

Article

Blockchain Technology: Potential Applications for Public Sector E-Procurement and Project Management

Malik Khalfan ^{1,2}, Neda Azizi ^{3,*} , Omid Haass ¹ , Tayyab Maqsood ¹ and Istiaq Ahmed ¹

- ¹ School of Property, Construction and Project Management at RMIT University, Melbourne, VIC 3000, Australia; malik.khalfan@rmit.edu.au or malik.khalfan@gmail.com (M.K.); omid.haass@rmit.edu.au (O.H.); tayyab.maqsood@rmit.edu.au (T.M.); iahmed19@gmail.com (I.A.)
² Plymouth Business School, University of Plymouth, Plymouth PL4 8AA, UK
³ School of Business, Torrens University Australia, Melbourne, VIC 3000, Australia
 * Correspondence: neda.azizi@torrens.edu.au

Abstract: Project implementations normally fail due to sustainable development problems that inhibit the usage levels required to facilitate successful implementations. This paper explores the successful implementation from a Bangladesh perspective. In particular, it identifies the possible applications of Blockchain in project procurement and management, and it develops a guideline for incorporating Blockchain into project management to improve the existing project and the procurement management practices in developing countries. This is a qualitative study with an interpretivist research methodology. By adopting an interpretive approach, this study construes knowledge as that only gained through social constructions, such as language, shared meanings, documents, industry reports, reviews of academic papers, and tools; it is a changing and relative phenomenon. This study reveals that developing countries are suffering in terms of the development of projects, including poor project management, a lack of transparency, poor procurement management, etc. A total of 38 issues were identified through this study, which are the main barriers to the successful implementation of public sector projects. One of the main reasons is due to the practice of awarding the lowest bidder during the procurement process due to the current regulatory requirements. This paper found that the Oracle platform, built on Blockchain technology as a cloud-computing platform, is one of the prominent E-procurement platforms that provides both the Blockchain platform and the cloud-based applications. Therefore, after observing and analysing the platform, it is found that Blockchain technology has the capability to resolve 25 issues out of 38 identified issues.

Keywords: blockchain technology; application interface; e-procurement; procurement management; project management



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1. Introduction

Successful project implementations remain a critical challenge for many organisations. Consequently, project management (PM) research has argued that much can still be learnt from studies of successful implementation and usage [1,2]. Sustainable development has been applied in PM research to create value for their stakeholders through realising benefits at an optimal resource cost, while optimising the risk [3,4].

De Mascia [3] illustrates that “a successful project is one that has delivered all aspects of the project plan, within time and budget, whilst ensuring that sponsors and stakeholder are satisfied with the quality of what has been delivered and that the delivered products or service are fit for purpose and sustainable”. Therefore, when a project cost increases, or when there are time delays due to project implementation-related problems, then, in theory, the project is not simply successful. Developing countries are facing extreme project implementation-related problems, which has become one of the main barriers towards sustainable development [5,6].

Extant PM studies have largely explored project quality, cost, and time-overrun problems have become a common phenomenon for public sector projects in developing countries [7,8]. For instance, in Bangladesh, a total number of 49 projects were completed in FY2016-17 under the Road Transport and Highway Division, where 41 of them suffered from both cost increases and schedule delays [9]. Additionally, it was found that the maximum time-overrun was 400% and the cost-overrun was 250% in those 41 projects [8,10]. Espousing these views, and an in-depth observation, reveals that accountability and trust are the issues involved with project implementation-related problems in developing countries [11,12]. Thus far, many studies and investigations have been conducted to identify the public sector project implementation problems; however, no proper technique has been identified which can eliminate the cost-overrun and time delay of development projects. However, there is a possibility that Blockchain may ensure the responsibility against the different tasks of a project, which may mitigate some of the public sector project implementation problems [13–16].

Blockchain is an upcoming technology in the project management field, which has the potential to resolve implementation-related problems [17–19]. Blockchain-based project management may increase the human life standard by reducing corruption [13,20]. It also protects the project from information manipulation. Carlozo [14] explained that “Blockchain is a digital ledger of economic transactions that is fully public, continually updated by countless users, and considered by many impossible to corrupt. It is a list of a continuous record of blocks”. Shojaei et al. [21] explained that this technology can be used as a tool for the project’s information system. Gausdal et al. [15] claimed that poor data management can increase the project costs by up to 20%. Additionally, they explained that digital innovation, such as Blockchain technology, may establish regulation, which has potential to reduce the project cost.

Accordingly, there are certain limitations in these studies, as they relate to understanding the concepts of Blockchain and project management systems. The previous excerpts imply that, to ensure a successful project, there is a need for more explanatory studies regarding the project problem [22,23]. In a recent study, Idrees et al. [24] suggested that Blockchain is a phenomenon involving the introduction of something new to an organisation, either objectively or subjectively. Fundamental to the notion of introducing Blockchain technology is the element of change initiated in the material and/or social world, as part of learning often involves the alteration of relationships and the prior ways of doing things. However, what is not well researched or known is the how Blockchain technology can influence project performance, and what the possible applicable areas in project management are. Consequently, the influence of Blockchain technology for managing projects effectively may well be relevant and, therefore, it conforms well to building a comprehensive framework as a guideline.

The purpose of this paper is, therefore, to:

- Investigate the issues that affect the successful implementation of the public sector infrastructure projects in developing/developed countries;
- Identify the possible application of Blockchain in project and procurement management;
- Develop a guideline to incorporate Blockchain into project management for improving the existing project and procurement management practices in developing countries, such as Bangladesh.

The remainder of this paper is organised as follows. The paper starts by explaining the basic concepts of projects and project management, followed by identifying the existing project implementation problem within the public sector projects in developing countries. Then, the paper talks about the basics of Blockchain technology and the possible applications of Blockchain technology in the field of project and procurement management. The following section presents the advantages and risks of a Blockchain-based E-procurement system and discusses the working principle of Blockchain technology under the Oracle platform [25,26]. Towards the end of the paper, the authors discuss the potentiality of the Blockchain technology for mitigating the existing project and procurement manage-

ment issues, and conclude by providing a conceptual framework for Blockchain-based E-procurement in Bangladesh.

2. Literature Review and Theoretical Background

2.1. *Projects vs. Project Management*

A distinction has been made between the concepts of project success and project management success by PM researchers. Aditya et al. [27] pointed out that project success focuses on the overall objectives of the project, while project management success focuses on scope of the projects, including the cost, time, and quality. They believe that the project success criteria consist of project management success and product success. According to PMI [28], “projects are undertaken to fulfil objectives by producing deliverables”. A project is undertaken to resolve a specific problem within a fixed budget and period. The success criteria of projects are determined by cost, quality, and time [29,30], also called the ‘iron or golden triangle’. If a project is to be completed within a particular time frame and to a desired quality, but the estimated cost is increased, then it is not considered a successful project [31]. Similarly, if a project fails to achieve any elements of the iron triangle, then it is considered an unsuccessful project.

On the other hand, proper project management support makes a project successful. According to PMI [28], “project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements”. Therefore, project management provides a guideline for success by adopting a systematic approach.

2.2. *Project Implementation Problem of the Public Sector Projects*

Public sector project implementation problems are common all over the world. However, developing countries need to minimize these problems immediately, as a huge amount of investment and foreign employment is related to them. Furthermore, when large project costs are increase or delayed, then it directly hampers the economic development of an underdeveloped or developing country. Hence, it is also very important to know the reasons of the project implementation problems in developed countries, because developed countries use more advanced technology compared to developing countries, and developing countries may face these problems in future. Thus, the analysis of both categories will ensure a better outcome of the research.

2.2.1. Project Implementation Problems in Developing Countries

Park and Papadopoulou [32] conducted a study on 35 transport infrastructure-related projects which were completed between 1983 and 2010 in Asian developing and emerging countries, including Bangladesh, Hong Kong, India, Malaysia, Myanmar, Pakistan, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam. They identified 27 project implementation problems, and their study found that the most significant reason for the cost-overrun in Asia is the common practice of awarding contracts to the lowest bidder for infrastructure-related projects.

The accessible knowledge and information about what has happened in past events, when it is available and verified during the planning stages, may provide helpful knowledge and information for future and ongoing projects. In essence, the use of project members’ knowledge can potentially reduce uncertainty and risky situations in its implementation. Thus, past records are considered as a valuable source for planning, time, and cost estimations. However, in developing countries, all the important documents of projects may not be managed properly, or may be destroyed after the completion of the projects. Gamez and Touran [33] studied 89 transportation infrastructure projects funded by the World Bank in 60 developing countries, and claimed that, for large infrastructure projects, costs are overestimated, and the duration is calculated very optimistically due to poor information management. The literature claims that project tracking, documentation, and reporting is not inclusive and is not properly done. They also found that the overall project cost was overestimated for 59% of projects and, in case of the project duration, the

average project delay was an increase of 35% from the original schedule. Therefore, keeping proper records of the project, and increasing the predictability of a similar type of project, will enhance the probability of success in the future.

An important factor for achieving a successful completion of a project within an organisations is governance. Project management processes change with time, and researchers emphasize good governance as a pre-condition to closing a project within an allocated budget and time. Zarewa et al. [2] argued that project governance has an impact on project performance, and improper project governance is a reason for large infrastructure project failures.

2.2.2. Issues Affecting the Public Sector Projects

The main objective of this section is to identify the main barriers against the successful completion of public sector projects in both developing and developed countries. Based on the data found from different sources, a total of 38 reasons have been identified. All the issues have been classified into four themes using brainstorming techniques and thematic analysis; these themes are legal, managerial, financial, and organisational. A few issues are listed within more than one theme.

Table 1 identifies all the issues involved with public sector projects after investigating various projects/samples from Bangladesh, Denmark, Germany, Hong Kong, India, Malaysia, Myanmar, Nigeria, the Netherlands, the OECD, Pakistan, the Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam [9,27,34–41].

Table 1. Issues that affect the implementation of the public sector projects.

SI	Issues	Themes	Identified after Investigating Projects/Samples	SI	Issues	Themes	Identified after Investigating Projects/Samples
S1	Shortage of materials	Managerial	15	S21	Contract awarded to lowest bidder	Legal	374
S2	Unforeseen site conditions	Managerial	85	S22	Inadequate site investigations	Managerial	85
S3	Change in orders by client (variations)	Legal	373	S23	Delay of drawings and site instructions	Legal	85
S4	Price fluctuations (inflation)	Financial	85	S24	Unsuitable construction methods	Managerial	85
S5	Inaccurate estimates	Financial and Organisational	373	S25	Acceleration required by client	Managerial	15
S6	Poor site management by contractor	Managerial	15	S26	Change in foreign exchange rate	Financial	15
S7	Shortage of skilled labour	Organisational	85	S27	Fraudulent practices, kickbacks, corruption	Legal	16
S8	Lack of communication between parties	Managerial and Organisational	85	S28	Owner's fund shortage	Financial	71
S9	Delayed payment of completed works	Financial	85	S29	Improper progress monitoring and cost control	Legal and Organisational	70
S10	Inadequate duration of contract period	Legal	373	S30	Inaccurate time and cost estimation	Managerial and Organisational	70
S11	Adverse weather	Organisational	85	S31	Inexperienced project manager (PM)/frequent transfer of PM	Managerial and Organisational	119

Table 1. Cont.

SI	Issues	Themes	Identified after Investigating Projects/Samples	SI	Issues	Themes	Identified after Investigating Projects/Samples
S12	Construction errors/ defective works	Legal	15	S32	Information manipulation (hiding negative information)	Legal and Organisational	2
S13	Poor contract management	Legal	373	S33	Consultant issues	Organisational	70
S14	Inappropriate gov-ernment policies	Legal	85	S34	Lack of accountability for poor decisions	Legal	70
S15	Work suspension owing to conflicts	Legal	85	S35	National and local politics	Organisational	71
S16	Incompetent subcontractors	Legal	85	S36	Improper planning	Managerial and Organisational	71
S17	Inadequate pre-construction study/ feasibility study	Organisational	422	S37	Land acquisition problems	Legal	63
S18	Inappropriate procurement/ contract type	Legal	15	S38	Improper cost-benefit analysis in advance	Organisational	1
S19	Slow inspection of completed works	Managerial and Organisational	373	S39	Delay from tender invitation to issuance of work order	Legal	63
S20	High cost of machinery	Financial	85	S40	Improper examination of EPC/Turnkey contract	Legal	50

2.3. Blockchain

In the new era, management is concerned with providing the right goods, at the right time, with the right amount, at the right place, at the right price, and under the right conditions for the right customer [12,24,42]. Using international standards and advanced technology, the Blockchain technology changes the traditional system and processes into a smart system.

Global Blockchain technologies are complex and face multiple uncertainties [43]. Despite the increasing use of Blockchain in a project management concept, we still face many challenges in this regard. Most challenges are related to security concerns and privacy [20,24]. Therefore, introducing a reliable and secure system has become the main concern of this era. Using artificial intelligence (AI) through robotics and nanotechnologies, have become popular for the fourth industrial revolution [1,44]. Previously, not only with international transactions, but for many local transactions, third parties were always involved with the payment system. One the one hand, the transaction costs a lot, and on the other hand, the process consumes a lot of time.

Nowadays, different vendors of different countries are famous for their best-quality products, which are an important component of procurement for most of the development projects. To make the procurement process easy and transparent, the introduction of the smart contracts and making the payment fast without a third party are the challenges of the project management arena. Blockchain-based project management could bring a revolutionary change to project management.

Blockchain is a new technology, and its name is hidden behind the operation process. Researchers claim that it is an upcoming technology, or a technology that is under experimentation [45,46]. Blockchain came into focus for mitigating the payment problem of the E-commerce system through Bitcoin. Bitcoin was invented by Nakamoto in 2008 [12,47,48]. However, few recent articles have explained that Blockchain-based project

management may mitigate project implementation-related problems [13,45,49]. Therefore, it is essential to properly understand the Blockchain technology and its working principles [17,50].

2.3.1. What Is Blockchain Technology?

Blockchain is a chain of interconnected secured blocks with the storing facilities of all transactions. Welfare [51] provides shorter and longer definitions of Blockchain in his book *Commercializing Blockchain: Strategic Applications in the Real World*, which are mentioned sequentially below:

“Trusted and efficient way of sharing data and transaction”; “Blockchain technology can be viewed as a distributed ledger of information, which maintains a continuously growing list of records, called blocks, secured from tempering and changes”.

Blockchain is a new technology that is considered a digital ledger for any online transaction [14]. Bitcoin was invented in the year 2008 to mitigate the payment problem of E-commerce. Bitcoin is a cryptocurrency based on Blockchain [52]. Blockchain is considered an unlimited interconnected database, where it can record all transactional information in blocks.

Blockchain consists of two elements, transactions and blocks, as shown in Figure 1. When the user performs any task, it is called transaction. On the other hand, blocks record all transactions [45]. Additionally, each block contains data and the hash value of the previous block. The hash function ensures a secure transaction.

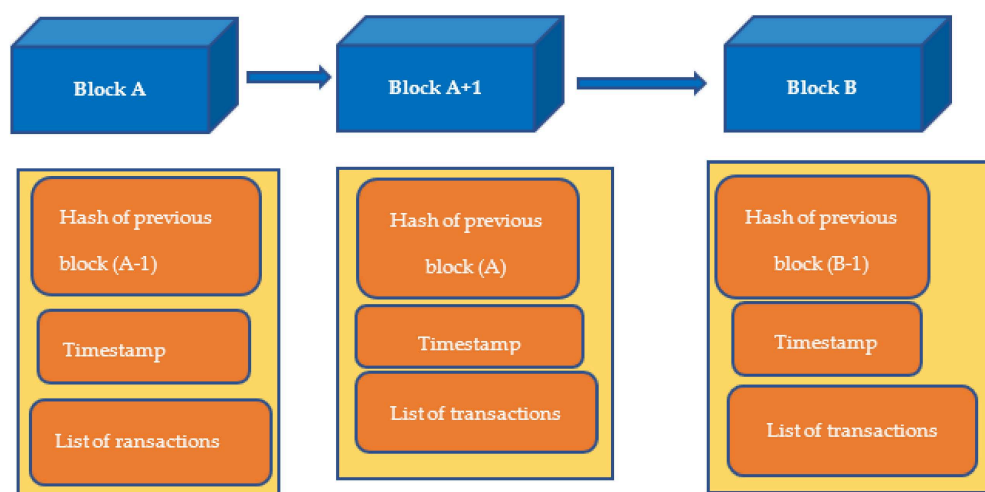


Figure 1. Structure of Blockchain.

2.3.2. Why Is Blockchain Unique?

Welfare [51] argued that there are a few characteristics that make Blockchain technology unique.

Trust: Nowadays, a lack of trust is a major problem, whether it is in business, government, communities, or processes. Due to this, it takes longer to make a supply and chain-related contract or to complete an audit. However, this technology ensures trust between different parties.

Transparency and openness: All the information in this system updates automatically and it is open to all. Therefore, customers, owners, and organisations rely on the available information. Every project manager can easily imagine the benefit of a project with a transparent and open procurement system.

Immutability: The basic characteristic of a Blockchain system is that, after inserting any information, it is not possible to either alter, delete, or change it. It will update automatically after the approval of the concerned persons.

Transaction automation and smart contracts: The most important advantage of Blockchain is the automation of certain tasks, which is known as a smart contract. After making a smart contract, it became possible to enable the automation of a few tasks and transactions.

2.4. Possible Applications of Blockchain Technology in Project Management

Cloud-based applications are those through which the cloud-based software makes it possible to access through local devices, such as Apple iCloud, Google, Amazon, Microsoft, and Oracle, who all provide cloud-based services [53]. Among those, Oracle also provides Blockchain technology, including a supply chain application [25]. Oracle-based Blockchain technology will be discussed to identify the possible application of Blockchain in the project management arena. Oracle provides various types of services, as shown in Figure 2 [26].



Figure 2. Service provided by Oracle (Source: [41]).

2.4.1. E-Procurement/Comprehensive Administration by Oracle Blockchain Platform E-Procurements or Comprehensive Administration

Procuring either goods, works, or services is a common requirement for development projects. It has been found that awarding the contract to the lowest bidder is one of the main causes for delaying projects [32,36,54]. Changing data or the improper evaluation alters the ranking of bidders during tender evaluation. Furthermore, procurement is the most common area that is known for corruption. However, introducing Blockchain for tender evaluation will resolve the main issues related to procurement [41]. Therefore, Blockchain-based E-procurement may change the project implementation process.

Components for Blockchain-Based E-Procurements System

Three components are essential to establish a Blockchain-based E-procurement system. Thio-Ac et al. [41] explained that those three components are a digital asset, digital signature, and multi-signature protocol, as shown in Figure 3.

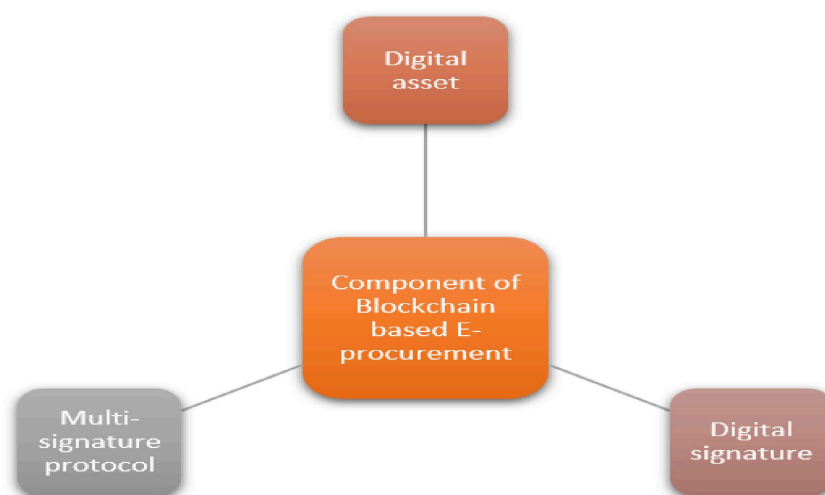


Figure 3. Components of Blockchain-based E-procurement system [41].

The digital asset is known as the digital notarization. In traditional procurement, the procurement entity/owner informs the requirement to different contractors/organisations through publishing advertisements. The digital asset is known as all the authentic documents related to the whole procurement process. All the associated users of a Blockchain system will have individual private and public keys. To validate a contract between two parties, these keys will be used, known as a digital signature. The digital signature makes any document a legal document. A multi-signature protocol is used for any financial transaction. After finishing any task by the contractor, the authorized group confirms it, and then the contracted money is transferred to the desired account through the multi-signature protocol.

E-procurement through Cloud/Blockchain Platform

Many organisations provide cloud/Blockchain-based services. Oracle provides both services. Based on that, the possible procurement steps for any projects are shown in Figure 4 [26,30].

In summary, at this point, the implication of the literature review for this study is that the sustainable development problems have been formulated by researchers as the search for relevant factors or variables that are, supposedly, correlated with outcomes. As reported, this study identifies the possible application of Blockchain in project and procurement management, and it develops a guideline to incorporate Blockchain in project management for improving the existing project and procurement management practices in developing countries. By adopting an interpretive approach, this study construes knowledge as only gained through social constructions, such as language, shared meanings, documents, industry reports, reviews of academic papers, and tools; it is a changing and relative phenomenon. Thus, it adopts a combination of systematic techniques, such as a research method and the socio-technical theory as the research-sensitizing concept. In order to do this systematic literature review, we used guidelines provided by Kitchenham [55] which suggests five different steps for the review: (1) identify the resources, (2) the study selection, (3) data extraction, (4) data synthesis, and (5) writing up the study as a report.

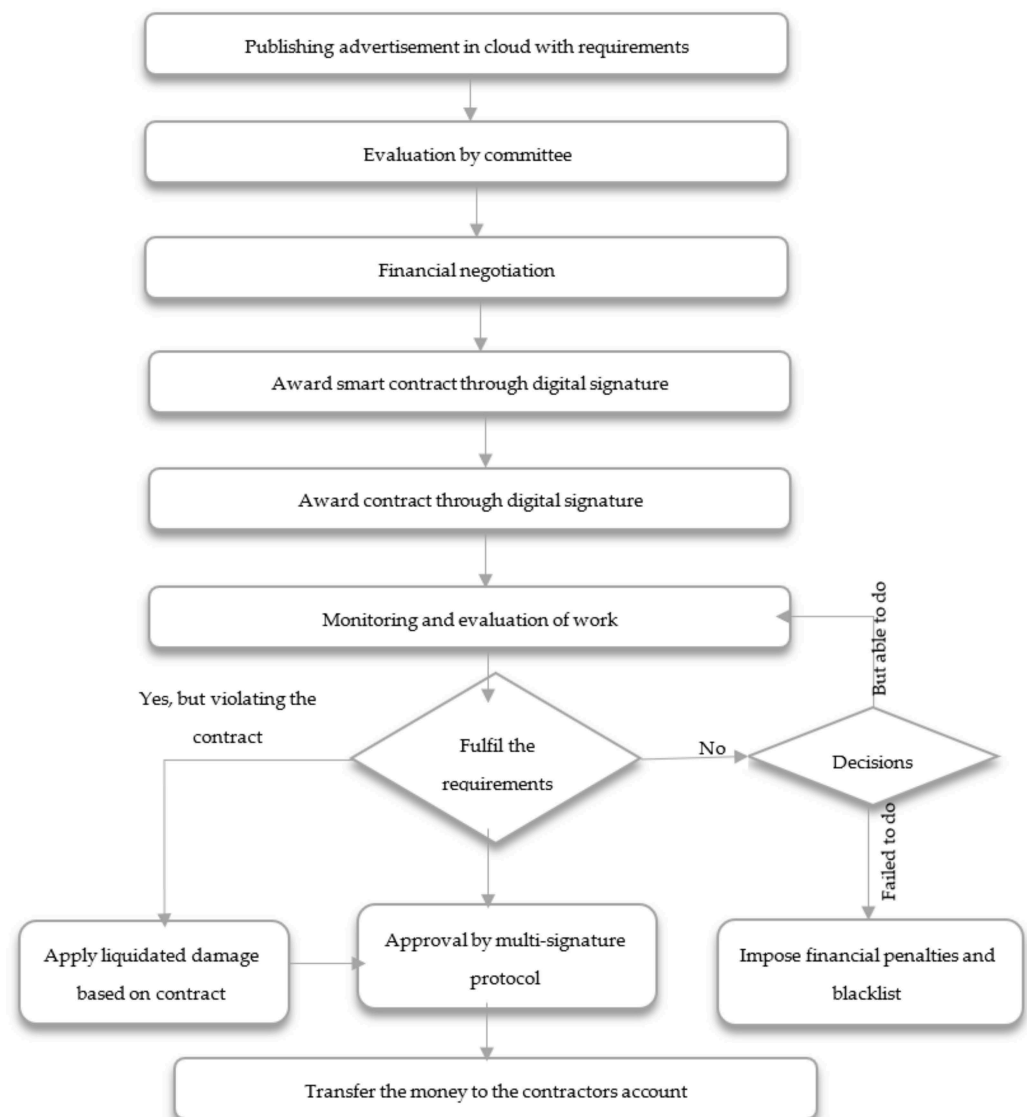


Figure 4. Cloud/Blockchain-based E-procurement system.

3. Findings

3.1. Advantages and Risks of Blockchain-Based E-Procurement System

Automatic operations: The automatic operation system is the most advantageous of the Cloud/Blockchain-based E-procurement system [30]. It has the potentiality to make a revolutionary change in the procurement system. It will resolve the barrier of location. Any bidder will be able to participate in the tendering process from anywhere in the world. Therefore, it will increase the probability of getting the contract to the most efficient contractor.

Controlling flexibility: Controlling and evaluating Blockchain-based procurement will be easy, compared to the traditional system [30]. It will enable us to view the status from a dashboard and to navigate the nodes through the network nodes. Everything will be possible to control from the dashboard.

Flexible monitoring and troubleshooting: Blockchain-based procurement will enable us to monitor the whole system [30,56]. Therefore, it will ensure transparency and accountability of the procurement. Additionally, it will enable us to troubleshoot if any serious problems occur.

The findings regarding the advantages of Blockchain-based E-procurement have been classified into four categories: the legal, managerial, financial, and organisational advan-

tages. The following section explains how Blockchain-based project management will support the reduction of the identified public sector project-related issues in developing countries.

3.1.1. Legal Advantages

Blockchain-based project management will ensure some legal advantages to the concerned organisations of developing countries. The potential advantages will be discussed in the following sections.

- (a) E-procurement: E-procurement is the main legal advantage of Blockchain-based project management. Blockchain-based project management will enable them to do all the procurement processes online [41]. Additionally, it will enable the shift from a paper-based procurement system to a paperless/online-based procurement system.
- (b) On-time tendering system: The delay in the tendering process is a common problem in developing countries. Due to this, infrastructure-related public sector projects are delayed in developing countries [41,57]. However, due to its automation and less human effort, all the procurement steps will be able to be complete within the assigned/allocated time against each step. Therefore, if Blockchain-based project management followed, then it is expected that the tendering process will be finished within the planned time of all projects.
- (c) Transparency: A lack of transparency is one of the main reasons for delaying public sector infrastructure-related projects in developing countries [35,36,57]. Blockchain-based project management ensures a secure and private network between the users. All the associated members of different organisations, and even top management, will be able to follow the task during the project's duration [41,51]. Therefore, all the project-related tasks during the project's processing and implementation will be transparent to everyone involved with the project.
- (d) Accountability: Poor accountability is another major problem in project management. A project may fail due to individuals making poor decisions [35]. When something goes wrong with a project, no one takes the responsibility for delaying public sector projects in developing countries. However, Blockchain is considered a digital ledger for any online transactions [14]. Additionally, it is not possible to either alter, delete, or change any Blockchain-based information without the permission of all concerned persons [51]. Therefore, it will become straightforward to identify the accountable person/organisation for whom any task has been delayed by.
- (e) Secured network system: All the nodes and APIs (Application Programming Interface) need to be designed for a specific project; therefore, the Blockchain network is considered to be the most secure network. Furthermore, the system updates automatically [51]. Therefore, the network will be trusted by the owner and the vendor [30,57,58].
- (f) Lowest bidder issue: The lowest bidder issue is one of the common and important issues discussed by the different researchers [32,36,41]. Due to a variety of reasons, the lowest and winner bidder increases the cost and duration of the project. However, with the Blockchain project management system, if any vendor failed to finish a project within the contracted time and cost without any valid reason, then the vendor may be punished by liquidated damages, or ministries may have the authority to blacklist the vendor.
- (g) Provenance of materials: Blockchain provides the facility of the vendors/contractors to participate in bidding from all over the world. It opens the opportunities to choose the best vendor. Furthermore, the buyer can monitor the production of materials to ensure the quality of materials [19].

3.1.2. Managerial Advantages

Blockchain-based project management will ensure some managerial advantages, as well as the potential advantages discussed below.

The tracking of equipment and materials: Project tracking is very important to check the achievement of the milestones of infrastructure projects. A lot of time is consumed to collect and prepare the update of projects, as well as sending the updates to different ministries. However, Blockchain-based project management will facilitate the tracking of projects and equipment [56]. Christodoulou et al. [54] also argued that it will also play a vital role in supply and chain management. A Blockchain-based tracking system will save a lot of time for project managers and will allow them to revise their plans based on the situation.

Fast inspection: Slow inspection is one of the managerial problems and one of the causes of project delays [32,36]. Fast inspection is important from both the owner's and vendor's points of view. A fast inspection will allow for the identification of the future needs and possible risks of the project, which will enhance the successful completion of the project [56].

Proper communication: A lack of communication between parties is also a barrier to a successful project [36,37,40]. However, Blockchain-based project management will enable the automatic communication between parties and various ministries within a government [30]. Moreover, it will also become proof of responsibility.

3.1.3. Financial Advantages

Blockchain-based project management will ensure some financial advantages to the concerned organisations in developing countries, and the potential advantages are discussed below.

Automatic and secured fund transfers through smart contracts: Automatic and secured fund transfers through smart contracts are one of the main advantages of Blockchain technology [56]. It ensures trust and support to reduce corruption, as all the transactions will be recorded permanently [58]. Furthermore, it will help the audit department of the public sector, because the auditor can easily trace the transaction of money in case of any fraudulent transactions.

Proper cost estimation for future projects: A higher cost estimation for machinery is a common problem in developing countries [32,36]. However, Blockchain-based record management will keep the actual price of the equipment against the projects, which will help to estimate similar project costs in the future [45,46].

Support to ensure adequate funds for the project: Sometimes the owner's fund shortage delays a project, and it can be considered poor financial planning by an organisation [36]. However, as top management of various ministries and organisations will be a part of the chain through Blockchain, the financial planning will become easier and more accurate. It will protect any financial deficiencies against a project as it will become very easy to identify the people responsible for the issue.

3.1.4. Organisational Advantages

Blockchain-based project management will ensure some organisational advantages, and these potential advantages are discussed below.

Vendor management: Organisations will be able to identify the performance of the different vendors or contractors overall. Sometimes vendors fail to achieve the target on time, but do not want to pay compensation, and the project suffers [9,41]. Therefore, all the organisations will be able to maintain the best vendor list based on their experiences.

Proper planning and estimation for future projects: Poor contract management and the improper planning of projects can be considered the institutional problem of an organisation, and the situation is not possible to improve until the organisation improves their information management system [27,35,36]. The proper information will help the organisation to plan and estimate the cost of the project properly. Gausdal et al. [15]

argued that improper data management can increase the cost of a project by up to 20%. Blockchain-based project management will not only manage the data of a project, but it will also store the data for future similar projects.

Customer- and end-user-centric worldview: Nowadays, the fourth industrial revolution is changing the construction industry. The projects receiving priority are those that have the potentiality to deliver the highest value to the customer. Blockchain technology is playing a vital role in improving collaboration and communication in the case of a cloud-based project management system. Therefore, it is only a matter of time before organisations will need to adopt new technology, such as Blockchain, to manage projects [13,16].

3.1.5. Risks of Blockchain

Blockchain technology may have few issues. Firstly, it is very difficult to change user habits. As it is a new system, people will be reluctant to use it (Welfare, 2019). Secondly, governments will get most of the benefits from this technology. However, if the government doesn't show any interest, then there will be a problem. Finally, this technology will be used all over the world. However, the internet and telecommunication policies are different for each country. Hence, to create a standard among all providers will be challenging [51,54].

Lu et al. [57] pointed out that although Blockchain technology has many advantages, the current operating system is still not perfect, and there are many risks. Risks can be divided into operational risks, cyber risks, and legal risks.

Operational risks mean that if Blockchain is applied to technical or social issues, it may produce unsuccessful results. This may be reflected in:

- A loss of data and identity;
- The transaction costs of the public Blockchain, which are high;
- A lack of recipients and users;
- A lack of long-term experience, which leads to imperfect management;
- The initial applications, which may have technical problems.
- A lack of a standardized mode of operation and function, as well as security deficiencies.

Cyber risks refer to bad behaviors, such as fraud, due to insufficient security levels or design flaws, which are reflected in [57]:

- There may be fraud in the interface between the real world and the Blockchain world;
- The exchange may be attacked by hackers, the user passwords may be hacked, and the funds transferred;
- The hard fork in the block will cause the trust of the entire network system to be questioned.

Legal risks refer to some illegal acts that may occur in the operation of block chains, which are reflected in [57]:

- Tax evasion may be triggered;
- Illegal use of information may occur;
- Blockchains are used for illegal transactions.

3.1.6. Application of Blockchain Technology in Project Management

Blockchain technology could be used to create smart contracts for tracking projects through the Oracle Blockchain platform. It is argued that projects fail due to poor tracking, and Blockchain provides a tracking facility through a smart contract. Improper project monitoring and activity scheduling are key reasons for project delays, and the consequence of it is a cost-overflow. The purchasing of equipment and materials are almost essential for all construction projects. Hence, delaying the supply of these materials is not acceptable for a successful project. Francisco and Swanson [56] claimed that traceability through smart contracts is the main advantage of Blockchain technology. Christodoulou et al. [54] also argued that the Blockchain-based contract possibly will mitigate logistic supply-related

problems through tracking. Therefore, project tracking through a smart contract may reduce some issues with project management.

Blockchain platforms, such as Oracle, or other providers, provide a smart contract facility [58]. To create a smart contract, the steps to follow are shown in Figure 5 [30]. At first, after opening an account, creating a real-time business to business (B2B) transaction/condition for establishing Blockchain business logic is needed. The transactions/conditions could be points of sales (POs), invoices, shipping information, etc. [30]. After that, Blockchain records every step; thus, all the steps will be converted into an automatic system through the Smart Development Kit (SDK) and will enable actions based on the event payload [30]. The event payload information is useful when anyone wishes to distribute an event through the API. Then, data schema, initialized data values, and methods need to be defined in the chain-code. Lastly, policies are endorsed regarding how many signatures from different officials are required to approve any task.

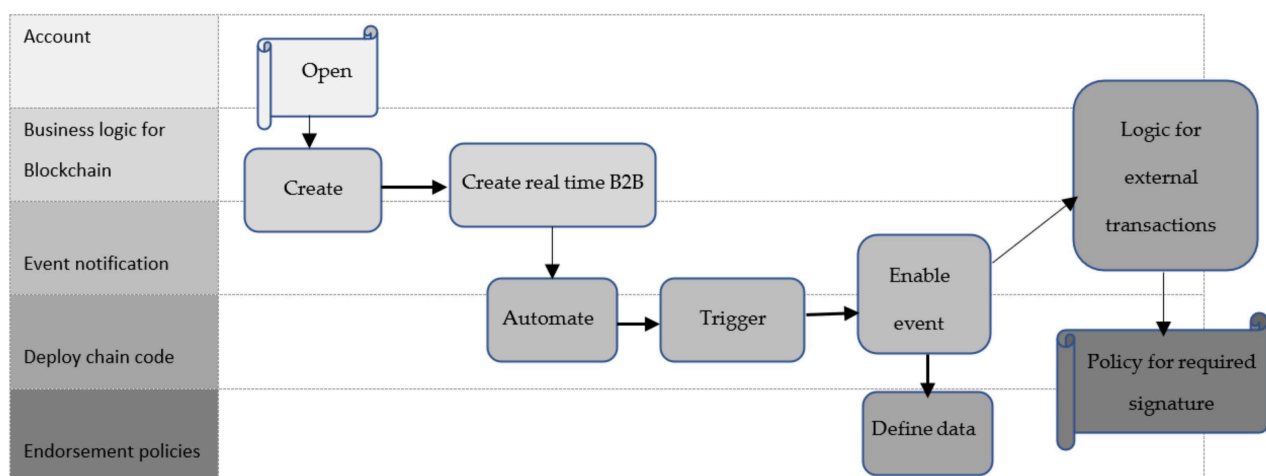


Figure 5. Steps to create smart contract [30].

3.1.7. Authentic Financial Transactions and Digital Payments through Oracle Blockchain Platform

Blockchain-based digital payments could ensure trust between owners and contractors. Already, a secured digital payment system has been implemented through Blockchain. Traditionally, one extra organisation ensures security between parties. The dependency on the extra organisation increases more when the contractor or supplier comes from a different country. Furthermore, this creates additional costs and more time. However, Ammous (2019) argued that, based on owner confirmations, the transaction is possible to finish almost instantly using Blockchain and without involving another organisation.

Digital payment is one of the major advantages of Blockchain technology. The steps for executing digital payments are shown in Figure 6 [30]. To initiate a digital transaction, a Blockchain-based platform/smart contract is required. The steps of a digital transaction are its initiation, record, notification, approval, and transfer. The whole transaction is done through a confidential domain and multiple channels.

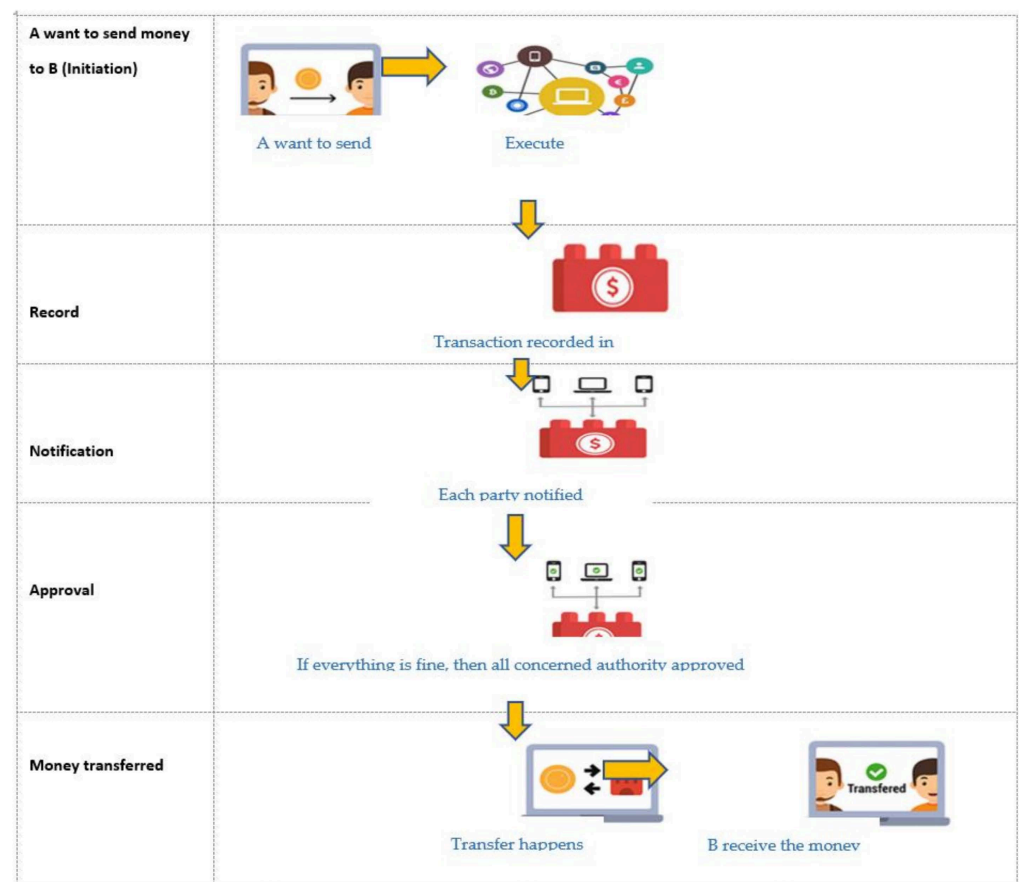


Figure 6. Digital payment steps through Blockchain platform [30].

3.1.8. Automated Document Management

Document management is an important part of project management, but developing countries do not maintain these properly. Gausdal et al. [15] argued that the project cost might raise by 20% only because of improper document management. Improper estimations and scheduling costs extra money and time. In Blockchain, all the project information will be recorded automatically [46]. It will not only support the ongoing project, but it will also support similar types of future projects.

3.2. Potential of the Blockchain Technology to Mitigate the Existing Project Management Risks

The above discussion pointing towards that Blockchain technology has the potential to resolve the 25 identified problems, out of 38, which hinder the successful implementation of public sector infrastructure-related problems in developing countries, especially for Bangladesh, as shown in Table 2. The below table also shows which problems might be partially resolved (five issues) and will not be resolved (10 issues) by Blockchain technology.

Table 2. Existing issues possible resolved by the Blockchain technology.

SI	Mitigation (May Resolve/May Partially Resolve/Cannot Resolve)	Key Points of Argument
S1	May partially resolve	Tracking facility will ensure arrival date of materials in the project area. However, it cannot resolve the issue if the amount of materials ordered is too low
S2	Cannot resolve	Unpredictable
S3	May partially resolve	Automatic operation and controlling facilities will support this. However, it will depend on smart contracts
S4	Cannot resolve	Unpredictable, as it depends on the economy
S5	May resolve	Automatic document management Transparency and accountability
S6	May resolve	Fast inspection will allow for identifying the future needs and possible risks
S7	May partially resolve	Vendor management, automatic communication, and smart contracts
S8	May resolve	Automatic communication feature
S9	May resolve	Automatic and secured fund transfer through smart contracts
S10	May resolve	E-procurement; on-time tendering system; transparency and accountability; provenance of materials; and automatic document management
S11	Cannot resolve	Unpredictable, such as heavy rain, flood, earthquake, etc.
S12	May partially resolve	Ensures accountability. Blockchain is considered to be a digital ledger. It is not possible to either alter, delete, or change any information
S13	May resolve	Automatic and on-time tendering system Transparency, as all the concerned people will be responsible for making the contract
S14	Cannot resolve	Depends on government
S15	May resolve	Secured network system will ensure transparency and accountability; hence, possibility of conflict will be less
S16	May resolve	Blacklist could be the solution if the subcontractor is found to be incompetent Transparency and accountability
S17	May resolve	Blockchain system will be able to identify the responsible person
S18	May resolve	A centralized and efficient team will ensure/choose the right contract type
S19	May resolve	Blockchain system/smart contract will mitigate the issue
S20	May resolve	Smart contract will ensure vendors participate in bidding process all over the world; hence, client will get a good-quality product with a low price
S21	May resolve	Blacklist feature will prevent the lowest bidder from taking illegal advantages
S22	Cannot resolve	Issue before project planning
S23	May resolve	Smart contract will ensure on-time delivery
S24	May partially resolve	Proper document management, accountability will support the resolution of the issue but it cannot eliminate it totally
S25	May resolve	Automatic contract management and deadline will force the team to finish within the deadline
S26	Cannot resolve	Depends on the economy
S27	May resolve	Transparency, accountability, and automatic fund transfer will resolve corruption issues. Moreover, it is not possible to either alter, delete, or change any information within Blockchain. Hence, fraudulent practices will be resolved
S28	May resolve	Automatic payment system will support the proper management of the funds
S29	May resolve	Client will be able to track project on a daily basis
S30	May resolve	Smart contract and automatic document management might resolve the issue

Table 2. Cont.

SI	Mitigation (May Resolve/May Partially Resolve/Cannot Resolve)	Key Points of Argument
S31	Cannot resolve	It depends on personal expertise or institutional experience
S32	May resolve	Personal liability will prevent information manipulation
S33	May resolve	International bidding will choose the most experienced consultant based on their previous performance
S34	May resolve	Blockchain system ensures accountability by default through its working principles. Moreover, it will provide the facility to identify any person
S35	Cannot resolve	Internal issue within a country
S36	May resolve	Blockchain-based document management has the potentiality to create institutional knowledge for project planning
S37	Cannot resolve	Depends on the land law of the country
S38	Cannot resolve	Depends on the context
S39	May resolve	Due to smart contracts, no one will be allowed to delay any tasks
S40	May resolve	Transparency, accountability, employee liability, and smart contracts will ensure the proper examination of EPC contracts

4. Discussion and Contributions

4.1. Conceptual Framework for E-Procurement in Bangladesh

The main goal of this research is to develop a conceptual framework to incorporate Blockchain into project management for improving the existing project management practices in developing countries, such as Bangladesh. Figure 7 shows the conceptual framework regarding how Blockchain technology can be introduced for E-procurement in the public sector project management of Bangladesh [41,42]. The following steps are needed to achieve this goal.

- (i) Use case identification: In Bangladesh, public sector projects are mainly approved by ECNEC. However, the small projects (based on cost) with conditions are approved by the Honourable Minister of Ministries. Then, before starting the procurement by the agencies after the required components, the cost, duration, and other criteria are finalized according to Digital Procurement Platform (DPP).
- (ii) Creating the account and consensus mechanisms: A project director/project manager is assigned by the ministry immediately after the final approval of a project in Bangladesh. In the next step, the project manager will open an account in Blockchain-based service provider websites, such as Oracle. Account verification is an essential step to opening an account. After opening an account, the private and public keys will generate against the account [41]. There are different types of Blockchain platforms provided by the different service providers, such as:
 - The Standard Edition: two OCPUs, 50 GB storage, two peers (additional peers can be added later) [30]. The OCPU is the Oracle Compute Unit per hour. Higher capacity options are also available.
- (iii) Buyer/supplier: In government projects, all the procurement deals are for buying either goods, works, or services; therefore, the project manager or the IT team of the project should deal as a buyer [30].
- (iv) Designing the nodes: The node design is a part of the Blockchain platform. It mainly provides permissions regarding who will be able to access the platform [59]. Therefore, during the bidding process, it will be open for all. After that, it will remain open for specific government organisations, such as the Ministry, Planning Commission, IMED, concerned agency, etc.

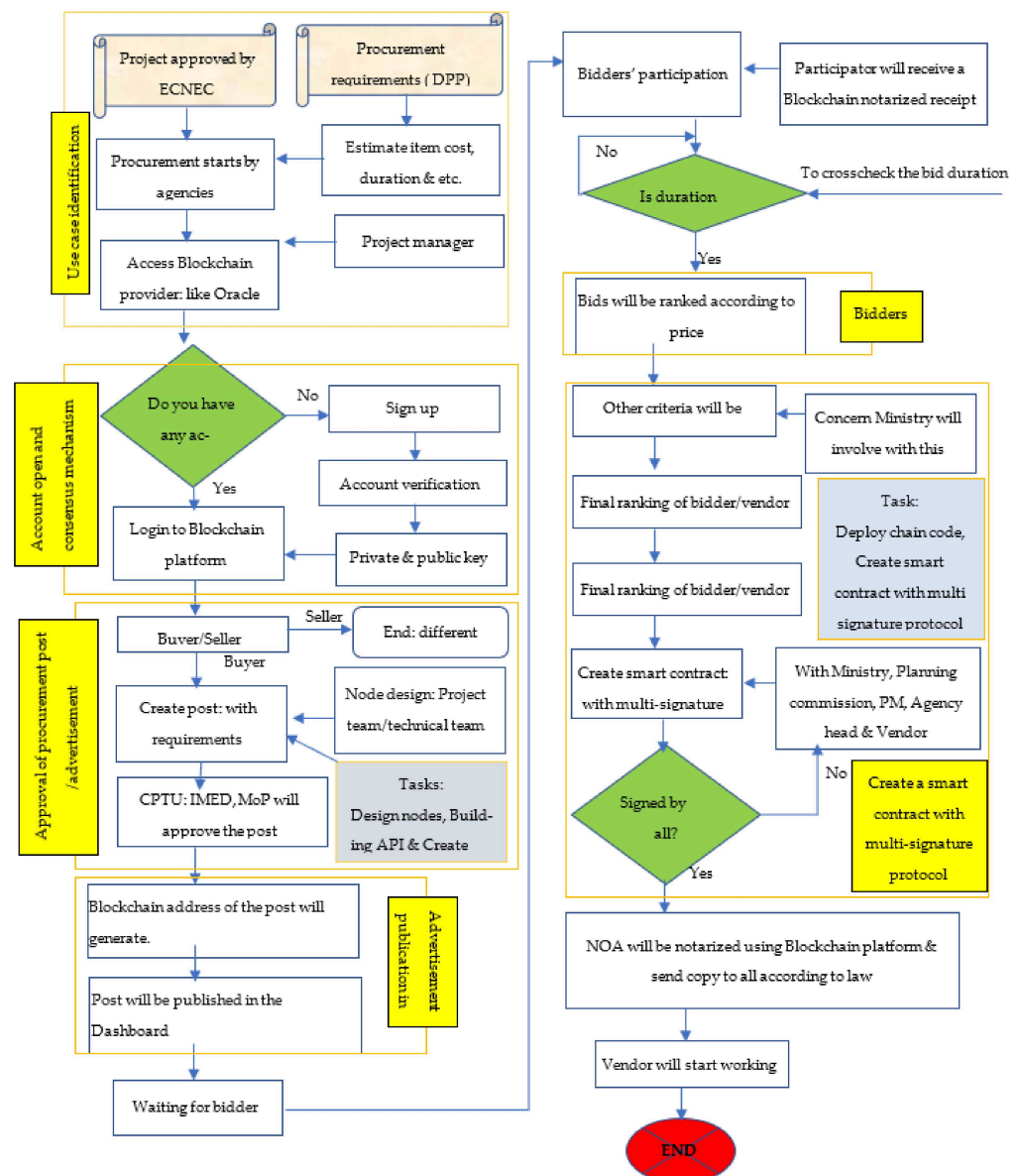


Figure 7. Conceptual framework for introducing Blockchain-based E-procurement in Bangladesh.

- (v) Building the API and creating/posting advertisements: The next step is very important as it deals with the Blockchain post based on the project requirements. An API is needed at this stage [30,59]. It may also be called the user interface. Various programming languages can be used to create the API, such as HTML5, CSS, PHP, C#, Java, Javascript, Python, Ruby, Golang, Solidity, Angular JS Nodejs, MySQL, and MongoDB [59]. A chain code is created through the API.
- (vi) Approval of procurement posts/advertisements: The project team will send a request to the CPTU (Central Procurement Technical Unit) for the approval of the post, as the CPTU controls the E-procurement of Bangladesh. The Blockchain address of the post will generate after the approval of the post by the CPTU.
- (vii) Procurement post/advertisement publication in the dashboard: Next, the advertisement will become available in the dashboard. Then, all the contractors/vendors will participate in getting the task, and the owner will wait for the bidder.
- (viii) Bidders' participation: In this stage, all the vendors will be allowed to participate in the bidding process within the allocated time. When vendors will submit their bid, then they will receive a Blockchain-notarized receipt.

- (ix) Bidders' rankings: Later, bidders will be ranked according to their price and other conditions. The project team, agency, and the concerned ministry will finalize the evaluation conditions of the vendor. Finally, the top-ranked vendor will be negotiated for the contract. If the top-ranked vendor agrees with the owner of the contract, then the vendor will be finalised [41].
- (x) Creating a smart contract with a multi-signature protocol: Deploying the chain code, the multi-signature protocol needed to create a smart contract, is done in this stage (Thio-Ac et al., 2019b). This stage is very important because all the government policies and fund release conditions will be integrated within the system, such as after the field visit of IMED, the fund will be released by the concerned ministry (if the task meets all the criteria). Otherwise, the ministry will not release the fund against the project.
- (xi) Notification of award (NOA): A NOA will be issued after creating the smart contract. The NOA will be notarized using the Blockchain platform and after that, it will be sent to all concerned stakeholders according to the law/policy of Bangladesh [41].
- (xii) Commencing the project/work package: Finally, the vendor will start working for the project according to the timeline of the project.

4.2. Future Research Agenda

The above discussion may have opened the opportunities to conduct further research, which are presented below:

- (a) Blockchain technology is a new technology. Hence, the researcher can try to find other applications of this technology which might support managing projects.

Researchers can also research private organisation projects which are using Blockchain technology for project management to explore the actual pros and cons of the technology.

- (b) ICT sector researchers can research developing the Blockchain platform and the API (Application Programming Interface) for experimenting on the overall efficiency and performance of Blockchain-based project management;
- (c) Further research can be done to develop a Blockchain-based E-procurement system for public sector projects in the context of developing countries.

5. Conclusions

The aggressive competition has shaped the need for implementing new frameworks to help organisations succeed in a project. Project implementations normally fail due to sustainable development problems that inhibit the usage levels required to facilitate successful implementation. The problems include the main reasons for delaying projects which end with a cost-overflow. It is easy to control small projects, but difficult to control large projects. The public sector invests a huge amount of money for large infrastructure-related projects through development projects. However, due to the shortcomings of the existing system, the cost and project duration increases become a common phenomenon for infrastructure-related projects in developing countries. Therefore, it is the proper time to bring in changes and to introduce new technology with the existing project management system. This paper explores the successful implementation from the Bangladesh perspective. In particular, it identifies the possible applications of Blockchain in project and procurement management and it develops a guideline to incorporate Blockchain into project management for improving the existing project and procurement management practices in developing countries.

Project management which uses Blockchain technology is known as Blockchain-based project management. This study investigates the potential use of Blockchain technology for public sector infrastructure-related projects in developing countries, especially for Bangladesh, concluding with the following statements based on the research question.

No proper evidence has found out which developing countries are using Blockchain technology for public sector infrastructure-related projects. However, it has been found that the governments of some countries are planning to use Blockchain-based project

management for E-procurement as a pilot basis, such as Mexico. Therefore, for public sector infrastructure project procurement activities, Blockchain is still in the experimental phase. Although, it has been found that many developing countries are using Blockchain technology for financial transactions. However, it is understood that currently, Blockchain technology has been practiced by many world-leading organisations/companies such as Amazon, IBM, BMW, General Electric, and Microsoft. Many other organisations are using Blockchain technology for different purposes.

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