue purus metus ultricies tellus. Proin et quam. Class aptent taciti sociosqu ad litora torquent per conubia nostra, per inceptos hymenaeos. Praesent sapien turpis, fermentum vel, eleifend faucibus, vehicula eu, lacus.

6.7 Practical Implications

Morbi luctus, wisi viverra faucibus pretium, nibh est placerat odio, nec commodo wisi enim eget quam. Quisque libero justo, consectetuer a, feugiat vitae, porttitor eu, libero. Suspendisse sed mauris vitae elit sollicitudin malesuada. Maecenas ultricies eros sit amet ante. Ut venenatis velit. Maecenas sed mi eget dui varius euismod. Phasellus aliquet volutpat odio. Vestibulum ante ipsum primis in faucibus orci luctus et ultrices posuere cubilia Curae; Pellentesque sit amet pede ac sem eleifend consectetuer. Nullam elementum, urna vel imperdiet sodales, elit ipsum pharetra ligula, ac pretium ante justo a nulla. Curabitur tristique arcu eu metus. Vestibulum lectus. Proin mauris. Proin eu nunc eu urna hendrerit faucibus. Aliquam auctor, pede consequat laoreet varius, eros tellus scelerisque quam, pellentesque hendrerit ipsum dolor sed augue. Nulla nec lacus.

References