SMART CONTRACT MANAGEMENT USING DISTRIBUTED LEDGER SYSTEM: A BANGLADESHI CONTEXT

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A thesis submitted to the BRAC Institute of Governance and Development in partial fulfillment of the requirements for the degree of Masters in Procurement and Supply Management

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Declaration

It is hereby declared that

1. The thesis submitted is my/our own original work while completing degree at BRAC University.
2. The thesis does not contain material previously published or written by a third party, except where this is appropriately cited through full and accurate referencing.
3. The thesis does not contain material which has been accepted, or submitted, for any other degree or diploma at a university or other institution.
4. I have acknowledged all main sources of help.

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Approval

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Executive Summary

The adoption of smart contracts in Bangladesh's public procurement system presents a transformative opportunity to enhance efficiency, transparency, and accountability. By automating procurement processes, smart contracts can reduce cycle times, minimize human errors, and improve contract execution. This will help tackle long-standing challenges such as corruption and inefficiency, fostering greater public trust. Additionally, smart contracts can reduce administrative costs by eliminating intermediaries and ensuring compliance through self-executing terms.

However, challenges remain, including inadequate digital infrastructure, the lack of a supportive legal framework, and digital literacy gaps. To overcome these, Bangladesh must invest in digital infrastructure, update legal provisions, and provide extensive training for stakeholders. Pilot projects, stakeholder collaboration, and enhanced data security are also critical for successful implementation. With careful planning, smart contracts can significantly improve public procurement, contributing to better governance and economic development in Bangladesh.

Keywords: Distributed Ledger System; Blockchain; Smart Contract; Public Procurement; Artificial Intelligence

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List of Acronyms

DLS	Distributed Ledger System
PE	Procuring Entity
DLT	Distributed Ledger Technology
DAG	Directed Acyclic Graph
PPA	Public Procurement Act
PPR	Public Procurement Rules
STD	Standard Tender Documents
SRFP	Standard Request for Proposal
CPAR	Country Procurement Assessment Report
CPTU	Central Procurement Technical Unit
RFQ	Requests for Quotations
PDO	Project Development Objective
DIMAPPP	Digitizing Implementation Monitoring and Public Procurement Project
IDA	International Development Association

Chapter 1

Introduction

1.1 Background of the thesis

In recent years, the rise of blockchain technology has revolutionized various sectors, from finance to supply chain management. A crucial component of blockchain technology is the **Distributed Ledger System (DLS)**, which enables secure, transparent, and decentralized record-keeping. This innovation has led to the development of **Smart Contracts**, self-executing contracts with the terms of the agreement directly written into lines of code, facilitated by blockchain. Smart contracts offer automated, secure, and transparent contract execution without the need for intermediaries, thereby reducing costs, increasing efficiency, and ensuring trust.

Bangladesh is a country with a growing economy, and its government and private sector are increasingly interested in adopting innovative technologies to improve governance, transparency, and service delivery. However, despite substantial progress, Bangladesh faces several challenges related to corruption, inefficient bureaucracy, lack of transparency, and a cumbersome legal and contractual system. Traditional contract management practices in Bangladesh often involve lengthy processes, high transaction costs, and disputes due to lack of trust between parties.

Given the challenges faced by Bangladesh, the adoption of Distributed Ledger Systems and smart contracts could offer significant benefits. By leveraging these technologies, Bangladesh can address issues such as **contract enforcement**, **corruption**, **delays in transaction processing**, and **data transparency**. The potential of smart contracts to automate legal and financial agreements and provide decentralized, immutable records can drastically improve the country's business climate, streamline government services, and enhance the legal system.

1.2 Rationale of the thesis

In procurement, specifically public procurement, the most vulnerable part of procurement management is contract management. Here, lots of uncertain issues rise while executing the work order like intentionally increasing the cost, time and quality of the delivery of products. As a result, the terms of the contract needs to be updated time to time. In practice, contractors in Bangladesh perform their job under the initial contract with the procuring

entity. If variations needed to the contract then usually it is not formalized. As a result, when the contractor does his job according to the requirements of the procuring entity as per commitment, there will be no issue of disagreement. However, when the contractor finds that it would be beneficial for him to skip the contract then he tries to avoid his commitment using the ambiguity of the contract. Here, the litigation issue of contract management starts. As contract variations are not formalized time to time, contractor can easily escape from legal bindings.

1.3 Objectives of the Report

The objectives of the thesis are:

a. Determine the breadth of DLT applications in contract management and investigate to which extent it has been used in procurement.
b. To criticize current problems, businesses experience in the procurement process.
c. To contextualize procurement by mentioning its importance in overall project success.
d. To examine how blockchains and smart contract technologies are utilized to overcome problems in procurement, as well as the benefits they provide to enhance the procurement process.
e. To analyze how these improvements support companies to gain competitive advantages in their industries.
f. To add a new dimension to the contract management.

1.4 Limitations of the thesis

When discussing the limitations of the **methodology** in this thesis, it's essential to reflect on constraints specific to the research design, data collection, and analysis methods used in the study. Some limitations have been mentioned below:

a. Limited Access to Primary Data

- **Lack of Industry Adoption:** Since smart contract technology is still emerging in Bangladesh, there is limited adoption of such technologies across industries. This makes it difficult to collect substantial real-world data or case studies from businesses actively using smart contracts.

- **Limited Availability of Participants:** Due to the nascent state of blockchain and smart contracts in Bangladesh, there is limited pool of experts, blockchain developers, or companies to interview or survey. This has led to a small sample size, affecting the generalizability of the findings.
- **Reluctance to Share Information:** Organizations are unwilling to share sensitive information regarding their contract implementations, especially if the technology is still in its early stages or involves proprietary systems.

b. Technical Constraints in Data Collection

- **Complexity of Smart Contract Platforms:** Data collection related to smart contracts requires an in-depth technical understanding of blockchain platforms (e.g., Ethereum, Hyperledger). This limits my ability to gather data effectively as I lack sufficient technical expertise or access to smart contract environments.
- **Difficulty in Measuring Impact:** The effects of smart contract adoption are not immediately measurable, as these benefits (e.g., reduced fraud, faster transactions) will take time to materialize. This makes it difficult to capture quantitative data on performance improvements in real-time.

c. Sampling Issues

- **Representativeness of Sample:** Given the limited adoption of smart contracts in Bangladesh, the sample of businesses or individuals involved in the study are not representative of the broader population. As such, conclusions drawn will not apply to early adopters rather than reflecting the entire market.

d. Ethical and Privacy Issues

- **Confidentiality of Data:** When interviewing organizations or individuals about their use of smart contracts, due to privacy concerns or confidentiality agreements in place, which limits the depth of data that can be collected. This restricts access to sensitive financial or contract information, hindering a thorough analysis.
- **Ethical Dilemmas in Data Usage:** The use of blockchain, which is inherently transparent, raises concerns over the misuse of data, particularly in cases where personal or financial information is involved in the contracts. Ethical considerations around privacy and informed consent limits the kind of data that should be collected and analyzed.

e. Research Design Limitations

- **Focus on a Single Case Study or Industry:** Smart contract studies focus on a several industries, limiting the ability to generalize findings to all sectors in Bangladesh. While the insights are valuable, they may not reflect the diverse needs and challenges across different industries (e.g., banking, healthcare, logistics).
- **Quantitative vs. Qualitative Data Balance:** Balancing quantitative and qualitative data in smart contract management research is often challenging. While quantitative data (e.g., transaction speed, cost reduction) provides measurable outcomes, qualitative data (e.g., user experience, stakeholder perceptions) is harder to assess systematically. The subjective nature of interviews or surveys could introduce bias.

f. Technological Constraints

- **Rapidly Evolving Technology:** The fast pace of blockchain and smart contract technology development means that methodologies relying on current systems may become outdated during the research period. New platforms or updates to existing ones might alter the functionality or benefits of smart contracts in unexpected ways, limiting the applicability of the findings over time.
- **Difficulty in Simulating Smart Contracts:** Due to the need for specialized platforms or environments (e.g. blockchain testnets), it can be challenging to simulate real-world applications of smart contracts within the scope of the thesis. This may result in a reliance on theoretical analysis rather than real-world implementations.

g. Data Analysis Limitations

- **Limitations in Blockchain Analytics Tools:** The tools and software available for blockchain analytics have limitations in terms of accuracy, accessibility, or cost. For example, analyzing blockchain transactions is complex and resource-intensive, requiring specialized software or access to large datasets.
- **Data Volatility in Blockchain:** Blockchain transactions are permanent but can be difficult to interpret due to their inherent complexity and lack of traditional financial structures. The dynamic natures of blockchain systems, where transactions occur continuously, make data analysis or make it difficult to isolate relevant variables for study.

h. Time and Resource Constraints

- **Limited Timeframe for Data Collection:** Due to the research timeline, there is constraint in how much data can be collected, especially for a technology as emergent as smart contracts. This led to incomplete or inconclusive findings.

i. Limitations in Existing Literature and Theoretical Framework

- **Scarcity of Literature on Local Context:** There are limited academic resources or research studies focused on smart contract management specifically within Bangladesh. This has posed a challenge when trying to build on existing knowledge or find relevant comparisons.
- **Lack of Established Theoretical Frameworks:** Many existing frameworks for smart contracts are based on global or developed markets and are not directly applicable to Bangladesh's unique economic, social, or technological landscape.

By acknowledging these methodological limitations, the researcher can provide a clearer understanding of the scope and validity of their findings, guiding future studies in the area of smart contract management within Bangladesh.

Chapter 2
Methodology

This research will adopt a qualitative approach to explore the potential application of Smart Contract Management using Distributed Ledger Systems (DLS) in the context of Bangladesh's public procurement system. Case studies of countries or organizations that have already implemented blockchain-based procurement systems will also be analyzed to provide a comparative perspective and inform the development of a hypothetical model for Bangladesh.

The data gathered through interviews and case studies will be analyzed using thematic analysis to identify key themes related to the adoption of smart contracts and DLS in procurement. This analysis will focus on understanding stakeholders' perceptions of the technology’s potential to enhance transparency, efficiency, and accountability in Bangladesh’s procurement system. The research will develop a hypothetical model for the integration of smart contracts in Bangladesh's public procurement, addressing regulatory, technical, and cultural challenges. The findings will contribute valuable insights for policymakers and procurement professionals on how to effectively implement DLS-based solutions in the country.

Chapter 3
Literature Review

3.1 What is Distributed Ledger System?

A **Distributed Ledger System (DLS)** is a type of database that is shared, replicated, and synchronized across multiple nodes or locations, rather than being controlled by a central authority. It allows for the recording of transactions or data in a way that ensures transparency, security, and decentralization. The key feature of a distributed ledger is that all participants in the network have access to the same information, and the system ensures that the data is immutable and tamper-resistant. In this system, all participants in the network have access to the same information, which enhances transparency, security, and trust. The core features of a DLS include immutability and tamper resistance, which ensure that once data is recorded, it cannot be altered without the consensus of the network participants (Xu et al., 2024). This makes DLS particularly valuable in applications such as cryptocurrencies, supply chain management, and voting systems (Zhang and Wang, 2023).

3.1.1 Key Features of a Distributed Ledger System:

1. **Decentralization**: Unlike traditional databases, where a central authority (e.g., a bank or government agency) controls and verifies data, in a distributed ledger, multiple participants (nodes) share control. No single participant has full control over the entire system, which helps prevent fraud and manipulation.
2. **Immutability**: Once data is entered into the ledger, it cannot be altered or deleted without the consensus of the network. This makes distributed ledgers ideal for use cases where data integrity and auditability are crucial, such as financial transactions or contract management.
3. **Transparency**: Every participant has access to the same version of the ledger, providing transparency. Each participant can independently verify the data, ensuring accountability and trustworthiness.
4. **Consensus Mechanisms**: To maintain consistency across the distributed network, consensus mechanisms (such as Proof of Work, Proof of Stake, or Practical Byzantine Fault Tolerance) are used. These mechanisms ensure that all nodes in the network agree on the validity of transactions or changes to the ledger.

5. **Security**: Distributed ledgers employ cryptographic techniques to secure the data and ensure that unauthorized participants cannot alter the ledger. Each transaction is cryptographically linked to the previous one, making it difficult to tamper with the data.

3.1.2 Types of Distributed Ledger Systems:

1. **Blockchain**: This is the most widely known form of distributed ledger technology. It organizes data in blocks that are linked together in a chronological order, ensuring data immutability and security through consensus mechanisms such as Proof of Work or Proof of Stake (Nakamoto, 2023). Blockchain is commonly used in cryptocurrencies like Bitcoin and Ethereum (Wang and Li, 2024).
2. **Directed Acyclic Graph (DAG)**: In contrast to blockchain, a DAG-based system does not use blocks or chains. Instead, it structures data in a graph where each transaction is linked to previous ones in a non-linear fashion, offering faster transaction speeds and scalability (Xu et al., 2024). This is used in projects like IOTA and Hedera Hashgraph (Zhang, 2023).
3. **Other DLS Models**: These are less common and use a unique approach, where data is structured in a way that allows for more flexibility and scalability in certain applications. They are still in experimental stages and are primarily discussed in academic research (Kuo and Chen, 2023).

3.1.3 Applications of Distributed Ledger Systems:

1. **Cryptocurrencies**: Distributed ledgers are most commonly associated with cryptocurrencies (e.g., Bitcoin, Ethereum), where they serve as the underlying technology for secure and transparent financial transactions.
2. **Supply Chain Management**: Distributed ledgers can improve traceability and transparency in supply chains. Each step of the product journey can be recorded on the ledger, allowing all stakeholders to track and verify the product's origin and journey.
3. **Smart Contracts**: Distributed ledger systems, especially blockchains, support smart contracts—self-executing contracts with the terms of the agreement directly written into code. These contracts automatically execute when predetermined conditions are met, without the need for intermediaries.

4. **Voting Systems**: Distributed ledgers can be used to develop secure and transparent voting systems, where every vote is recorded on the ledger and cannot be tampered with, ensuring election integrity.
5. **Financial Services**: DLS is used in various financial applications, including cross-border payments, asset tracking, and securities trading, enabling faster, cheaper, and more secure transactions.
6. **Healthcare**: In healthcare, distributed ledgers can be used to manage patient records, ensuring data privacy, security, and interoperability among healthcare providers.

3.1.4 Advantages of Distributed Ledger Systems:

- **Reduced Risk of Fraud**: Due to the decentralized nature and the immutability of the ledger, there is a reduced risk of fraud or data tampering.
- **Increased Efficiency**: DLS can streamline processes that typically require intermediaries, reducing time and cost.
- **Enhanced Transparency and Trust**: Since all participants have access to the same data, there is increased transparency, which can help build trust among parties.
- **Improved Security**: Distributed ledgers use cryptographic techniques to secure data and ensure that transactions are valid and authenticated.

3.1.5 Challenges of Distributed Ledger Systems:

- **Scalability**: As the number of participants and transactions increases, some distributed ledger systems (especially blockchain) may face scalability issues, which could slow down processing times and increase transaction costs.
- **Regulation and Legal Framework**: The regulatory environment for distributed ledger systems, particularly in financial services, is still developing. Governments and institutions are working on creating legal frameworks to govern their use.
- **Energy Consumption**: Some distributed ledger systems, such as Bitcoin's blockchain, require significant energy consumption due to their consensus mechanisms, such as Proof of Work.

3.2 What is Smart Contract?

A **smart contract** is a self-executing contract where the terms of the agreement are directly written into lines of code. These contracts run on blockchain technology, which ensures their

security, transparency, and immutability. In the context of public procurement, smart contracts can be utilized to automate various stages of the procurement process, from tender submission to contract execution, to final payment. Below is an exploration of the basic structure of smart contracts in procurement, followed by a literature review of how these contracts are transforming procurement practices.

3.2.1 Basic Structure of Smart Contracts in Procurement

The basic structure of a smart contract in procurement typically involves the following components:

1. **Contract Parties**: This refers to the stakeholders involved in the contract. In procurement, this includes the contracting authority (government agency, procurement body) and the contractor (supplier, vendor, service provider).
2. **Contract Terms**: These are the conditions or rules embedded within the smart contract, which govern the relationship between the parties. They are usually based on procurement specifications, milestones, delivery schedules, quality assurance measures, and payment schedules.
3. **Blockchain Platform**: Smart contracts in procurement typically run on a blockchain, such as Ethereum or Hyperledger. This provides an immutable ledger where all contract transactions, amendments, and performance data are securely recorded.
4. **Automation Triggers (Events)**: Smart contracts include automated triggers or events that execute specific actions when certain conditions are met. For example, a payment might automatically be released when a project milestone is completed or when a delivery of goods is verified.
5. **Oracles**: Smart contracts often rely on external data sources, or "oracles," to trigger events. In the procurement process, this could include data about delivery, performance, or compliance with agreed specifications. Oracles fetch real-world data and feed it into the blockchain to update the contract's state.
6. **Execution Mechanism**: Once the predefined conditions are met, the contract self-executes. For example, if a vendor submits the required product or service, and the quality checks are satisfied, the smart contract can automatically release payment to the vendor.
7. **Dispute Resolution Mechanism**: While many smart contracts are designed to operate autonomously, some may include built-in mechanisms for handling disputes, such as

arbitration or mediation, in cases where one of the parties disagrees with the contract's execution.

8. **Audit Trail**: Blockchain technology ensures that every action taken under the contract is permanently recorded. This provides an audit trail, increasing transparency and trust in the procurement process.

3.2.2 Literature Review on Smart Contracts in Procurement

Smart contracts have been identified as a tool for enhancing procurement efficiency, transparency, and accountability. The potential of blockchain technology to streamline procurement processes is widely discussed in both academic and industry literature. Below is a summary of key findings from the literature:

1. **Efficiency and Automation**: Several studies highlight the role of smart contracts in automating procurement procedures, reducing manual intervention, and speeding up processes. In traditional procurement, delays often occur due to manual document verification, approval hierarchies, and invoicing procedures. Smart contracts can automate these tasks, reducing the time taken to complete procurement cycles. For example, if a supplier meets delivery milestones, the payment can automatically be triggered without human oversight.
2. **Transparency and Accountability**: One of the key advantages of using smart contracts in procurement is their ability to ensure transparency. Since all transactions and contract-related actions are recorded on the blockchain, there is a publicly accessible ledger that prevents fraud, corruption, and manipulation of procurement data. This makes it easier for procurement authorities and citizens to monitor contract execution in real time.
3. **Cost Reduction**: According to research by Tapscott & Tapscott, smart contracts help reduce administrative costs by eliminating the need for intermediaries such as banks or lawyers. For example, once a contract is executed, payments can be made automatically without requiring banks to process the transaction. Moreover, by removing inefficiencies, procurement costs can be reduced, allowing more resources to be allocated to the actual procurement.
4. **Compliance and Security**: Smart contracts can ensure that procurement agreements comply with specified regulations by automatically enforcing the terms of the contract. They provide a higher level of security compared to traditional contracts due

to the decentralized nature of blockchain technology, which protects against tampering or unauthorized changes. Additionally, these contracts can include features such as automatic penalty clauses for delays or non-compliance, ensuring that vendors adhere to deadlines and quality standards.

5. **Challenges in Implementation**: While the advantages are significant, some studies highlight the challenges in implementing smart contracts in procurement systems. According to Risius & Spohrer, issues such as technological complexity, regulatory barriers, and the need for widespread adoption can slow down the implementation process. The infrastructure needed to support smart contracts, including blockchain technology and digital identities for participants, can also be costly and time-consuming to establish.
6. **Global Applications and Pilot Projects**: Several countries have started experimenting with smart contracts in procurement. For example, in Estonia, the government has piloted the use of smart contracts for public procurement, particularly in the construction sector. Similarly, in the United Arab Emirates, Dubai has implemented blockchain technology for procurement, with plans to transition all government transactions to blockchain in the future.

The basic structure of smart contracts in procurement represents a promising shift towards more automated, transparent, and efficient systems for managing public contracts. Literature supports the notion that smart contracts can significantly reduce procurement cycle times, enhance transparency, and improve compliance, leading to better outcomes for public sector procurement. However, the adoption of smart contracts in procurement faces challenges related to infrastructure, regulatory adaptation, and technological complexity. Despite these challenges, ongoing pilot projects and advancements in blockchain technology indicate that smart contracts will play an increasingly important role in transforming global procurement systems in the coming years.

Chapter 4

Existing procurement management in Bangladesh and analyze the process

4.1 Public Procurement Reform in Bangladesh

As part of its efforts to strengthen governance across various sectors, the Government of Bangladesh initiated a comprehensive program to enhance the performance of public procurement. To support this objective, the Central Procurement Technical Unit (CPTU) was established in 2002 as the key body responsible for implementing procurement reforms and monitoring their progress. The reform process led to the development of a unified procurement processing system, including the issuance of the Public Procurement Regulations (PPR) 2003, Implementation Procedures for PPR 2003, Public Procurement Processing and Approval Procedures (PPPA), the Revised Delegation of Financial Powers (DOFP), and various Standard Tender Documents (STDs) and Standard Request for Proposal (SRFP) Documents for the procurement of Goods, Works, and Services. In 2006, the Public Procurement Act (PPA 2006) was passed by Parliament, and in 2008, the Public Procurement Rules (PPR 2008) were introduced, both of which came into effect on January 31, 2008.

4.1.1 Country Procurement Assessment Report (CPAR) and the Public Procurement Reform Project (PPRP)

The slow performance of procurement processes in various projects led to a comprehensive assessment of the public procurement policy, framework, institutions, and staff skills in 2001. The Country Procurement Assessment Report (CPAR), prepared by the World Bank and ADB in collaboration with the Government of Bangladesh, identified several major deficiencies in the procurement system, including:

- The lack of a robust legal framework for public sector procurement
- Complex bureaucratic procedures leading to delays
- A lack of proper planning
- Multiple layers in the approval and review processes
- Insufficient professional competence among staff to manage procurement effectively
- Poor-quality bidding documents and bid evaluation
- Ineffective contract administration
- Inadequate mechanisms to ensure transparency and accountability

In response to these challenges, there was a strong need to enhance governance in public procurement management. Consequently, the first "Public Procurement Reform Project" was approved on February 14, 2002, with assistance from IDA. The project's primary goal was to improve public procurement performance by introducing measures to align the system with internationally recognized standards for efficiency, transparency, and accountability, while increasing procurement capacity through training and the development of a pool of national procurement professionals.

During the implementation of the Public Procurement Reform Project (PPRP) from 2002/03 to 2006/07, significant improvements were made, including the completion of the following major policy reforms:

- The issuance of the Public Procurement Regulations (PPR) in 2003, which remained in effect until January 30, 2008, along with implementation procedures, procurement processing, and guidelines. In July 2006, a procurement Act was passed by Parliament, which incorporated many aspects of internationally recognized public procurement practices.
- A specialized unit, initially called the Central Procurement Technical Unit (CPTU), was established to manage and support the implementation of procurement reforms.
- The CPTU created a website (www.cptu.gov.bd) to publish Invitations to Tenders, Requests for Proposals (RFPs), Requests for Quotations (RFQs), and contract awards for public access.
- A centralized Procurement Management Information System (PROMIS) was developed.
- A pool of 25 national trainers was created, and more than 1,800 staff members from 260 organizations were trained by March 2007.
- A comprehensive set of Standard Tendering Documents was developed to comply with the Public Procurement Regulations 2003 for use by all government-funded agencies.
- The delegation of financial powers was revised.
- The Public Procurement Act was ratified by Parliament in 2006.
- A new set of public procurement rules and supporting procedural guidelines was prepared.

In 2008, the Public Procurement Regulations 2003 were replaced by the Public Procurement Rules (PPR) 2008, framed under the Public Procurement Act of 2006. The new rules introduced several key changes to improve the procurement process, including:

- The introduction of Framework Contracts
- The introduction of Concession Contracts
- The use of the Request for Quotation method for procuring divisible commodities in bulk
- Special provisions to address urgent national needs

Public Procurement Reform Project II (PPRP-II)

To further strengthen and sustain the public procurement reform efforts, the government approved a technical assistance project called the "Public Procurement Reform Project II (PPRP-II)" in June 2007. This project, which was extended twice, was implemented by the former Central Procurement Technical Unit (CPTU) of IMED. PPRP-II aimed to address various challenges and initiatives through a comprehensive set of four major components:

- Component 1: Advancing Policy Reform and Institutionalizing Capacity Development
- Component 2: Enhancing Procurement Management at the Sector Level & CPTU/IMED
- Component 3: Implementing e-Government Procurement (e-GP)
- Component 4: Promoting Communication, Behavioral Change, and Social Accountability

The PPRP-II successfully concluded on June 30, 2017. According to the World Bank's Final Review Mission, the project's development progress was deemed satisfactory. By the project's completion, all five Project Development Objective (PDO) indicators were met, with four exceeding the targets, leading to a lasting systemic change in Bangladesh's public procurement environment.

4.1.2 Digitizing Implementation Monitoring and Public Procurement Project (DIMAPPP)

A Financing Agreement of US$ 55 million was signed between the Government of Bangladesh and the International Development Association (IDA) of the World Bank Group. This agreement, signed at the NEC-II Conference Room of the Economic Relations Division (ERD), was to implement the five-year "Digitizing Implementation Monitoring and Public

Procurement Project (DIMAPPP)" from July 2017 to June 2022. The agreement was signed by Kazi Shofiqul Azam, Secretary of ERD, and Mr. Qimiao Fan, Country Director of the World Bank, on behalf of their respective organizations. Senior officials from both the Government of Bangladesh and the World Bank attended the ceremony. The project was carried out by the former Central Procurement Technical Unit (CPTU) of the Implementation Monitoring and Evaluation Division (IMED) under the Ministry of Planning.

The DIMAPPP consisted of four key components:

1. Restructuring CPTU and Policy Reform
2. Enhancing the Digitization of Public Procurement
3. Professionalizing Procurement and Citizen Engagement (CE)
4. Digitizing Project Implementation Monitoring

The project involved 32 Selected Public Sector Organizations (SPSOs), including four major target agencies (BREB, BWDB, LGED, RHD), which handle most of the public procurement activities. The goal is to gradually bring all Public Sector Organizations (SPOs) under the e-GP system, facilitating the full digitization of public procurement in Bangladesh.

The main objective of the DIMAPPP is to improve public procurement performance and enhance the capacity for implementing monitoring of development projects and programs through digitization. This includes restructuring the CPTU into an authority, institutionalizing the e-GP system, digitizing the procurement process for all government organizations, providing training to government officials and bidders, professionalizing procurement, and strengthening the Implementation Monitoring and Evaluation Division (IMED) for digital project monitoring. The project aims to contribute to building a prosperous Bangladesh by speeding up and ensuring transparency and accountability in the public procurement process.

DIMAPPP Additional Financing (AF)

The agreement for Additional Financing (AF) for DIMAPPP was signed by the Government of Bangladesh and the World Bank on April 11, 2021. The World Bank Board approved the AF on February 5, 2021. The IDA contributed US$ 40 million, with an additional US$ 5 million from the Government of Bangladesh. The AF extended the project's duration from July 2022 to December 2023. The Government of Bangladesh approved a revised TAPP in February 2021.

The main purposes of the AF were:

1. To expand the coverage and features of the e-GP system in response to the COVID-19 pandemic.

2. To cover the additional costs related to extending the original project by 18 months to complete ongoing activities, which required more time and resources due to the pandemic.
3. To incorporate the recommendations of the MAPS (Methodology for Assessing Procurement Systems) jointly made by the Government of Bangladesh and the World Bank in 2020 into the procurement law.

The first phase of the DIMAPPP Additional Financing ended in December 2023. A second revised DIMAPPP phase began in January 2023 and is scheduled to conclude in December 2024.

Project Progress as of November 2024

From July 2017 to November 2024, the DIMAPPP made significant progress across all its planned activities. In March 2021, the World Bank recognized DIMAPPP as the most innovative, collaborative, and impactful project. Despite the challenges posed by the COVID-19 pandemic, the project continued to progress, with the e-GP system operating without disruption. By June 2021, several activities under the project components were successfully completed.

Restructuring CPTU and Policy Reform

On September 18, 2023, the former CPTU was restructured into the Bangladesh Public Procurement Authority. The government approved the Sustainable Public Procurement (SPP) Policy in 2023, and the SPP Guidelines were issued in 2024. Additionally, the Asset Disposal Policy has been drafted.

Enhancing Digitization of Public Procurement

The procurement of computers and accessories for 28 NSPSOs, covering 2,085 PEs, has been completed. As of November 2024, during the DIMAPPP period, a total of 33,058 individuals have been trained on e-GP. Of these, 12,948 are from government procuring entities, 13,102 from the tendering community, 1,725 from banks, 693 policy-level officials, 1,001 from the Tenderers' Database, and 2,000 PE users. From 2011 to November 2024, a total of 41,697 individuals, including officials from procuring entities, tenderers, administrators, bank staff, and policy-level officials, received various e-GP training. Among them, 1,021 tenderers received training on the Tenderers' Database (TDB), and 2,169 PEs were trained on TDB.

As of October 31, 2024, there were 118,084 registered tenderers, 1,472 agencies, and 868,093 tenders invited, with a total value of 107.35 billion US dollars. Additionally, e-GP training was completed for 888 local government institutions (LGIs). The e-GP system has been

upgraded (Java) by the developer to facilitate international tenders and is currently live on the training server. As part of the technological modernization, efforts are underway to transition the e-GP system from a monolithic to a micro-services architecture. An independent audit firm has been hired to assess the e-GP system's security and vulnerabilities. The Tenderers' Database has been developed and is now in use and expanding.

The electronic contract management system (e-CMS) was piloted and then implemented across other agencies. An audit module has also been developed and integrated into the e-GP system, which is now operational. Furthermore, the e-GP system has been integrated with IBASS++, NID, and e-PMIS. International competitive tenders (ICT), service procurement, and framework agreements have been incorporated into the system. The e-GP system has earned four ISO certifications for its operations, service quality, business continuity, and environmental management. Following the implementation of e-CMS, e-GP has become a fully automated system, covering everything from annual procurement planning to contract management. So far, 11 countries and 5 international organizations have visited the e-GP system to learn about its successful implementation in Bangladesh.

4.1.3 Professionalizing Procurement

The BPPA's pool of national procurement trainers has now grown to 73. Under the DIMAPPP, a total of 3,484 officers participated in three-week training sessions across 115 batches from 2019 to 2023. Additionally, 4,333 participants from various stakeholder groups attended public procurement training in 167 short-course batches between 2019 and 2022. A total of 57 government officers earned the MCIPS qualification under DIMAPPP. From 2003 to December 2023, 12,520 participants took part in 412 three-week training sessions on public procurement management, and 15,241 participants, including media representatives, received training on public procurement topics in 505 short-course batches.As part of the Additional Financing of PPRP-II, 25 government officers completed an MSc in public procurement from ITC-ILO, Turin University. Moreover, 52 of the 60 national procurement trainers in Bangladesh received short-term training at ITC-ILO, Turin University, under the project.

4.1.4 Citizen engagement

The "Sorkari Kroy Batayan" citizen portal, designed to disclose procurement information to the public, was developed in 2020 and became operational in August of the same year. A

social media strategy was also implemented for the former CPTU. Additionally, a citizen feedback mechanism was created, and piloting began in 2024.

Physical monitoring of contract implementation was carried out in 48 upazilas. Furthermore, the BPPA launched a communication program on public procurement, utilizing both "above the line (ATL)" and "below the line (BTL)" content and materials.

Engaging citizens in public procurement has been a key initiative of the Bangladesh Public Procurement Authority (BPPA). Following recommendations from the high-level Public-Private Stakeholders Committee (PPSC) on public procurement, BPPA introduced local citizen monitoring of public procurement contract implementation under the DIMAPP project. This initiative, which began in 2019, established local citizen groups in 48 Upazilas across 18 districts, covering all 8 divisions of Bangladesh.

4.1.5 Citizen Monitoring: Process and Outcomes

The citizens selected for monitoring were trained on monitoring techniques, following a predefined framework that defined their scope of work. From 2019 to March 2022, 254 citizen groups monitored a total of 316 public procurement contracts. These groups were formed based on factors such as age, education, gender, and social acceptability. Citizen engagement was organized into two models: structured citizen groups and unstructured groups.

The initiative worked in partnership with key implementing agencies, including the Local Government Engineering Department (LGED), the Public Health Engineering Department (DPHE), and the Education Engineering Department (EED). As part of the monitoring process, 316 signboards were installed across the 316 contracts, involving 2,516 citizen team members and impacting 24,402 individuals either directly or indirectly. Citizens raised 443 complaints, with 409 of them successfully resolved.

4.1.6 Awareness and Capacity-Building Efforts

BPPA organized 24 citizen forum workshops in eight divisional cities and 16 district headquarters. Additionally, 17 meetings of the Public-Private Stakeholders Committee (PPSC) were held to discuss the outcomes of citizen monitoring and other public procurement issues. To raise public awareness, BPPA also produced three research studies and three documentary videos.

4.1.7 Digitizing Project Implementation Monitoring

A contract to upgrade and enhance the existing Electronic Project Monitoring Information System (e-PMIS) at IMED was signed in March 2021. The e-PMIS system has been made operational and integrated with e-GP and NID. This electronic system provides real-time data on various projects under the Annual Development Program (ADP). For the fiscal year 2024-25, there are 1,343 projects under the ADP. As of November 2024, 1,268 project directors had registered with e-PMIS. In total, 616 officers received functional user training, and 595 project directors were oriented on the e-PMIS software.

4.1.8 Contract management

The country's legal procurement framework clearly defines the responsibilities for managing contracts during implementation. It covers aspects such as delivery inspection, progress monitoring, contract amendments, payment processes, contract completion, time extensions, terminations, and dispute resolution. Disputes are resolved in a sequential manner: (i) through amicable solutions, (ii) through adjudications, and (iii) via arbitration, as outlined in the contract and disclosed in the bidding documents. The final outcome of the dispute resolution process is legally enforceable. Contract implementation and payment are monitored by the contract administrator, typically the Project Director or Procuring Entity, in line with standard contract provisions (such as the GCC and work schedule). According to 80% of the bidders surveyed, civil works contracts are generally supervised regularly (at least once a week) by the authority to ensure timely completion. However, none of the respondents were certain that such supervision positively impacted the quality of the civil works. Moreover, procurement records indicate that only 30% of contracts are completed on time, which remains a significant concern for the country.

In the context of Bangladesh, the procurement process involves a series of steps aimed at ensuring efficiency, transparency, and accountability. Below is an explanation of each of the key points:

1. **Need Assessment**: Before initiating a procurement process, a thorough need assessment is conducted to determine the requirements of the government entity. This helps in understanding the necessity of goods, services, or works required for public projects. It often includes a review of existing resources, anticipated demand, and alignment with national development goals.
2. **Procurement Plan**: The procurement plan is developed based on the need assessment and outlines the schedule, procedures, and methods for procurement. This plan

includes the specific items or services to be procured, the timeline for procurement, and the budget allocated. In Bangladesh, the procurement plan is closely aligned with the Annual Development Program (ADP).

3. **Specification/BoQ/ToR**: The specifications, Bill of Quantities (BoQ), and Terms of Reference (ToR) are critical documents that outline the technical and functional requirements of the procurement. These documents are prepared to ensure that the goods, services, or works meet the required standards and are delivered as per the agreed terms.
4. **Official Estimated Cost**: The official estimated cost is determined based on market research, historical data, and expert assessments. It reflects the anticipated cost for the goods, services, or works to be procured. This estimate is used for comparing bids and ensuring that procurement stays within the allocated budget.
5. **Document Preparation**: Procurement documents, including tender documents, Request for Proposals (RFPs), or Requests for Quotations (RFQs), are prepared and issued. These documents provide all the necessary information about the procurement process, including the terms and conditions, eligibility criteria, and evaluation methods.
6. **Advertisement**: The procurement opportunity is advertised to the public to encourage competition and transparency. In Bangladesh, advertisements are typically published in national newspapers, official government websites, and on platforms such as the e-GP (electronic Government Procurement) system.
7. **Submission**: Bidders or suppliers submit their proposals or tenders in response to the advertisement. The submission process is designed to ensure that all necessary documents, such as financial proposals, technical documents, and bid security, are submitted by the deadline.
8. **Opening**: The tender or proposal opening is done publicly, where the submitted bids are opened in the presence of relevant officials and stakeholders. This ensures transparency and allows interested parties to observe the process.
9. **Evaluation**: The submitted bids are evaluated based on predefined criteria, such as technical capabilities, financial proposal, and compliance with specifications. In Bangladesh, evaluation teams are responsible for reviewing and scoring bids to select the most appropriate supplier or contractor.
10. **Approval as per DoFP**: Once the evaluation is completed, the procurement proposal must be approved in accordance with the Delegation of Financial Powers (DoFP).

This document outlines the authority limits for approving contracts and payments at different levels of government.

11. **Notification of Award**: After approval, the selected bidder is notified of the award decision. The notification is typically sent via formal communication channels, and the awardee is informed of the terms and conditions of the contract.
12. **Contract Signing**: The contract is signed by both the procuring entity and the awarded bidder or contractor. This legally binding agreement formalizes the obligations, timelines, and conditions under which the procurement will be executed.
13. **Contract Management**: Once the contract is signed, it is actively managed by the procuring entity to ensure compliance with the terms and conditions. This involves monitoring the contractor's progress, ensuring quality, managing risks, and addressing issues as they arise.
14. **Payment**: Payments are made according to the agreed terms in the contract. In Bangladesh, payment is typically processed after the completion of specific milestones or deliverables, as outlined in the contract. Payments are made after the review and approval of the progress.
15. **Warranty/Defect Liability Period**: After the completion of the project or delivery of goods, a warranty or defect liability period begins. During this period, the contractor or supplier is responsible for addressing any defects or issues that arise in the delivered goods or completed work.
16. **Contract Closing**: The contract is formally closed once all deliverables have been met, payments are completed, and any defects or issues have been resolved. This involves final approval and documentation to confirm the completion of the procurement and contract obligations.

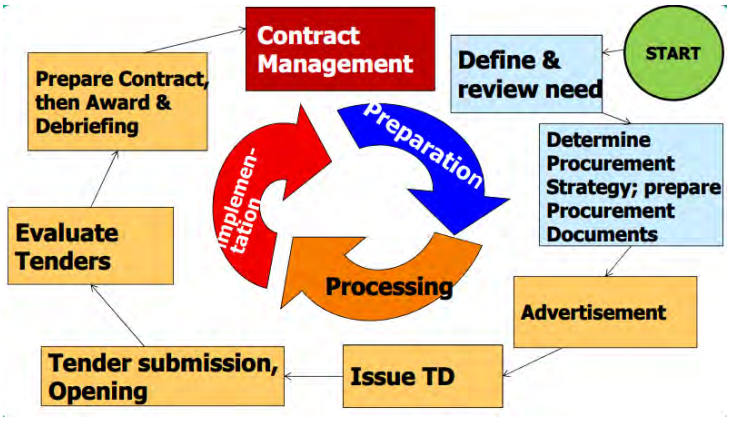

Figure 1: Public Procurement Cycle in Bangladesh

Chapter 5

Countries or organizations that have implemented blockchain-based procurement systems

Several countries and organizations have started to implement blockchain-based procurement systems to enhance transparency, reduce fraud, and streamline the procurement process. Below are a few notable case studies:

5.1 Estonia: Blockchain in Public Procurement

Estonia is one of the pioneers in digital governance and has adopted blockchain technology for several applications, including public procurement. The Estonian government uses blockchain technology as part of its "e-Residency" initiative and for secure record-keeping. The government aims to improve transparency, traceability, and security in procurement processes by integrating blockchain into their e-Procurement platform. By doing so, Estonia ensures that all public procurement data, such as bidding, contract award, and payment processes, are transparently stored and immutable. This reduces opportunities for corruption, enhances the accuracy of procurement records, and allows citizens to track the procurement process in real-time.

5.2 United Arab Emirates (UAE): Dubai Blockchain Strategy

The UAE has launched an ambitious initiative to become the first government in the world to conduct all its transactions on a blockchain platform by 2024. Under this strategy, Dubai has been exploring the use of blockchain for public procurement processes. The Dubai government’s Procurement Department has partnered with various stakeholders to experiment with blockchain applications in procurement management. The aim is to create a more efficient, secure, and transparent procurement system by leveraging blockchain to track contract execution, monitor supplier performance, and ensure accountability in the bidding and payment processes. Through this initiative, the UAE hopes to eliminate paper-based processes, reduce delays, and increase stakeholder trust.

5.3 Sierra Leone: Blockchain for Transparency in Procurement

In 2018, Sierra Leone became the first country in the world to use blockchain technology for its election process. Building on this success, the government has begun integrating blockchain into its procurement system to combat corruption and enhance transparency. With the support of international organizations like the World Bank, Sierra Leone has been piloting

the use of blockchain to track procurement contracts and ensure public access to procurement data. By utilizing blockchain, the government aims to create an immutable, transparent record of all procurement-related activities. This provides an audit trail that stakeholders can verify, ensuring that procurement processes are fair, transparent, and less prone to corruption.

5.4 Georgia: Blockchain for Land Registry and Procurement

Georgia has been another early adopter of blockchain technology, particularly in its land registry system. The government has also begun exploring blockchain in the procurement process, aiming to enhance transparency and reduce bureaucracy in the tendering process. Blockchain technology allows Georgian officials to securely track the entire lifecycle of procurement contracts, from the bidding process through to contract fulfillment. By creating a decentralized and tamper-proof record of all transactions, Georgia aims to make the procurement system more efficient and ensure that public contracts are awarded fairly.

5.5 South Korea: Blockchain for Supply Chain and Procurement

South Korea has implemented blockchain technology in various sectors, including supply chain management and procurement. In 2018, the South Korean government began testing blockchain applications in the procurement of raw materials and goods for public institutions. The government uses blockchain to increase transparency, minimize fraudulent activities, and ensure that public institutions make procurement decisions based on verified data. South Korea is also exploring blockchain to optimize government contracts by ensuring that performance standards are met and that the delivery of goods and services is closely monitored.

5.6 Supply Chain Consortiums: VeChain and Walmart

In the private sector, companies like VeChain have implemented blockchain for supply chain and procurement management. VeChain works with various businesses, including Walmart China, to trace the origin of products and ensure the quality and authenticity of goods in the supply chain. Walmart uses VeChain's blockchain to track the journey of food products, which helps improve procurement by ensuring that only high-quality, compliant products are sourced. The use of blockchain allows Walmart to track every step of the procurement process, from supplier to shelf, ensuring quality control and reducing fraud.

5.7 The World Bank: Blockchain for Public Procurement

The World Bank has been exploring blockchain solutions to improve public procurement practices in developing countries. In partnership with various governments, the World Bank has supported the implementation of blockchain pilots to improve transparency, reduce corruption, and enhance accountability. In countries like Georgia and Kenya, the World Bank has worked to implement blockchain solutions to create more transparent procurement processes. By providing a decentralized ledger that can be accessed by both the government and the public, the World Bank aims to increase trust in public procurement systems and reduce the scope for mismanagement or fraud.

These case studies show that blockchain-based procurement systems can be an effective tool to improve transparency, reduce corruption, and enhance the efficiency of procurement processes. Countries such as Estonia, the UAE, Sierra Leone, and South Korea, among others, have adopted blockchain in various stages of their procurement processes with positive results. These international examples offer valuable lessons and insights that can help other countries, including Bangladesh, consider integrating blockchain solutions into their public procurement systems.

Chapter 6

Hypothetical Model incorporating smart contract management

6.1 Block creation model

Creating a blockchain block for a procurement process involves understanding both blockchain structure and how procurement activities can be represented in a decentralized, secure, and transparent way. The block creation model refers to the process by which new blocks are added to a distributed ledger system, particularly in blockchain technology. This process involves several steps:

Transaction Validation: Before a block is created, transactions within the network must be validated to ensure they meet certain criteria, such as authenticity, correctness, and the absence of double-spending (Zhang and Wang, 2023).

Block Formation: Once transactions are validated, they are grouped together into a block. This block contains a list of verified transactions, a timestamp, and a reference to the previous block (the parent block), creating a chain structure (Swan, 2024).

Proof of Work/Proof of Stake: The creation of a new block often requires a consensus mechanism. In Proof of Work (PoW), miners must solve complex mathematical problems to create a valid block (Nakamoto, 2023). In Proof of Stake (PoS), validators are chosen to create a block based on the amount of cryptocurrency they hold and are willing to "stake" as collateral (Mohan et al., 2024).

Block Addition: Once consensus is reached, the new block is added to the blockchain, becoming immutable and visible to all participants in the network. This process ensures transparency and security, as altering any data in the block would require recalculating the subsequent blocks (Wang and Li, 2024).

These steps ensure that blocks are added in a secure, transparent, and decentralized manner, maintaining the integrity of the blockchain.

6.1.1 Understanding the process in procurement

In procurement, the process typically includes steps such as:

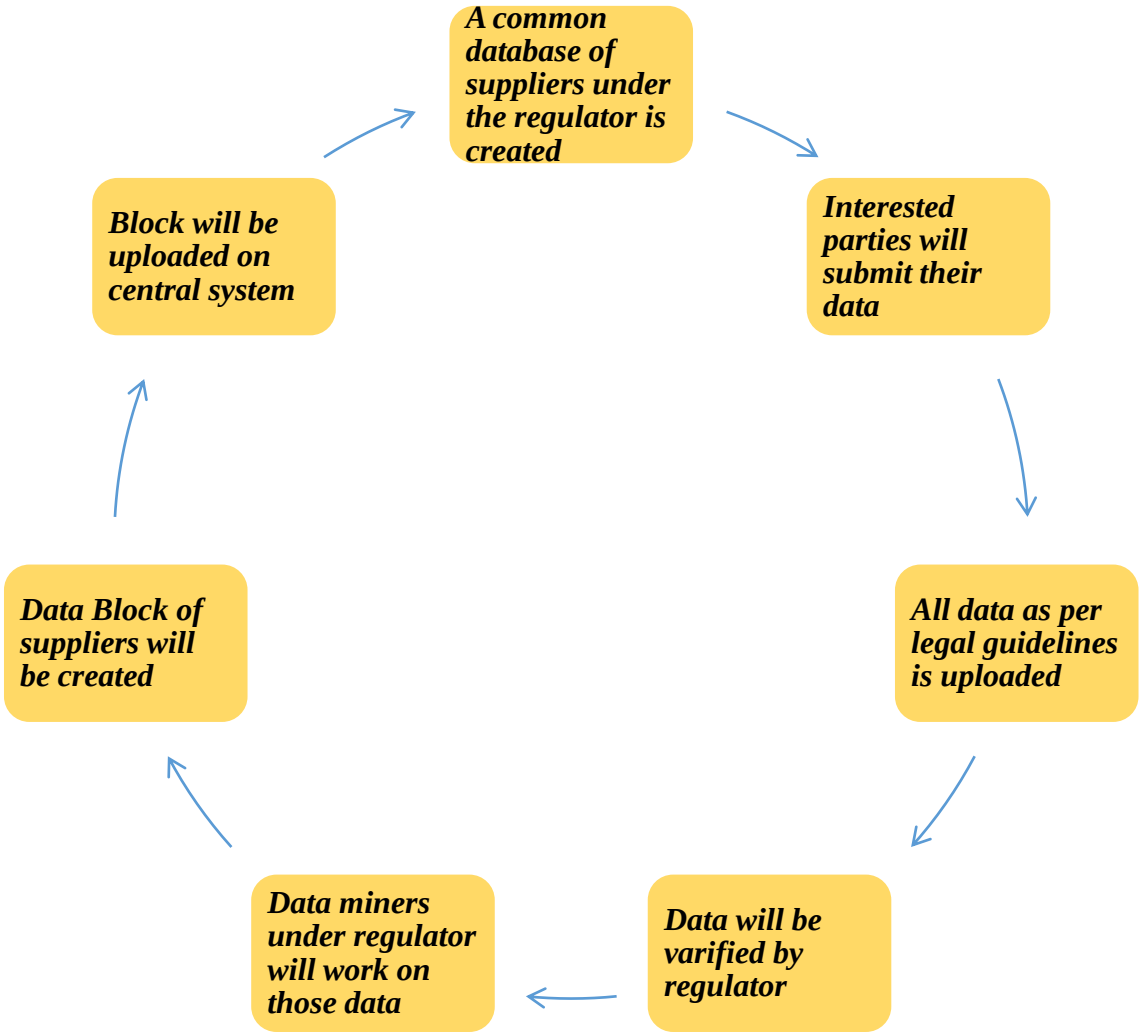

Figure 2: Incorporating Blockchain in Procurement Process

Procurement Process includes these steps:

Request for Tender: A formal request for bids from suppliers.

Supplier Selection: Choosing a supplier based on criteria.

Purchase Order (PO): A formal contract that specifies what is being purchased.

Receiving Goods or Services: Verification and receipt of goods/services.

Invoice and Payment: Payment for the goods or services rendered.

Each of these stages has different pieces of data that could benefit from blockchain's features, such as traceability, transparency, and security.

6.1.2 Define the Blockchain Block Structure

A blockchain block typically contains:

Block Header: Metadata about the block itself (e.g., block hash, timestamp, previous block hash).

Transaction Data: Information regarding the transaction that the block is recording. This is the data part.

For a procurement process, the block structure could look something like this:

Block Hash: A unique identifier for the block.

Timestamp: The time when the block is created.

Previous Block Hash: The hash of the previous block, which links blocks together and ensures immutability.

Block Number: A sequential identifier for each block in the blockchain.

Procurement ID: A unique identifier for the procurement process.

Supplier Information: Name, contact, and identification details of the supplier.

Goods/Services Ordered: Description, quantity, and cost of the items being procured.

Purchase Order (PO) Number: A reference to the formal purchase order.

Tender Data: Information related to the Tender, including submission date, accepted bid, and conditions.

Receipt Confirmation: Verification of the receipt of goods or services.

Invoice Data: Details of the invoice submitted by the supplier.

Payment Status: Information on whether the payment has been processed and details of the transaction.

6.1.3 Create Blockchain Smart Contracts for Procurement

Smart contracts are self-executing contracts with the terms directly written into code. These can automate actions in the procurement process, such as:

Contract Creation: Automatically generating a purchase order when a supplier is selected.

Invoice Verification: Verifying and matching invoices with delivery receipts and purchase orders before releasing payment.

Payment Release: Releasing payment to the supplier once all conditions are met (e.g., goods received, invoice validated).

For instance, you could write a smart contract to verify that an order is fulfilled before releasing a payment. The blockchain would automatically check if goods have been delivered and an invoice matched with the purchase order.

6.1.4 Implement Consensus Mechanism

To ensure that all parties (e.g., buyers, suppliers, third-party auditors) agree on the state of the procurement transaction, you need to implement a consensus mechanism. This could be:

Proof of Authority (PoA): A suitable choice where trusted entities (e.g., corporate officers or procurement managers) validate blocks.

Proof of Stake (PoS): Participants who have a stake in the process (e.g., verified suppliers or buyers) are involved in consensus.

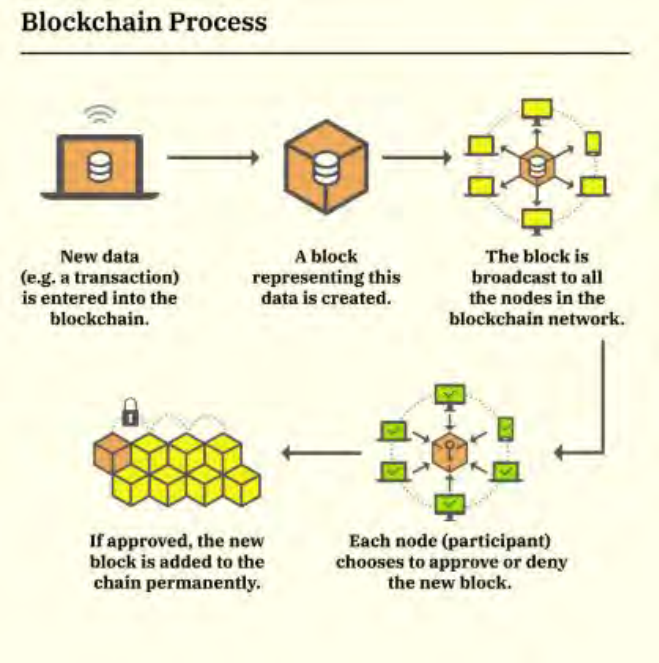

Figure 3: Block Chain Process

6.1.5 Blockchain Storage

Each time a procurement transaction (e.g., purchase order, invoice) is added to the blockchain, the details get stored in a block. The data is immutable, meaning once a transaction is recorded, it cannot be changed, which prevents fraud and maintains data integrity. You should also make sure to store only essential and non-sensitive data directly on the blockchain. Larger documents (e.g., purchase orders, invoices) can be stored off-chain with a reference (e.g., a hash or IPFS link) on-chain.

6.1.6 Integration with Procurement Systems

Blockchain implementation needs to integrate with existing procurement systems. APIs or middleware can facilitate this integration, allowing for seamless data flow between the blockchain and other procurement tools (e.g., ERP systems).

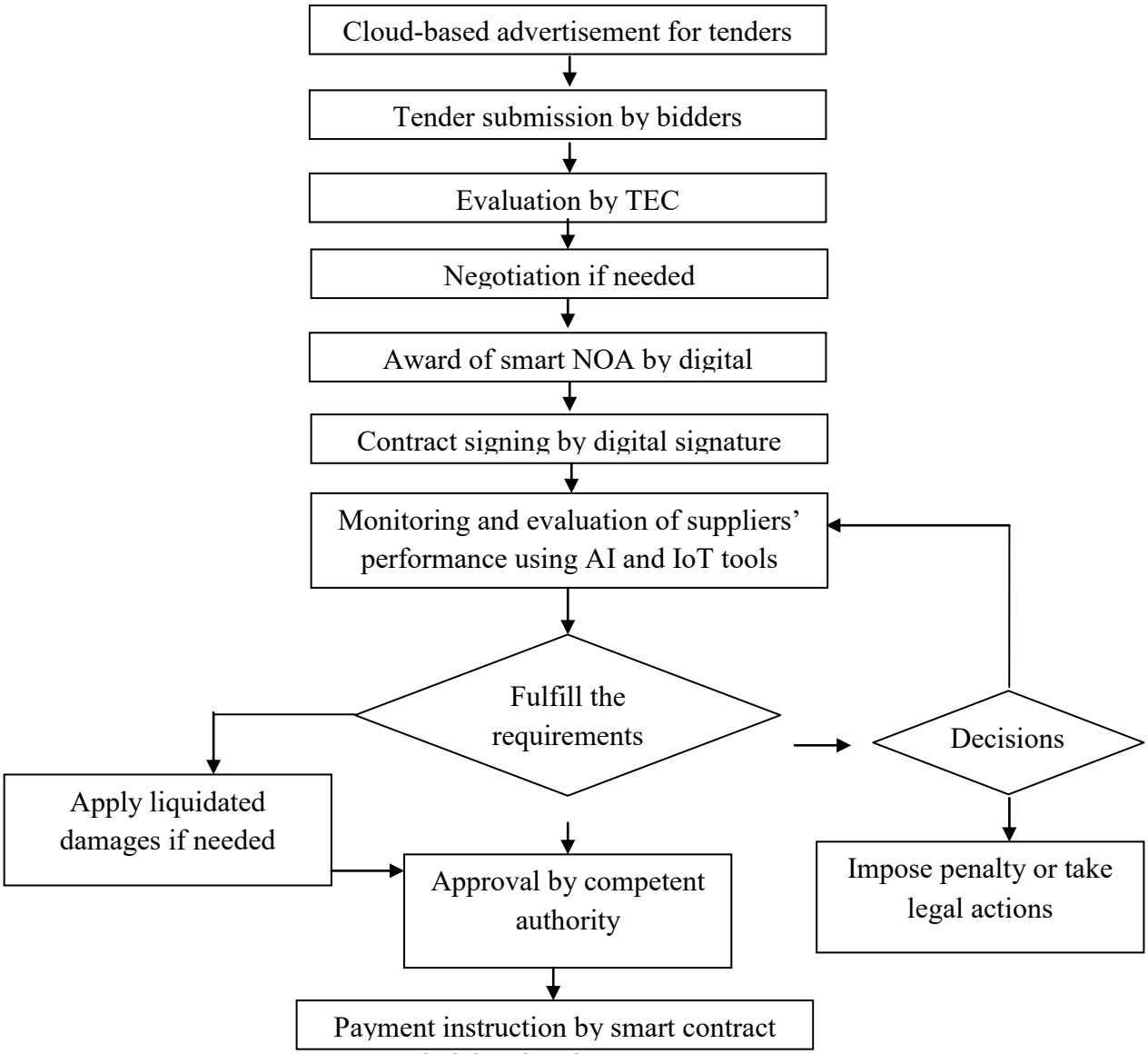

Figure 4: Blockchain based procurement ecosystem

6.2 How Does a Smart Contract Work?

A **smart contract** is a self-executing contract where the terms of the agreement are written directly into code. It runs on a blockchain network, which ensures that once the conditions are met, the contract will automatically execute without needing intermediaries. Smart contracts enable secure, transparent, and automated agreements between parties. The code is stored and replicated on the blockchain, ensuring its immutability and security. A smart contract is a self-executing contract with the terms of the agreement directly written into

code, running on a blockchain or distributed ledger. It automatically enforces and executes the agreed-upon actions when predefined conditions are met, without requiring intermediaries (Tapscott and Tapscott, 2023).

The process works as follows:

Code and Conditions: A smart contract is coded with specific rules and conditions. For example, it could state that if a payment is made to a certain address, then the ownership of a digital asset will transfer automatically to the buyer (Buterin, 2023).

Deployment on Blockchain: The contract is deployed on a blockchain network, which ensures that it is immutable and tamper-resistant. Once the contract is live, it is distributed across all nodes in the network, and every participant has access to its execution (Narayanan et al., 2024).

Execution and Verification: When the agreed-upon conditions are met, the smart contract automatically executes the corresponding action. For example, if the contract specifies a transfer of funds upon completion of a service, the contract will initiate the transaction and update the ledger without human intervention (Zohar and Kogan, 2023).

Transparency and Security: Since smart contracts are deployed on blockchain networks, they are transparent, secure, and irreversible. The blockchain's consensus mechanism ensures that once the contract's conditions are met and the contract is executed, it cannot be altered or tampered with (Miller et al., 2023).

Smart contracts are increasingly used in various sectors, including finance, supply chain management, and legal services, due to their ability to reduce administrative overhead, increase efficiency, and ensure trustless transactions (Schatsky and Muraskin, 2024).

6.2.1 Define the Terms of the Agreement

Before the smart contract can execute, the participants (or developers) need to define the rules and conditions of the contract. This is done in the form of code (written in programming languages like Solidity for Ethereum, Chaincode for Hyperledger, etc.).

For example:

- **Buyer and Supplier Agreement**: A contract where the supplier agrees to deliver goods to the buyer after receiving payment. The payment is only processed after the goods are confirmed to be delivered.

The contract's logic will specify what happens under certain conditions:

- If goods are delivered, release the payment.
- If the agreed terms are not met (e.g., the delivery is late), impose a penalty.

6.2.2 **Deploy the Contract on the Blockchain**

Once the contract is written, it's deployed on the blockchain network. This means the contract code is distributed across all the nodes in the network, ensuring that it is available, transparent, and tamper-proof. The deployment is usually done by a **smart contract creator** (could be a developer or a trusted authority in the system), and they will submit the contract to the blockchain.

6.2.3 **Interaction with the Smart Contract (Triggering the Contract)**

Smart contracts usually require **external input** or **events** to trigger their execution. These can come from users, other smart contracts, or external data feeds (called **oracles**). The contract remains dormant until the triggering conditions are met.

For example:

- **Payment Confirmation**: A buyer can send a transaction to the smart contract, informing it that a payment has been made.
- **Goods Receipt**: The supplier or buyer might send a signal to the smart contract that the goods have been delivered.

6.2.4 **Evaluate the Conditions (If-Then Logic)**

Once triggered, the smart contract evaluates whether the pre-defined conditions have been met. These conditions are written into the code as logic. If the conditions are true, the contract executes the agreed-upon action automatically.

For example:

- If the goods were received and the payment is confirmed, the contract might check if the payment matches the invoice value.
- If all conditions are met, the smart contract will trigger the next action (like transferring funds to the supplier).

This is often called the **"If-Then"** logic:

If the payment is confirmed **and** the goods are received, **then** release the payment.

6.2.5 **Execution of the Contract's Action**

If the conditions specified in the smart contract are satisfied, the contract automatically executes the specified action. Some common actions include:

- **Transferring Digital Assets**: The contract might transfer cryptocurrency or tokens (e.g., Ether on Ethereum) to the supplier's address.

- **Sending Notifications**: The contract can send an alert or notification to relevant parties (e.g., notifying the buyer that goods have been shipped).
- **Issuing Digital Certificates or Tokens**: In some use cases, smart contracts can generate or issue tokens representing ownership, rights, or access.

For example, once the delivery is confirmed:

- The contract will automatically transfer the payment from the buyer's account to the supplier's account.

6.2.6 **Completion and Recording on the Blockchain**

After the smart contract executes the action, the transaction (e.g., payment, delivery confirmation) is recorded on the blockchain. This ensures that the action is immutable and transparent; meaning everyone in the network can verify that the contract's terms were fulfilled.

The transaction is stored in a **block**, and the block is appended to the blockchain. This guarantees that the contract's execution is auditable and cannot be tampered with.

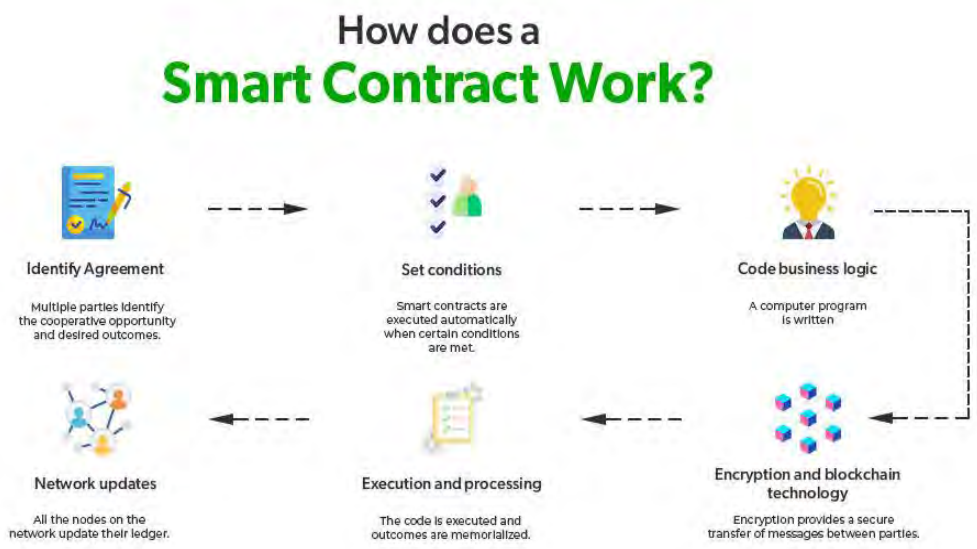

Figure 5: Smart contract ecosystem

Chapter 7

Examine the proposed process and compare efficiency and outcomes

To evaluate the efficiency of **smart contract management** in the **public procurement process** in Bangladesh, we need to consider how the proposed blockchain-based smart contract system would apply to existing practices. The comparison will address the potential benefits and challenges in terms of efficiency, transparency, security, and scalability within the context of Bangladesh's procurement environment.

7.1 Current State of Public Procurement in Bangladesh

The procurement process in Bangladesh, especially in public sector projects, typically involves several manual and bureaucratic steps:

1. **Request for Proposals (RFP)**: Public institutions invite bids for goods, services, or infrastructure projects.
2. **Tender Submission**: Suppliers or contractors submit bids, including pricing, terms, and conditions.
3. **Evaluation and Awarding**: A team reviews the bids based on set criteria (price, qualifications, etc.).
4. **Contract Signing**: Once a bidder is selected, a formal contract is signed.
5. **Project Execution**: Goods/services are delivered according to the contract terms.
6. **Payment Processing**: After successful delivery and verification, payment is made.

However, there are challenges within this traditional system:

- **Corruption and Mismanagement**: There is a significant risk of bribery, fraud, and inefficiency.
- **Delayed Payments**: Payments are often delayed due to administrative bottlenecks.
- **Lack of Transparency**: Stakeholders may not have real-time visibility into the procurement process.
- **Paper-based Processes**: Documentation is typically paper-based, which can be time-consuming and error-prone.

7.2 How Smart Contracts Can Improve Efficiency in Public Procurement

The introduction of **smart contracts** powered by blockchain technology offers potential improvements across several areas of the procurement process. Smart contracts have the potential to significantly improve efficiency in public procurement by automating processes,

enhancing transparency, and reducing administrative overhead. Here's how they can be beneficial:

1. **Automation of Contract Execution**: Smart contracts can automatically execute procurement agreements once predefined conditions are met. For example, when a government department receives goods or services, the contract could automatically trigger payment, eliminating the need for manual processing and approval, thus speeding up the procurement process (Amin et al., 2023). This reduces delays and errors associated with traditional methods (Miller and Zhang, 2024).
2. **Transparency and Traceability**: By deploying smart contracts on a blockchain, all contract details, including terms, conditions, and transactions, are publicly recorded on an immutable ledger. This increases transparency in procurement processes and ensures that all parties have access to the same information, which helps prevent fraud and corruption (Johnson and Miller, 2024). Additionally, each transaction is traceable, which makes it easier to track the progress and status of public procurement projects (Choi et al., 2023).
3. **Reduction of Costs and Intermediaries**: Traditional procurement often involves multiple intermediaries, such as legal professionals and auditors, to ensure compliance and validate transactions. Smart contracts can replace these intermediaries by automating verification and compliance checks, thus reducing the associated costs and time delays (O'Reilly and Li, 2023). This makes the procurement process more cost-effective and streamlined (Rahman and Singh, 2024).
4. **Improved Compliance and Risk Management**: Smart contracts can be programmed with compliance rules and regulations, ensuring that all procurement activities adhere to legal and policy requirements. The automation of compliance checks minimizes human error and the risk of non-compliance, providing more reliable and predictable outcomes (Patel et al., 2024).
5. **Efficient Payments and Dispute Resolution**: Smart contracts can include provisions for automatic payments upon completion of milestones. This reduces payment delays and the potential for disputes between suppliers and procuring entities. Moreover, any disputes can be resolved faster as all the conditions and transactions are securely stored on the blockchain, offering clear evidence (Singh and Mohan, 2023).

By leveraging smart contracts, public procurement systems can become more efficient, transparent, and accountable, leading to significant improvements in both the speed and quality of government spending and project execution (Lee et al., 2023).

7.2.1 Automation and Speed

Traditional Process: The traditional procurement process is often slow due to manual verification, paperwork, and multiple layers of approval.

Smart Contract Advantage:

- Smart contracts can automate many aspects of procurement. For example, **payment releases** can be automated once conditions (such as goods delivery or work completion) are met.
- Contracts can be automatically executed once pre-agreed conditions are verified, reducing the need for intermediaries, minimizing delays, and speeding up the process.

Efficiency Comparison: With automation, tasks that would normally take days or weeks (e.g., contract execution, payment release, compliance checks) can be completed in a matter of hours or even minutes.

7.2.2 Transparency and Accountability

Traditional Process: Transparency in Bangladesh's public procurement is a significant concern. Public tenders are often subject to corruption and lack of clarity in decision-making processes. Stakeholders, including taxpayers, are often unaware of procurement details until contracts are awarded.

Smart Contract Advantage:

- Blockchain's inherent **transparency** ensures that all actions (such as contract signing, delivery verification and payment processing) are recorded on a **public ledger**, visible to all participants and auditors.
- The **immutability** of blockchain ensures that once a transaction is recorded, it cannot be altered, which increases accountability and reduces opportunities for fraud.

Efficiency Comparison: The smart contract system would provide real-time access to procurement data for all stakeholders, reducing opportunities for corruption and enhancing the credibility of the procurement process.

7.2.3 Security and Integrity

Traditional Process: Paper-based systems and even electronic systems are prone to **data manipulation**, **fraud**, and **tampering** due to lack of secure data management mechanisms.

Smart Contract Advantage:

- Blockchain-based smart contracts offer **strong encryption** and **decentralized** storage of contract data, which makes tampering with the records much harder.

- With **cryptographic signatures** and consensus mechanisms, all actions in the contract process are verifiable and protected from unauthorized changes.

Efficiency Comparison: The security of blockchain technology will significantly reduce the risk of fraud or tampering, thereby ensuring that contracts are executed exactly as agreed upon.

7.2.4 Cost Efficiency

Traditional Process: Traditional procurement involves many **intermediaries**, such as legal advisors, auditors, and government officials, all of whom increase the costs of procurement. Additionally, manual processes for auditing and contract enforcement are resource-intensive.

Smart Contract Advantage:

- By **automating tasks**, smart contracts can drastically reduce the need for intermediaries, thereby **cutting costs** related to personnel, legal fees, and administrative overhead.
- **Auditability**: Auditors and stakeholders can easily access the blockchain to verify contracts and payments, reducing the need for manual auditing and oversight, which is often time-consuming and expensive.

Efficiency Comparison: The reduced reliance on intermediaries and the automation of tasks will lead to direct cost savings in public procurement.

7.2.5 Dispute Resolution

Traditional Process: Disputes in procurement often arise due to delays, misunderstanding of contract terms, or misreporting of deliveries. Resolving these disputes can be lengthy and require legal intervention.

Smart Contract Advantage:

- Smart contracts can provide **clear, immutable records** of all transactions, which can help resolve disputes quickly by serving as indisputable evidence.
- In cases of non-compliance (e.g., late delivery), the contract can automatically **trigger penalties or actions** defined in the contract (e.g., withholding payment, triggering late fees).

Efficiency Comparison: Automated dispute resolution and predefined conditions (e.g., penalties, actions) significantly reduce the time and effort required for resolving procurement-related issues.

In terms of **efficiency**, the integration of smart contracts into the public procurement process in Bangladesh could potentially transform the system by:

1. **Reducing administrative delays** and speeding up the execution of contracts.
2. **Increasing transparency** which would reduce corruption and increase trust among all stakeholders.
3. **Enhancing security**, making it harder for fraudulent activities to take place.
4. **Lowering costs** through automation and reducing reliance on intermediaries.
5. **Improving dispute resolution** by having clear, immutable records.

However, the **successful implementation** of smart contracts depends on addressing challenges like **digital infrastructure**, **legal reforms**, and **training** to ensure that stakeholders are equipped to participate in the blockchain-powered procurement process. Therefore, while the efficiency gains are significant, they require a holistic approach to ensure smooth integration into Bangladesh's public procurement system.

Chapter 8

Survey on Smart Contract Management using blockchain within Bangladesh

The procurement sector in Bangladesh, like many other developing economies, is undergoing a digital transformation to streamline its processes, reduce inefficiencies, and combat issues such as fraud and corruption. One such innovation that has garnered significant attention worldwide is **smart contracts** powered by **blockchain technology**. Smart contracts are self-executing contracts where the terms of agreement between buyer and seller are directly written into code. They automatically execute actions when predefined conditions are met, ensuring transparency, accuracy, and security without relying on intermediaries.

This survey aims to explore the awareness, challenges, adoption, and perceived benefits of **smart contract technology** in the procurement processes within Bangladesh. As the procurement landscape becomes more complex and organizations strive to improve their operational efficiencies, the role of **blockchain and smart contracts** presents an opportunity to modernize and address key issues such as trust, fraud, and delays in traditional procurement systems.

The findings of this survey will provide valuable insights into the **current state of smart contract adoption**, the **barriers to implementation**, and the **potential impact** on procurement practices in Bangladesh. It aims to gather input from professionals directly involved in procurement management, such as procurement managers, legal advisors, and IT specialists, in both the **private and public sectors**. The survey will also assess the level of **technological readiness**, the **legal framework**, and the **perceived benefits** of smart contracts, ultimately offering a glimpse into how organizations in Bangladesh view the potential integration of this emerging technology into their procurement operations.

In addition to gathering baseline information on adoption rates and challenges, the survey will also explore broader issues such as **government support**, **regulatory frameworks**, and the **skills gap** necessary for successful implementation. By identifying these factors, the survey seeks to foster a clearer understanding of the steps required to overcome the barriers to adoption and pave the way for a more efficient, secure, and transparent procurement system in Bangladesh.

Result of the survey:

A questionnaire of 20 questions has been made and responses from 30 procurement professionals of public, private and other sectors has been recorded by google form has been given in the annexure. The result and analysis of the survey has been incorporated below:

1. Demographics and Familiarity with Smart Contracts

Survey responses indicate a diverse representation of procurement professionals, including government officials (80%), private sector procurement specialists (10%), and suppliers/vendors (3.3%). The majority of respondents (83.3%) work in large organizations, while medium (6.7%) and small enterprises (10%) constitute the remainder. Regarding familiarity with smart contracts, 63.3% of respondents claim to have a basic understanding, 6.7% are highly knowledgeable, and 30% have little to no familiarity. This suggests a need for educational initiatives to bridge the knowledge gap.

2. Limited Experience with Smart Contracts

A significant portion of respondents (90%) have never implemented smart contracts in their procurement processes. This demonstrates that while there is awareness of the technology, actual application is still in the early stages. This may be due to the relative novelty of blockchain technology in Bangladesh, as well as the perceived complexity of integrating it with traditional procurement systems.

3. Current Procurement Challenges

Respondents highlighted several challenges in traditional procurement, with 70% citing manual processing delays as a major issue. Transparency concerns (70%) and fraud risks (50%) were also prevalent. Other challenges included contract enforcement difficulties (50%). These findings suggest that inefficiencies and lack of trust are significant barriers in the current procurement system, making a strong case for exploring smart contract solutions.

4. Perceived Benefits of Smart Contracts

Among the benefits of smart contracts, respondents emphasized improved transparency (90%), faster contract execution (80%), and reduced disputes (56.7%). Additionally, 53.3% believe that automation can lead to cost reductions in procurement operations. These responses indicate a positive perception of smart contracts' potential to streamline procurement processes and enhance accountability.

5. Areas Most Suitable for Smart Contract Implementation

The survey identified the following procurement processes as most suitable for smart contract integration:

- **Bid Evaluation & Supplier Selection (30%)**: Automating bid assessments can reduce favoritism and enhance fairness.
- **Contract Enforcement & Compliance (30%)**: Smart contracts can ensure compliance by executing terms automatically upon fulfillment.
- **Performance Monitoring & Dispute Resolution (20%)**: Transparent, blockchain-based monitoring can minimize disputes and enforce accountability.

6. Barriers to Smart Contract Adoption

Despite the perceived benefits, several barriers were identified:

- **Lack of Awareness & Expertise (60%)**: A key challenge in Bangladesh, requiring targeted training programs.
- **Resistance to Technology Adoption (20%)**: Traditional procurement practices and reluctance to embrace digital solutions pose additional challenges.

7. Legal & Regulatory Concerns

When asked about the adequacy of Bangladesh's legal framework for smart contracts, only 16.7% of respondents believe it fully supports implementation, while 36.7% consider it partially supportive, and 46.7% feel there is no legal clarity.

Legal concerns include:

- **Legality & Enforceability (33.3%)**: Questions on whether smart contracts are legally binding in Bangladeshi courts.
- **Data Privacy & Security (36.7%)**: Risks of unauthorized access and cyber threats.
- **Government Procurement Compliance (23.3%)**: Uncertainty on how smart contracts align with e-GP (Electronic Government Procurement) regulations.

These findings highlight the need for updated regulations to support the adoption of blockchain-based contracts.

8. Security Risks and Infrastructure Readiness

While 13.3% of respondents reported some level of blockchain infrastructure in their organizations, 86.7% had no existing systems. Cybersecurity was a major concern, with 56.7% of participants worried about hacking risks and 33.3% concerned about coding errors

in smart contracts. These insights suggest that investment in cybersecurity frameworks and robust blockchain systems is necessary before large-scale adoption.

9. Future Adoption and Policy Recommendations

Respondents were divided on the timeline for smart contract adoption:

- **3-5 Years (20%)**: The majority see a mid-term adoption timeline, dependent on regulatory advancements.
- **More than 5 Years (80%)**: Skeptics believe the transition will be slow due to structural challenges.

To accelerate adoption, survey participants recommended:

- **Clear Legal & Regulatory Framework (70%)**: Government-led legal reforms to establish the validity of smart contracts.
- **Pilot Projects (80%)**: Public-private partnerships to test smart contract implementation in selected procurement cases.
- **Training & Capacity Building (83.3%)**: Workshops and certification programs to educate procurement professionals.
- **Financial Incentives (53.3%)**: Government subsidies or tax incentives to encourage blockchain investment.

The survey findings indicate strong interest in smart contract management in procurement but highlight several barriers that must be addressed. Awareness campaigns, legal reforms, and infrastructure investments are essential for successful adoption in Bangladesh. By overcoming these challenges, smart contracts can revolutionize procurement, ensuring efficiency, transparency, and trust in the system. The next steps involve collaboration between government bodies, private sector stakeholders, and technology providers to facilitate a smooth transition towards blockchain-enabled procurement in Bangladesh. A strategic roadmap is essential to address the challenges and leverage the benefits of smart contracts. With the right policy support, technological investments, and education, Bangladesh can position itself as a leader in innovative procurement practices, ensuring sustainable economic growth and development.

Chapter 9

Findings of the thesis

The thesis reveals both the potential and challenges of implementing smart contracts and blockchain technology in Bangladesh. While there is growing interest in these technologies, the adoption rate remains slow due to limited awareness, regulatory uncertainty, and technological barriers. The research highlights that sectors like finance, agriculture, and public governance stand to benefit significantly from smart contract implementation, offering improvements in efficiency, transparency, and security. However, the lack of a clear legal framework, infrastructure limitations, and societal trust issues pose significant hurdles. These findings provide valuable insights into the opportunities and obstacles facing Bangladesh in adopting blockchain solutions, with recommendations for overcoming these challenges and promoting wider adoption. Some major findings are:

1. Awareness and Adoption of Smart Contracts in Bangladesh

- **Limited Awareness**: A significant portion of businesses and government sectors in Bangladesh still lack awareness about smart contracts and distributed ledger systems (DLTs) like blockchain. Despite this, a growing interest in blockchain technology has been noted, especially in sectors such as finance and supply chain.
- **Slow Adoption**: While large corporations and tech startups in urban areas like Dhaka are exploring blockchain, the general adoption in smaller businesses or rural areas is slow. The lack of education and training in blockchain technology has impeded the adoption rate.

2. Legal and Regulatory Challenges

- **Absence of Legal Framework**: Bangladesh lacks a dedicated legal framework for the use of blockchain and smart contracts. This absence creates uncertainty regarding the enforceability of contracts executed on a blockchain. While the Digital Security Act, 2018, touches upon digital data security, it does not directly address blockchain or smart contracts.
- **Regulatory Overlap and Confusion**: The regulatory bodies in Bangladesh are still learning about blockchain technology, leading to confusion and overlap in jurisdictional authority. This presents a barrier to the widespread implementation of smart contracts in the country.

3. Technological Barriers

- **Infrastructure Limitations**: The existing technological infrastructure in Bangladesh is not fully prepared to support large-scale deployment of distributed ledger systems. Issues like internet connectivity, particularly in rural areas, and inadequate technological support for decentralized systems create obstacles to widespread adoption.
- **Security Concerns**: Although blockchain is considered secure, there is a lack of trust in decentralized systems due to concerns over data privacy and security. Security vulnerabilities in smart contract code, including hacking incidents from other countries, further increase skepticism.

4. Impact on Financial Sector

- **Efficiency in Transactions**: Smart contracts could significantly enhance the efficiency of financial transactions, particularly in remittances. With Bangladesh being one of the highest recipients of remittances globally, using blockchain could streamline remittance transfers, reduce costs, and increase transaction speed.
- **Financial Inclusion**: The use of distributed ledger systems could enhance financial inclusion by providing secure, transparent, and accessible services to the unbanked population, especially in rural areas where traditional banking infrastructure is limited.

5. Potential in Supply Chain and Agriculture

- **Agriculture Supply Chain**: Bangladesh's agriculture sector could benefit from blockchain-based smart contracts. By tracking the entire supply chain from farm to market, smart contracts can ensure transparency, reduce fraud, and improve efficiency. This could lead to fairer pricing and ensure that producers are paid fairly and on time.
- **Transparency and Traceability**: The implementation of DLT in supply chains could improve the traceability of goods and services, offering transparency in how products move through the economy. In particular, industries like tea, jute, and textiles could greatly benefit from smart contracts by proving the authenticity and ethical sourcing of their products.

6. Opportunities for Government and Public Sector

- **Smart Governance**: Smart contracts could revolutionize public sector services, such as land registry, contract management, and public procurement. The transparency provided by DLT can reduce corruption and increase accountability in government transactions.
- **Public Sector Collaboration**: Collaborations between the government, blockchain startups, and international organizations could create a framework for public-private partnerships, leading to more widespread use of blockchain technologies in Bangladesh.

7. Cultural and Societal Challenges

- **Trust and Perception**: While there is a growing interest in technology, traditional practices and skepticism towards new systems pose challenges. People are more inclined to trust traditional paper-based contracts and official institutions rather than the autonomous and decentralized nature of smart contracts.
- **Digital Literacy**: A significant portion of the population, especially in rural areas, lacks the digital literacy needed to understand and utilize blockchain technology, which is a major barrier to adoption.

8. Future Prospects and Recommendations

- **Education and Awareness**: To bridge the knowledge gap, educational programs and workshops should be developed, targeting business owners, policymakers, and the general public. Universities can play a key role in promoting blockchain education.
- **Regulatory Support**: The government of Bangladesh should consider introducing a legal and regulatory framework that recognizes blockchain-based smart contracts and establishes clear guidelines for their use.
- **Incentives for Adoption**: Incentive structures, such as tax breaks or subsidies for companies investing in blockchain technology, can encourage adoption, particularly among SMEs (Small and Medium Enterprises).
- **Focus on Pilot Projects**: Government and private sectors should collaborate to run pilot projects in high-impact areas like finance, agriculture, and supply chain management to test the feasibility and benefits of smart contract deployment.

Chapter 10

Limitation for implementing smart contract management in Bangladesh

Implementing **smart contract management** in Bangladesh's public procurement system, while offering significant potential benefits, also faces several **limitations** that could hinder its full-scale adoption. These limitations stem from **technological, legal, social, and infrastructural factors** that may challenge the transition from traditional procurement systems to blockchain-based smart contracts. Below are the key limitations:

1. Limited Technological Infrastructure

- **Lack of Robust Digital Infrastructure**: While Bangladesh has made progress in digital transformation, the country still faces challenges in terms of widespread **internet connectivity**, **data centers**, and **reliable electricity supply**. In rural areas or for certain government departments, consistent access to the technology required for blockchain systems might be limited.
- **Low Access to Modern Technology**: Many governmental institutions and smaller contractors or suppliers may lack access to the necessary technology (e.g., **blockchain platforms**, **smart devices**) or the capability to implement or interact with blockchain-based systems.

2. Digital Literacy and Awareness

- **Skill Gaps**: A significant proportion of government officials, contractors, and suppliers may not have the required knowledge or skills to understand or use blockchain-based systems. **Digital literacy** among procurement officers and other key stakeholders could be a major barrier to implementing smart contracts.
- **Resistance to Change**: People accustomed to manual or legacy systems may resist adopting new technologies, especially in bureaucratic settings where tradition and manual oversight have been entrenched for decades.

3. Legal and Regulatory Challenges

- **Absence of Clear Legal Framework**: Bangladesh's existing legal frameworks may not fully support the use of **smart contracts** or **blockchain technology**. Laws related to **digital signatures**, **electronic contracts**, and **automated contract enforcement** would need to be updated or introduced to accommodate blockchain-based contracts.

- **Legal Recognition of Blockchain Records**: In many jurisdictions, including Bangladesh, **blockchain records** (such as data in a smart contract) might not yet be recognized as **legally binding** in a court of law. There may be challenges in **dispute resolution**, **enforcement of automated penalties**, or **contract execution** if there's no clear legal framework for blockchain transactions.
- **Regulatory Compliance**: Ensuring that smart contracts comply with **national procurement laws**, **anti-corruption regulations**, and **financial regulations** may require continuous oversight and potentially new regulatory bodies to monitor blockchain activity.

4. Data Privacy and Confidentiality Concerns

- **Public Disclosure of Sensitive Information**: While blockchain ensures transparency, the public nature of the **ledger** could lead to concerns about the confidentiality of sensitive procurement information, such as **bid prices**, **supplier information**, and **contract terms**. Striking a balance between **privacy** and **transparency** is a challenge.
- **Concerns About Data Security**: Although blockchain is considered secure, its decentralized nature might raise concerns about the **security of government data** in jurisdictions where the technology is new and untested at scale. There could be risks associated with the **protection of intellectual property**, **commercial confidentiality**, or **national security**.

5. Scalability and System Performance

- **Scalability Issues**: Blockchain systems, particularly public blockchains like **Ethereum**, may face **scalability challenges**. As the volume of procurement contracts increases, the network could become congested, leading to slower transaction processing times and higher costs.
- **High Energy Consumption**: Depending on the type of blockchain used, **energy consumption** could become a significant concern. Blockchain networks like **proof-of-work** blockchains consume large amounts of energy, which may not be sustainable or cost-effective in the long term for Bangladesh.
- **Transaction Fees**: Blockchain networks typically require **transaction fees** for executing smart contracts, which might add up, especially for large-scale public procurement projects involving multiple contracts and participants.

6. Integration with Existing Systems

- **Legacy Systems Compatibility**: Bangladesh's public procurement process currently relies on traditional, often paper-based, systems. Integrating **blockchain** with existing systems could be complex and time-consuming. The **interoperability** between legacy systems (such as **electronic procurement platforms**) and new blockchain systems will require significant resources for **data migration** and **system upgrades**.
- **Adoption by Stakeholders**: Not all stakeholders (especially small and medium-sized enterprises, or SMEs) might be ready to adopt blockchain-based smart contracts. Suppliers and contractors who are accustomed to traditional procurement systems may resist the change due to unfamiliarity or lack of resources to invest in new technologies.

7. Cost and Resource Constraints

- **Initial Setup Costs**: Establishing a blockchain infrastructure (e.g., setting up private or consortium blockchains, deploying smart contract management tools) can require significant upfront investment. **Hardware, software**, and **human resources** will need to be procured and trained, which may be a financial burden for both the government and contractors.
- **Ongoing Maintenance Costs**: Blockchain systems need to be continuously maintained and updated. This includes **system monitoring**, ensuring **network security**, and addressing bugs or vulnerabilities, which requires specialized personnel and resources. For Bangladesh, this could mean additional costs for government agencies already operating under tight budgets.

8. Trust Issues and Social Acceptance

- **Lack of Trust in Technology**: Although blockchain offers **security** and **transparency**, some stakeholders, particularly in **government institutions**, may not trust the technology due to its association with **cryptocurrencies** and lack of familiarity with decentralized systems.
- **Cultural and Institutional Barriers**: Government bureaucracies are often **resistant to change**. There could be concerns about **power dynamics**, **control over data**, and the fear of losing traditional oversight or authority. Moving to a decentralized, transparent system could be seen as undermining existing power structures or reducing personal influence over procurement processes.

9. Vulnerability to Misuse

- **Code Vulnerabilities**: While smart contracts are designed to execute automatically based on preset conditions, the **code** itself could be subject to errors, bugs, or exploits. Any flaws in the contract code could lead to unintended consequences, such as incorrect execution, payments to wrong parties, or penalties that are not aligned with the original contract terms.
- **Manipulation Risks**: If the smart contract's code is not properly audited, it might be manipulated by malicious actors. For instance, changes in the code or the introduction of bugs could lead to a manipulation of contract terms, affecting procurement outcomes.

10. Lack of Standardization

- **No Universal Blockchain Standards**: There is no widely adopted or standardized framework for smart contracts in the public procurement sector. This can result in fragmentation, where different government bodies or contractors use different platforms or blockchain technologies, leading to **compatibility issues** and **fragmented data** across multiple systems.
- **Varied Contract Formats**: Smart contracts need to be standardized in terms of their structure, terms, and execution logic to ensure consistent implementation across all procurement projects. Without uniform standards, adopting smart contracts for procurement at scale could be difficult.

Chapter 11

Recommendations

To successfully implement smart contracts in public procurement in Bangladesh, several key recommendations must be considered to ensure the technology is effectively integrated into the existing systems and delivers its full potential. These recommendations address both the technological and socio-legal challenges that may arise during the adoption of blockchain-based smart contracts.

1. **Develop a Comprehensive Legal Framework**

The government must establish clear legal provisions that recognize smart contracts as legally binding. Current laws may not fully support the use of blockchain technology in procurement, so updates or new legislation will be required to ensure the legal validity of smart contracts. This framework should address issues such as contract enforceability, dispute resolution mechanisms, and compliance with national procurement regulations, providing legal certainty to all stakeholders involved in the process.

2. **Strengthen Digital Infrastructure**

For smart contracts to function effectively, Bangladesh needs to improve its digital infrastructure, particularly internet access and the reliability of electronic systems. This includes ensuring high-speed internet availability in rural areas, as well as equipping procurement officers and contractors with the necessary hardware and software tools. Strengthening these technological foundations will allow for smoother implementation and operation of blockchain systems across the public procurement sector.

3. **Enhance Digital Literacy**

A significant barrier to the adoption of smart contracts in Bangladesh is the lack of digital literacy among key stakeholders, including government procurement officers, suppliers, and contractors. It is essential to launch widespread training programs that educate these groups on the functionality and benefits of smart contracts. This will increase trust in the technology, reduce resistance to change, and facilitate smoother implementation across all levels of government and the private sector.

4. **Pilot Projects and Phased Rollout**

Rather than attempting a nationwide rollout, Bangladesh should consider launching pilot projects to test smart contract implementation in select sectors or regions. A phased approach will help identify potential issues, refine the system, and gather feedback from users. This strategy will allow the government to make necessary adjustments before scaling up the

technology, ensuring the system's efficiency, reliability, and acceptance in the broader procurement landscape.

5. **Collaboration and Stakeholder Engagement**

Successful implementation of smart contracts requires the collaboration of multiple stakeholders, including government agencies, technology providers, legal experts, and the private sector. Engaging all relevant parties early on can ensure that the system is developed with input from a wide range of perspectives, creating a solution that meets the needs of all users. Additionally, ongoing dialogue will help build trust and resolve potential issues as they arise.

6. **Address Data Privacy and Security Concerns**

While blockchain offers transparency, it is crucial to ensure that sensitive procurement data, such as pricing details or supplier contracts, are protected from unauthorized access. Smart contracts should be designed with strong data encryption and privacy features to safeguard confidential information. A hybrid blockchain model, which combines the benefits of public and private blockchains, could be explored to provide transparency while maintaining privacy for certain sensitive data.

7. **Continuous Monitoring and Evaluation**

Once smart contracts are implemented; the government should establish a system for continuous monitoring and evaluation. Regular audits and assessments will help identify issues early on, ensure compliance with procurement standards, and measure the effectiveness of the technology in achieving its intended goals. This feedback loop will allow for ongoing improvements and adjustments to the system, ensuring it evolves alongside technological advancements and changing needs.

8. **Foster Public Awareness and Build Trust**

To encourage widespread adoption of smart contracts, the government must actively promote public awareness of the benefits of blockchain technology in procurement. This can include public information campaigns, transparency reports, and case studies demonstrating the success of smart contract implementations in other countries or sectors. Building public confidence in the system will be crucial for its success, as stakeholders need to understand the advantages and security features of the technology.

In conclusion, implementing smart contracts in Bangladesh's public procurement system holds significant potential for improving transparency, efficiency, and accountability. However, to achieve these benefits, the government must focus on building a solid legal and technological foundation, enhancing digital literacy, fostering collaboration, and addressing

privacy concerns. By following these recommendations, Bangladesh can pave the way for a modern, secure, and transparent procurement system that meets the needs of all stakeholders while contributing to better governance.

Chapter 12

Conclusion

The adoption of smart contracts in public procurement in Bangladesh offers significant potential for improving the efficiency, transparency, accountability, and cost-effectiveness of government operations. By automating key aspects of procurement, smart contracts can transform the way procurement processes are managed, making transactions faster, more secure, and transparent. This technology can drastically reduce procurement cycle times by automating processes such as contract execution, payment processing, and compliance verification, ultimately minimizing human errors and accelerating the overall process. Additionally, the transparency provided by blockchain ensures that all actions and contract details are publicly accessible, reducing the risk of corruption and improving public trust. This is particularly important in Bangladesh, where corruption and inefficiency in procurement have long been challenges.

Moreover, smart contracts can lead to significant cost savings by eliminating intermediaries, reducing administrative overhead, and ensuring better contract execution. This is especially relevant for Bangladesh, where public sector procurement often faces budgetary constraints and delays. Furthermore, the self-executing nature of smart contracts helps in managing risks more effectively by automatically enforcing terms and penalties when needed. This reduces the need for manual oversight and improves compliance with procurement rules, ensuring that suppliers meet their obligations and that any discrepancies are promptly addressed.

However, despite the promising benefits, several challenges must be addressed for successful implementation. One of the main challenges is Bangladesh's technological infrastructure. While the country has made significant progress in digital transformation, internet connectivity and reliable access to digital tools remain limited in some areas, particularly in rural regions. This could hinder the accessibility and effectiveness of blockchain-based systems. Moreover, the legal framework in Bangladesh currently lacks clear provisions to recognize and enforce smart contracts. There is a need to update existing laws or introduce new regulations to accommodate blockchain technology and ensure that smart contracts are legally binding.

Another challenge is the digital literacy gap. Many government officials, suppliers, and contractors may not be familiar with blockchain technology or smart contract systems. This lack of knowledge and familiarity could hinder widespread adoption. Resistance to change within government institutions, which are often slow to embrace new technologies, could also

pose a barrier to the adoption of smart contracts. This bureaucratic inertia may slow down the implementation process, especially in the early stages.

For smart contract management to be successful in Bangladesh's public procurement system, the government needs to focus on building the necessary technological infrastructure. Investments in digital infrastructure and efforts to improve internet access are crucial for ensuring the widespread accessibility of blockchain-based systems. At the same time, the government must develop a comprehensive legal framework that recognizes and governs smart contracts, ensuring their enforceability and legality. Furthermore, it is essential to engage stakeholders, including government officials, suppliers, and contractors, through awareness campaigns and training programs to enhance digital literacy and build trust in the technology. Finally, piloting the system through smaller-scale implementations or pilot projects can help identify potential challenges early and allow for a more gradual and manageable transition.

In conclusion, while the implementation of smart contracts in Bangladesh's public procurement system presents a number of challenges, the potential benefits of increased efficiency, reduced corruption, cost savings, and improved governance make it a worthwhile pursuit. With careful planning, investment in infrastructure, and the creation of a suitable legal framework, smart contracts could play a transformative role in reshaping the country's procurement practices and contribute to better governance and economic development.

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Annexure

Questionnaire for Survey on Smart Contract Management using blockchain within Bangladesh and summary responses

Dear Respondent,
This survey aims to assess the understanding, implementation, and challenges of smart contract management in procurement within Bangladesh. Your responses will be kept confidential and used solely for research purposes.

Section 1: General Information

1. What is your role in the procurement process?
    - a) Government official
    - b) Private sector procurement professional
    - c) Supplier/vendor
    - d) Other (please specify)
2. What is the size of your organization?
    - a) Small (1-50 employees)
    - b) Medium (51-200 employees)
    - c) Large (201+ employees)
3. How familiar are you with blockchain technology and smart contracts?
    - a) Very familiar
    - b) Somewhat familiar
    - c) Not familiar at all
4. Has your organization used smart contracts in procurement?
    - a) Yes
    - b) No, but planning to implement
    - c) No, and no plans to implement

Section 2: Smart Contract Implementation in Procurement

5. What type of procurement processes does your organization follow?
    - a) Public procurement (government tenders, e-GP, etc.)
    - b) Private procurement (corporate contracts, supply chain agreements, etc.)
    - c) Both
6. What are the biggest challenges in traditional procurement contract management in Bangladesh? (Select all that apply)
    - a) Manual processing delays
    - b) High risk of fraud/corruption
    - c) Lack of transparency
    - d) Disputes in contract enforcement
7. What benefits do you expect from smart contract implementation in procurement? (Select all that apply)
    - a) Faster contract execution
    - b) Improved transparency and accountability
    - c) Reduced contract disputes

- d) Lower operational costs

8. Which procurement processes do you think would benefit most from smart contracts?
    - a) Bid evaluation and supplier selection
    - b) Payment processing and invoicing
    - c) Contract enforcement and compliance tracking
    - d) Performance monitoring and dispute resolution
9. What are the biggest barriers to adopting smart contracts in procurement in Bangladesh?
    - a) Lack of awareness and expertise
    - b) Regulatory and legal uncertainties
    - c) High initial setup costs
    - d) Resistance to technology adoption

Section 3: Regulatory & Legal Framework

10. Do you believe the current legal framework in Bangladesh supports the use of smart contracts in procurement?

- a) Yes, fully supports
- b) Partially supports
- c) No, lacks clear regulations

11. What legal issues concern you most regarding smart contract adoption in procurement?

- a) Legality and enforceability of smart contracts
- b) Data privacy and security risks
- c) Compliance with government procurement regulations
- d) Lack of dispute resolution mechanisms

12. Do you think smart contracts can reduce corruption in public procurement in Bangladesh?

- a) Yes, significantly
- b) Yes, but only to some extent
- c) No, corruption will persist

Section 4: Technology & Security Aspects

13. What level of blockchain infrastructure does your organization currently have?

- a) Fully developed and operational
- b) Partially implemented
- c) No blockchain infrastructure yet

14. How concerned are you about cybersecurity risks in smart contract implementation?

- a) Very concerned
- b) Somewhat concerned
- c) Not concerned

15. Which of the following risks do you see in smart contract deployment? (Select all that apply)

- a) Hacking and cyber threats
- b) Technical errors or coding flaws
- c) Data privacy violations

- d) Dependence on external digital infrastructure

Section 5: Future Adoption & Recommendations

16. What measures would encourage the adoption of smart contracts in procurement in Bangladesh? (Select all that apply)

- a) Clear legal and regulatory framework
- b) Government-led pilot projects
- c) Training and capacity building programs
- d) Public-private partnerships for blockchain adoption

17. How soon do you think smart contracts will be widely adopted in Bangladesh's procurement sector?

- a) Within 1-2 years
- b) 3-5 years
- c) More than 5 years
- d) Never

18. Would you be interested in training or workshops on smart contracts for procurement?

- a) Yes, definitely
- b) Maybe
- c) No, not interested

19. Do you believe smart contracts could improve Bangladesh's global competitiveness in procurement?

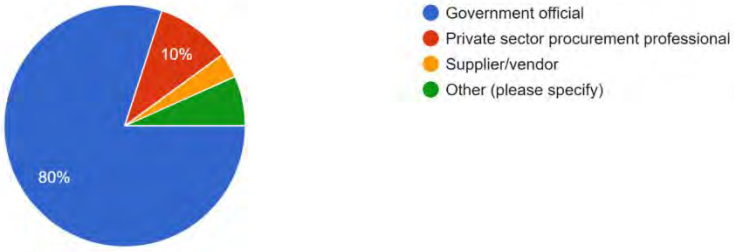
- a) Yes, significantly
- b) Yes, but with proper implementation
- c) No, other factors matter more

20. Any additional comments or recommendations regarding smart contract adoption in procurement?
    (Open-ended response)

Summary of Survey Responses

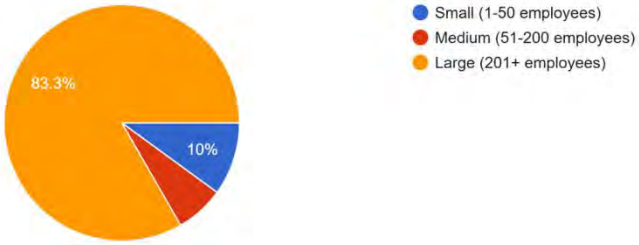
1. What is your role in the procurement process?

30 responses



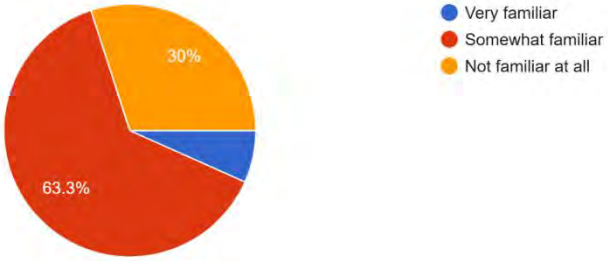
2. What is the size of your organization?

30 responses



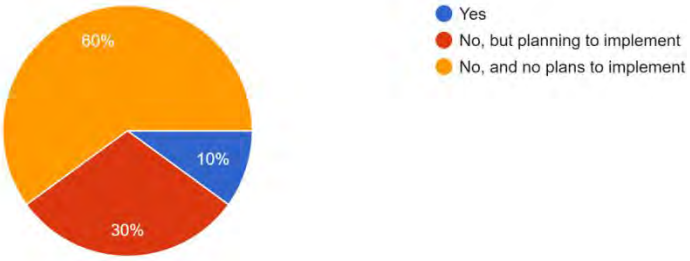
3. How familiar are you with blockchain technology and smart contracts?

30 responses



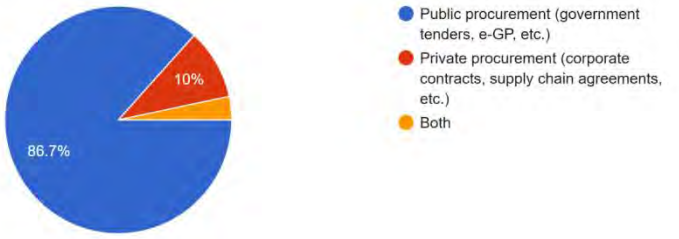
4. Has your organization used smart contracts in procurement?

30 responses



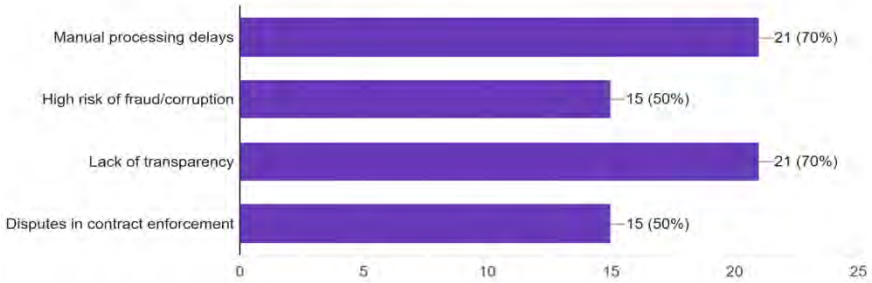
5. What type of procurement processes does your organization follow?

30 responses



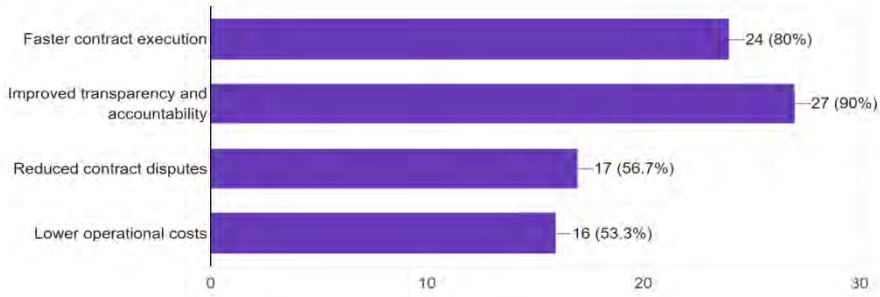
6. What are the biggest challenges in traditional procurement contract management in Bangladesh? (Select all that apply)

30 responses



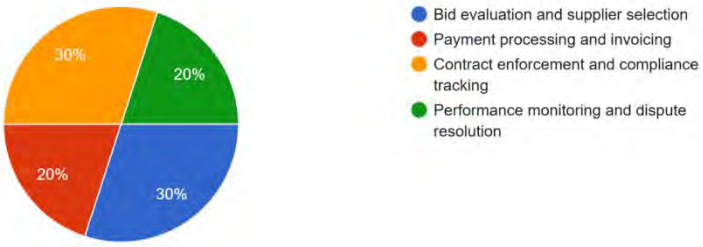
7. What benefits do you expect from smart contract implementation in procurement? (Select all that apply)

30 responses



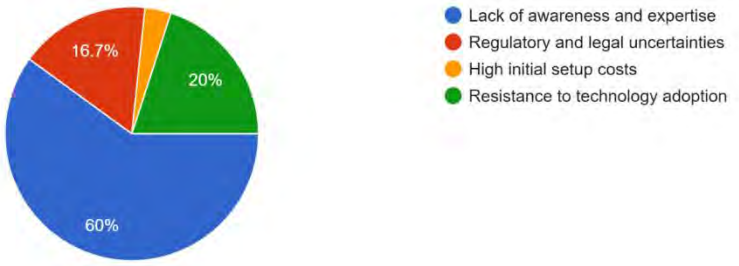
8. Which procurement processes do you think would benefit most from smart contracts?

30 responses



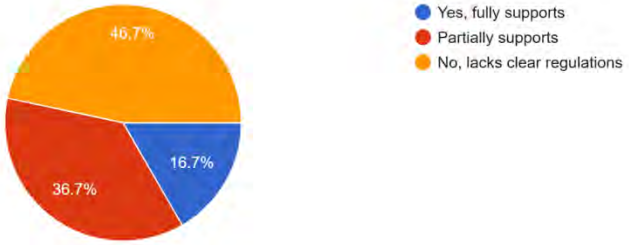
9. What are the biggest barriers to adopting smart contracts in procurement in Bangladesh?

30 responses



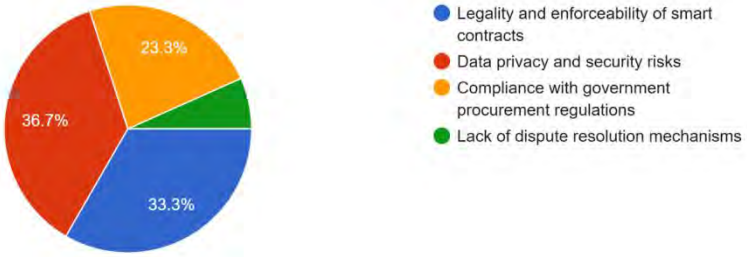
10. Do you believe the current legal framework in Bangladesh supports the use of smart contracts in procurement?

30 responses



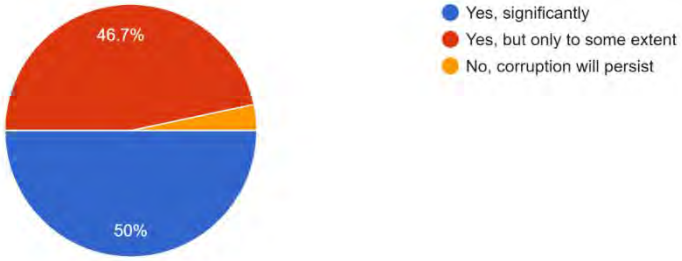
11. What legal issues concern you most regarding smart contract adoption in procurement?

30 responses



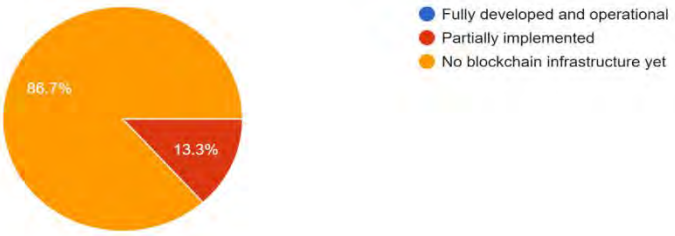
12. Do you think smart contracts can reduce corruption in public procurement in Bangladesh?

30 responses



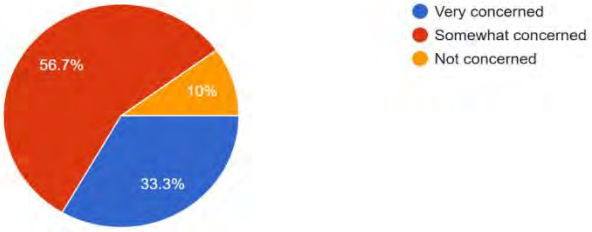
13. What level of blockchain infrastructure does your organization currently have?

30 responses



14. How concerned are you about cybersecurity risks in smart contract implementation?

30 responses

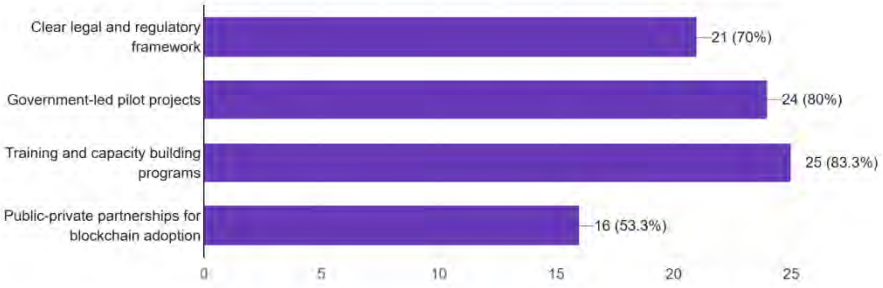


15. Which of the following risks do you see in smart contract deployment? (Select all that apply)

30 responses

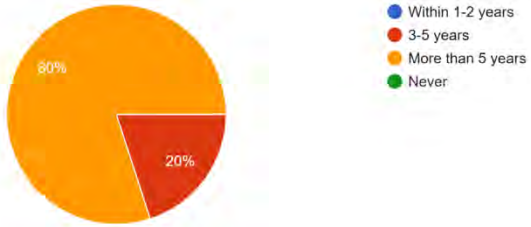
16. What measures would encourage the adoption of smart contracts in procurement in Bangladesh? (Select all that apply)

30 responses



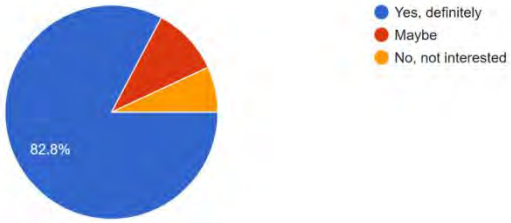
17. How soon do you think smart contracts will be widely adopted in Bangladesh's procurement sector?

30 responses



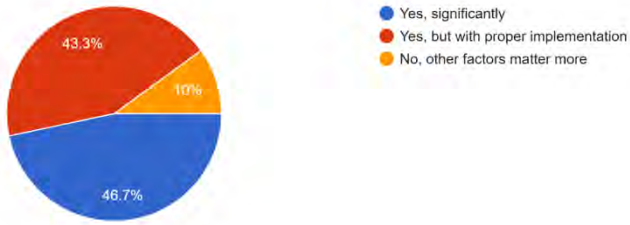
18. Would you be interested in training or workshops on smart contracts for procurement?

29 responses



19. Do you believe smart contracts could improve Bangladesh's global competitiveness in procurement?

30 responses



20. Any additional comments or recommendations regarding smart contract adoption in procurement?

5 responses

1. Smart contract infrastructure/coding should be treated as core. So these should be developed in house at most, because ppp or outsourcing will increase the risk of cyber threat, and the conflict of interest.
2. no
3. None
4. Blockchain is the most important way of reducing corruption in public procurement rather than the eGP system.
5. No