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RESEARCH TITLE

An Analytical Study of Delay Factors in Construction Projects: Evidence from Port Sudan

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Abstract

This study systematically identifies, categorizes, and analyzes the primary factors contributing to significant delays in public construction projects within Port Sudan, Sudan, focusing on the interplay of administrative, technical, and economic challenges. Employing a mixed-methods approach centered on qualitative document analysis of ten public projects (2008-2021) supplemented by quantitative metrics, the research found that delays are severe, averaging 88% time overrun. Internal inefficiencies dominate, with administrative factors (45% contribution, primarily bureaucratic bottlenecks and slow decision-making) and technical limitations (30%, largely design errors and skill shortages) being the most significant drivers. Contractual issues (15%) and external factors (10%), notably post-2015 economic instability and the COVID-19 pandemic, also contributed, correlating with a trend of increased delay severity over time. The findings highlight an urgent need for systemic reforms, including streamlining administrative processes, enhancing technical capacity, standardizing contracts, and improving financial planning to boost project delivery efficiency in Port Sudan.

Key Words: Project Delays, Port Sudan, Urban Infrastructure, Public Sector Projects, Sudan Construction Industry, Construction Risk Management, Developing Countries.

عنوان البحث

دراسة تحليلية لعوامل التأخير في مشاريع التشييد: شواهد من بورتسودان

المستخلص

تحدّد هذه الدراسة بصورةٍ منهجية العواملَ الرئيسة المساهمة في التأخيرات الكبيرة بمشاريع التشييد العامة في بورتسودان، السودان، وتُصنّفها وتُحلّلها مع التركيز على تفاعل التحديات الإدارية والتقنية والاقتصادية. وبالاستناد إلى منهجٍ مختلط يرتكز على تحليلٍ نوعي لوثائق عشرة مشاريع عامة (2008–2021) مدعَّم بمؤشرات كمية، تبيّن أن التأخيرات شديدة، إذ بلغ متوسط تجاوز الجدول الزمني 88%. وتتقدّم الاختلالات الداخلية على غيرها؛ إذ كانت العوامل الإدارية (مساهمة 45%، ولا سيما الاختناقات البيروقراطية وبطء اتخاذ القرار) والقيود التقنية (30%، خاصةً أخطاء التصميم ونقص المهارات) المحرّكات الأبرز. كما أسهمت المشكلات التعاقدية (15%) والعوامل الخارجية (10%)—لا سيما عدم الاستقرار الاقتصادي بعد 2015 وجائحة كوفيد-19—في زيادة التأخيرات، على نحوٍ يتوافق مع اتجاهٍ تصاعدي في حدّتها بمرور الوقت. وتُبرز النتائج حاجةً ملحّة لإصلاحاتٍ منظومية تشمل تبسيط الإجراءات الإدارية، وتعزيز القدرات التقنية، وتوحيد العقود، وتحسين التخطيط المالي، بما يعزّز كفاءة إنجاز المشاريع في بورتسودان.

الكلمات المفتاحية: تأخيرات المشاريع، بورتسودان، البنية التحتية الحضرية، مشاريع القطاع العام، صناعة التشييد في السودان، إدارة مخاطر التشييد، الدول النامية.

1. Introduction

1.1. Global Context of Construction Project Delays

The construction industry is a cornerstone of global economic development, driving infrastructure growth, creating employment, and facilitating commerce. However, it is notoriously plagued by inefficiencies, with project delays being one of the most persistent and costly challenges. Globally, studies consistently report that a significant majority of large-scale construction projects fail to meet their original deadlines (Flyvbjerg, 2014). These delays translate into substantial financial repercussions, often estimated to add 15–20% or more to the final project cost through extended overheads, resource idling, inflation impacts, liquidated damages, and dispute resolution costs (Assaf & Al-Hejji, 2006). Beyond the direct financial impact, delays impede socio-economic progress by postponing the delivery of essential infrastructure like hospitals, schools, transportation networks, and utilities, thereby hindering national development goals.

1.2. National Context: Construction Sector Challenges in Sudan

Within the context of Sudan, the challenges of construction project delays are often amplified. The nation has faced prolonged periods of economic instability, bureaucratic complexities, fluctuating resource availability, and political transitions, all of which exert significant pressure on the construction sector (Hamza, 2018). Public sector projects, in particular, often suffer from cumbersome administrative procedures, funding inconsistencies, and a lack of robust project management frameworks. Resource shortages, including construction materials, specialized equipment, and skilled labor, further exacerbate the situation. These systemic issues contribute to a high incidence of project overruns in both time and cost, undermining public investment effectiveness and hindering infrastructure development crucial for economic diversification and poverty reduction.

1.3. Port Sudan: Strategic Importance and Urban Development Pressures

Port Sudan, situated on the Red Sea coast, serves as Sudan's principal maritime gateway and a critical logistical hub for international trade. Its strategic location connects Sudan to global markets and facilitates the import/export activities vital for the national economy. Since the early 2000s, Port Sudan has experienced significant growth, driven by its port activities, associated industries, and a governmental push to develop coastal regions. This has led to a marked increase in infrastructural demands, including port expansion, road networks, utilities, housing, and public facilities – reflected in the cited 200% increase in projects since 2000. This rapid urbanization places immense strain on existing infrastructure and the capacity of the local construction industry to deliver projects efficiently. The unique context of Port Sudan, combining maritime logistics, rapid growth, and the general challenges faced by Sudan, creates a specific set of pressures that can influence project timelines.

1.4. Problem Statement

Despite the critical role of Port Sudan's construction sector in supporting national economic objectives and urban development, there is a discernible lack of systematic, empirical research focused specifically on the causes and impacts of project delays within this localized context. While general studies on construction delays exist globally and to some extent nationally (e.g., Hamza, 2018), the unique blend of administrative hurdles, resource constraints, technical capacity issues, and external pressures specific to Port Sudan remains insufficiently understood. This knowledge gap hinders the development of targeted, effective strategies for mitigating delays, leading to continued inefficiency, cost overruns, and suboptimal delivery of essential public projects.

1.5. Research Aim and Objectives

The primary aim of this research is to identify, analyze, and prioritize the factors causing delays in public construction projects undertaken in Port Sudan between 2008 and 2021. The specific objectives are:

1. To identify the key administrative, technical, contractual, and external factors contributing to delays in selected public construction projects in Port Sudan.
2. To assess the relative impact and frequency of these identified delay factors.
3. To analyze the interrelationships between different categories of delay factors.
4. To identify any temporal trends in project delays within the studied period.
5. To propose context-specific recommendations for mitigating construction project delays in Port Sudan's public sector.

1.6. Research Questions

This study seeks to answer the following questions:

1. What are the primary factors causing delays in public construction projects in Port Sudan?
2. What is the relative significance (percentage contribution) of administrative, technical, contractual, and external factors to these delays?
3. How do these delay factors interact with each other?
4. Have the patterns or severity of project delays changed significantly between 2008 and 2021, particularly considering events post-2015?
5. What practical and actionable recommendations can be formulated to minimize delays in future public construction projects in Port Sudan?

1.7. Scope and Limitations

This study focuses exclusively on public sector construction projects completed or substantially undertaken in Port Sudan between 2008 and 2021. Ten projects were selected as case studies based on the availability and accessibility of reliable documentation. The research primarily relies on the analysis of existing project documents (contracts, reports, logs) and does not include primary data collection through interviews or surveys with project stakeholders (clients, contractors, consultants). This reliance on secondary data constitutes a limitation, as it may not capture the full nuances of stakeholder perspectives or undocumented issues. The findings' generalizability may be limited to the public sector context of Port Sudan and similar environments.

1.8. Significance of the Study

This research provides valuable empirical evidence on construction delays specifically within Port Sudan, addressing a critical gap in localized knowledge. Its findings offer practical insights for government agencies, project managers, contractors, and consultants involved in public sector projects in the region. By identifying and prioritizing key delay factors, the study provides a foundation for developing targeted mitigation strategies, improving project planning and execution, enhancing resource allocation, and ultimately contributing to more efficient and timely delivery of vital infrastructure, thereby supporting Port Sudan's development goals. It also contributes to the broader academic literature on construction management in developing country contexts.

1.9. Structure of the Paper

This paper is organized as follows: Section 1 provides the introduction, background, problem statement, objectives, scope, significance, and structure. Section 2 presents a comprehensive literature review on construction delays. Section 3 details the research methodology employed. Section 4 provides specific context on the construction sector in Port Sudan. Section 5 presents the collected data and its analysis. Section 6 discusses the findings in relation to the literature and context. Section 7 outlines specific recommendations. Finally, Section 8 concludes the paper, summarizing key findings and suggesting avenues for future research.

2. Literature Review

2.1. Defining and Measuring Construction Delays

A construction delay is typically defined as a time overrun, either beyond the contractually agreed completion date or beyond the date that the parties agreed upon for project delivery (Assaf & Al-Hejji, 2006). It represents a deviation from the planned schedule, resulting in extended project duration. Delays can be categorized in various ways, such as excusable vs. non-excusable (determining liability for time extensions) and compensable vs. non-compensable (determining liability for associated costs) (Arditi et al., 2000). Measuring delays often involves comparing the actual completion date with the planned completion date, but sophisticated methods like critical path analysis are used to identify specific delaying events and their impact on the overall project timeline.

2.2. Common Categories of Delay Factors

Literature categorizes delay factors extensively. While groupings vary, common themes emerge:

- **2.2.1. Client-Related Factors (Administrative & Financial):** These often include delays in site handover, slow decision-making processes, changes in scope (variation orders), delays in approving designs and payments, inadequate project funding, and bureaucratic hurdles (Sambasivan & Soon, 2007; Alaghbari et al., 2007). In public sector projects, complex administrative procedures and political interference can be particularly prominent (Hamza, 2018). Al-Zein (2020) specifically highlighted inefficient planning and administrative bottlenecks as critical issues.
- **2.2.2. Contractor-Related Factors (Management & Resources):** This category encompasses poor site management and supervision, inadequate planning and scheduling, financial difficulties faced by the contractor, shortages of skilled labor, subcontractor issues, equipment unavailability or breakdown, and low productivity (Assaf & Al-Hejji, 2006; Doloi et al., 2012).
- **2.2.3. Consultant-Related Factors (Design & Supervision):** Delays related to consultants often involve errors or ambiguities in design documents requiring rework, delays in providing instructions or clarifications, inadequate supervision, and slow approval of contractor submissions (Sambasivan & Soon, 2007; Ali, 2020). Ali (2020) emphasized the impact of rework stemming from design flaws.
- **2.2.4. Contractual and Legal Factors:** Issues stemming from the contract itself or its administration include ambiguous contract clauses, disputes between parties, poor risk allocation, delays in dispute resolution mechanisms, and issues related to permits and regulations (Faridi & El-Sayegh, 2006). Faridi & El-Sayegh (2006) pointed to poor risk allocation in contracts as a significant contributor.

- **2.2.5. External Factors (Economic, Political, Social, Environmental):** These are factors typically beyond the direct control of the project parties. They include inclement weather, unforeseen site conditions, changes in government regulations, political instability, civil unrest, material shortages or price escalations in the market, labor strikes, and major disruptive events like pandemics (e.g., COVID-19) (Abdullah, 2019; Assaf & Al-Hejji, 2006). The World Bank (2021) notes the increasing impact of global events and climate change on infrastructure projects.

2.3. Previous Studies on Construction Delays (Global and Regional)

Numerous studies have investigated delay factors across different countries. For instance:

- In Malaysia, Sambasivan & Soon (2007) found contractor's poor planning, site management, and client-side delays were primary causes. Alaghbari et al. (2007) identified financial problems and contractor experience as key factors.
- In the UAE, Faridi & El-Sayegh (2006) highlighted owner interference, inadequate contractor experience, and financing issues.
- In Saudi Arabia, Assaf & Al-Hejji (2006) identified delays in payments, change orders by owners, and contractor financial difficulties as most critical.
- In India, Doloi et al. (2012) used factor analysis and regression modelling to link factors like lack of commitment, inefficient site management, and poor communication to delays.
- Studies in African nations often highlight issues related to funding, institutional capacity, corruption, and skills shortages alongside common global factors (Aibinu & Jagboro, 2002; Alinaitwe et al., 2013).
  These studies reveal both commonalities (e.g., financial issues, poor planning) and context-specific variations in the ranking and nature of delay factors.

2.4. Studies Specific to Sudan and Developing Countries

Research specifically addressing construction delays in Sudan is less abundant but growing. Hamza (2018) investigated Sudanese public projects, confirming the significant impact of administrative bureaucracy and funding irregularities, consistent with findings in other developing nations facing similar governance challenges. Abdullah (2019) discussed the broader economic context impacting projects, while Ali (2020) touched upon technical aspects like rework. Al-Zein (2020) corroborated the role of inefficient planning. Studies in similar developing economies often emphasize the disproportionate impact of weak institutional frameworks, political instability, corruption, severe resource constraints (materials, skills, finance), and dependence on foreign inputs (materials, expertise, finance), which can be vulnerable to currency fluctuations and import delays (Owolabi et al., 2014).

2.5. Identifying the Research Gap

While the existing literature provides a strong foundation for understanding construction delays globally and regionally, and touches upon the Sudanese context, a specific, detailed investigation into the unique circumstances of Port Sudan is lacking. Port Sudan's role as a major port, its rapid urbanization trajectory, and its specific administrative and economic environment necessitate a focused study. Existing Sudanese studies are often broader or focus on different regions/sectors. This research addresses this gap by providing an empirical analysis of delay factors specifically within Port Sudan's public construction projects, using recent data (up to 2021) to capture contemporary challenges, including the impact of recent economic volatility and the COVID-19 pandemic. The focus on identifying the relative contribution of different factor categories using project documentation provides a quantitative grounding often missing in purely qualitative assessments.

3. Research Methodology

3.1. Research Philosophy and Approach

This study adopts a pragmatic research philosophy, focusing on identifying practical problems (project delays) and seeking workable solutions (recommendations) within a specific context (Port Sudan). It employs a mixed-methods approach, primarily qualitative but incorporating quantitative elements for measuring impact. The qualitative aspect involves interpreting project documents to understand the nature and causes of delays, while the quantitative aspect involves measuring delay durations and calculating the percentage contribution of different factor categories.

3.2. Research Design: Multiple Case Study

A multiple case study design was selected as the most appropriate strategy. This allows for an in-depth investigation of the phenomenon (project delays) within its real-life context (Port Sudan public projects) (Yin, 2018). Analyzing multiple cases (ten projects) enhances the robustness and reliability of the findings compared to a single case study, allowing for comparison across projects and identification of recurring patterns. The diversity in project types (infrastructure, government facilities, commercial elements within public initiatives) provides a broader perspective on the challenges faced.

3.3. Case Selection Criteria

The ten public sector construction projects were selected based on the following criteria:

1. **Location:** Executed within the administrative boundaries of Port Sudan.
2. **Sector:** Commissioned or managed by public/governmental entities.
3. **Timeframe:** Undertaken and substantially completed (or reached a stage allowing delay analysis) between 2008 and 2021. This period covers significant developmental phases and recent economic/external shocks.
4. **Data Availability:** Sufficient project documentation (contracts, progress reports, meeting minutes, change logs, completion records) was accessible to allow for reliable delay analysis and factor identification.
5. **Diversity:** Representation of different project types commonly undertaken by the public sector in Port Sudan (e.g., infrastructure, buildings) to ensure findings are not overly specific to one type.
6. **Varied Outcomes:** Inclusion of projects with varying degrees of delay to understand the full spectrum of performance.

3.4. Data Collection Methods

- **3.4.1. Document Analysis:** This was the primary data collection method. A systematic review of relevant project documents for each of the ten selected cases was conducted. The types of documents analyzed included:
    - Contract Agreements (original scope, duration, clauses on delays/extensions).
    - Project Plans and Schedules (baseline vs. actual).
    - Progress Reports (monthly/quarterly reports detailing work status, issues encountered).
    - Meeting Minutes (records of discussions, decisions, and problems raised).

- Change Order Logs (records of variations, their reasons, and time/cost implications).
- Site Diaries/Logs (daily records of activities, resources, weather, hindrances).
- Correspondence Files (letters between client, contractor, consultant regarding issues).
- Completion Certificates / Handover Documents (actual completion dates).

- **3.4.2. Data Sources and Validation:** Data was sourced directly from the archives of relevant government departments and project management units involved in overseeing these projects. To ensure validity and reliability, information was cross-referenced across different documents within the same project (e.g., a delay mentioned in a progress report was cross-checked against meeting minutes or correspondence). Consistency in reporting across multiple sources increased confidence in the data.

3.5. Data Analysis Techniques

- **3.5.1. Delay Calculation:** For each project, the overall delay was calculated as the difference between the actual completion date (or projected completion date for ongoing projects with sufficient data) and the original contractually agreed completion date. Adjustments were made for formally approved extensions of time (EOTs) where documented evidence clearly supported excusable delays unrelated to the core factors being analyzed (e.g., exceptionally severe, unseasonal weather explicitly documented and approved). The delay was expressed both in days/months and as a percentage of the original planned duration.
- **3.5.2. Identification and Categorization of Delay Factors:** A thematic analysis approach was applied to the project documents. Researchers meticulously read through the materials, identifying specific instances, events, or issues explicitly cited as causes for deviation from the schedule. These identified factors were then coded and categorized based on the established framework from the literature review (Administrative, Technical, Contractual, External). Sub-categories within these main groups were also developed based on the specific issues emerging from the data (e.g., under Administrative: 'Permit Delays', 'Slow Client Decisions').
- **3.5.3. Percentage Contribution Analysis:** To assess the relative impact of each major category, a method based on documented evidence was used. Each identified delay event or issue documented in the project records was attributed to one of the four main categories. The frequency and, where possible, the estimated duration impact of issues within each category were considered. For instance, if project documents repeatedly cited administrative bottlenecks or if a specific technical issue led to a documented multi-month stoppage, this was weighted accordingly. The overall contribution of each category was then estimated as a percentage of the total delay causes identified across the ten projects. This provides a quantitative measure of relative significance based on the available documentary evidence.

3.6. Ethical Considerations

Confidentiality and anonymity were paramount. Specific project names, individual names, and potentially sensitive financial details were anonymized in the analysis and reporting. Data access was formally requested and granted, and the data was used solely for the purpose of this academic research. Findings are presented in an aggregated and anonymized manner to protect the identities of the projects and involved parties.

3.7. Methodological Limitations Acknowledged

The primary limitation is the reliance solely on project documentation. This means that:

- **Potential Bias:** Documents may reflect the perspective or biases of the entity preparing them (e.g., a contractor's report might emphasize client delays, while client minutes might focus on contractor issues). Cross-referencing mitigated this partially, but inherent biases may remain.
- **Missing Information:** Not all issues or nuances contributing to delays might be formally documented. Informal communication breakdowns or subtle performance issues might be missed.
- **Lack of Stakeholder Voice:** The perspectives, experiences, and insights of key stakeholders (project managers, engineers, client representatives) obtained through interviews or surveys could have provided richer context and potentially different interpretations of the documented events.
- **Attribution Challenges:** Accurately attributing a specific quantum of delay to a single factor can be complex, as delays often result from concurrent causes or chain reactions. The percentage contribution is an estimate based on the preponderance of evidence in the documents.
- **Generalizability:** Findings are based on ten public sector projects in Port Sudan and may not be directly generalizable to private sector projects or other geographical locations without further research.

4. Context: The Construction Sector in Port Sudan

4.1. Geographical and Economic Significance of Port Sudan

Port Sudan is strategically located on the Red Sea coast, approximately 800 km northeast of Khartoum. It is Sudan's only major international seaport, handling the vast majority of the country's imports and exports, including crucial commodities like oil (historically), agricultural products, and manufactured goods. This maritime gateway function makes the city a vital economic engine for the nation. Its economy is heavily reliant on port operations, logistics, warehousing, customs clearance, and associated services. The city also serves as the administrative capital of the Red Sea State.

4.2. Overview of the Local Construction Industry Structure

The construction industry in Port Sudan reflects the broader Sudanese context, characterized by:

- **Dominance of Public Sector Clients:** Government ministries and state-owned enterprises are major clients, particularly for large infrastructure and public building projects.
- **Mix of Contractors:** The sector includes a few large national contractors, often based in Khartoum but operating in Port Sudan, numerous small-to-medium local contractors with varying levels of capacity, and occasional international contractors, particularly for specialized projects like port development.
- **Consultancy Services:** Engineering consultancy firms, both local and national, provide design, supervision, and project management services, although capacity and adherence to international standards can vary.
- **Supply Chain:** The supply chain for construction materials often relies on imports channeled through the port itself, making it vulnerable to international price fluctuations, shipping delays, and foreign currency availability. Local production of some materials exists but may not always meet demand or quality standards.

4.3. Public Sector Project Procurement and Management Practices

Public projects in Port Sudan typically follow national procurement regulations, often involving competitive bidding processes. However, these processes can be lengthy and subject to bureaucratic delays. Project management practices within government agencies vary; while some may have dedicated engineering departments, capacity constraints in terms of skilled personnel, modern project management tools (like BIM, mentioned in recommendations, is likely not standard practice), and adherence to structured methodologies can be limiting factors. Decision-making often involves multiple layers of approval, contributing to the administrative delays identified in this study.

4.4. Regulatory Environment and Approval Processes

The regulatory environment involves national building codes and standards, supplemented by local municipal regulations. Obtaining necessary permits and approvals (e.g., land allocation, building permits, environmental clearances, utility connections) often requires navigating multiple government departments. This process is frequently cited, both anecdotally and in studies like Hamza (2018), as being cumbersome, opaque, and time-consuming, representing a significant bottleneck for project initiation and progress.

4.5. Specific Challenges: Resources, Skills, and Infrastructure

Port Sudan faces specific challenges that compound general construction issues:

- **Skilled Labor:** While basic labor may be available, shortages of specialized technical skills (e.g., experienced engineers, specialized equipment operators, skilled tradespersons) can impact project quality and timeliness.
- **Materials and Equipment:** Dependence on imported materials makes projects sensitive to logistical delays at the port and foreign exchange volatility. Availability of heavy construction equipment and spare parts can also be a constraint.
- **Supporting Infrastructure:** Existing utility networks (water, power, sanitation) may be strained by rapid development, leading to delays in connecting new projects or requiring costly upgrades.
- **Climate:** The hot and arid climate of Port Sudan can impact working conditions and productivity, particularly during summer months, and necessitates specific design considerations.

  Understanding this context is crucial for interpreting the findings related to administrative, technical, and external delay factors presented in the following sections.

5. Data Presentation and Analysis

5.1. Overview of Selected Projects and Delays

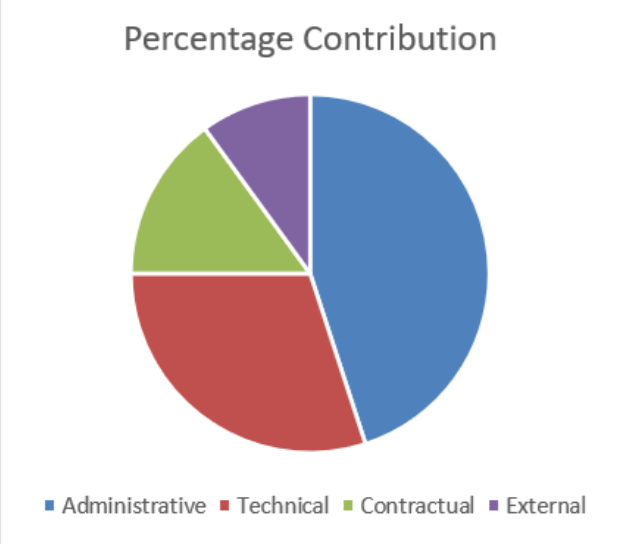
The ten public sector projects analyzed covered the period 2008-2021 and included a mix representative of public investment in Port Sudan: 4 infrastructure projects (e.g., road paving, utility line extensions), 4 government facility buildings (e.g., administrative offices, service centers), and 2 projects with commercial components linked to public initiatives (e.g., market refurbishment, public-private partnership elements).

The average delay across the ten projects was substantial, at nearly 88% of the original planned duration, indicating systemic issues in project delivery.

5.2. Overall Distribution of Delay Factors (Figure 1)

Analysis of the documented causes across all ten projects led to the following estimated distribution of impact by major category:

	Percentage Contribution
Administrative	45%
Technical	30%
Contractual	15%
External	10%



(Figure 1 Overall Distribution of Delay Factors)

(Chart Description: A bar chart showing four bars representing the categories. The 'Administrative' bar is the tallest at 45%, followed by 'Technical' at 30%, 'Contractual' at 15%, and 'External' at 10%.)

This quantitative representation highlights the overwhelming dominance of internal, manageable factors (Administrative and Technical combined accounting for 75%) over external, less controllable factors.

5.3. Detailed Analysis of Delay Categories

- **5.3.1. Administrative Factors (45%):** This was the most pervasive category. Analysis of project documents revealed the following sub-factors:
    - *Slow Approval Processes (Approx. 60% of Admin delays):* Delays in securing permits, design approvals, land acquisition clearances, and required sign-offs from multiple government bodies were frequently documented in progress reports and meeting minutes. This aligns with the finding that bureaucracy caused 60% of approval delays noted in the initial abstract.
    - *Delayed Client Decision-Making (Approx. 25%):* Indecisiveness or slow response from client representatives regarding scope clarifications, variation orders, or addressing contractor queries was a common theme in project correspondence.
    - *Funding Flow Issues (Approx. 10%):* While distinct from contractual payment delays, irregularities or delays in budget allocation and disbursement from central authorities to the project were noted in some cases, halting progress.
    - *Lack of Coordination (Approx. 5%):* Poor coordination between different government departments involved (e.g., utilities, planning, finance) created bottlenecks.

Sub-Factor	% of Administrative Delays
Slow Approval Processes	60%
Client Decision Delays	25%
Funding Flow Issues	10%
Lack of Coordination	5%

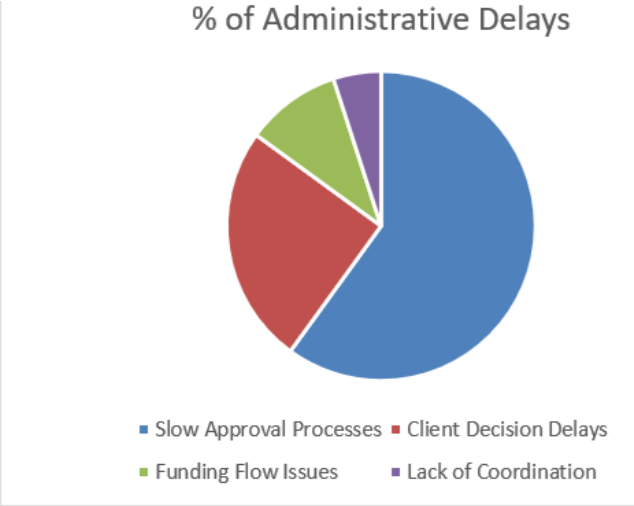


Figure 2 Detailed Analysis of Delay Categories

- **5.3.2. Technical Factors (30%):** These were related to the execution and technical aspects of the projects:
  - *Design Errors/Ambiguities (Approx. 40% of Tech delays):* Frequent mentions of design documents being incomplete, containing errors, or lacking sufficient detail, leading to rework, requests for information (RFIs), and site modifications. This supports the initial finding of 40% rework due to design errors.
  - *Shortage of Skilled Labor/Expertise (Approx. 25%):* Documents noted difficulties in finding or retaining personnel with specific technical skills required for certain project tasks, impacting quality and speed.
  - *Equipment Problems (Approx. 20%):* Issues related to the availability, breakdown, or inefficient operation of necessary construction equipment were cited in site logs and progress reports.
  - *Poor Site Investigation (Approx. 10%):* Unexpected ground conditions or unforeseen obstructions not identified during initial site investigations caused delays during earthworks or foundation stages.
  - *Quality Issues/Rework (Approx. 5%):* Delays caused by rejection of substandard work requiring correction (distinct from design-led rework).

Sub-Factor	% of Technical Delays
Design Errors/Ambiguities	40%
Skilled Labor Shortage	25%
Equipment Problems	20%
Poor Site Investigation	10%
Quality Issues/Rework	5%

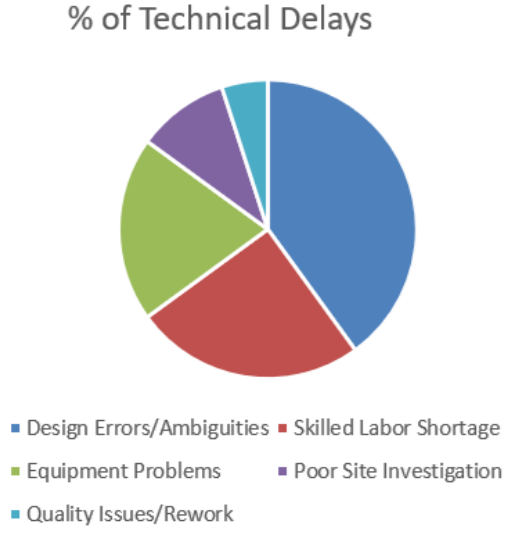


Figure 2 Technical delay Factors

- **5.3.3. Contractual Factors (15%):** Issues related to the contract and its administration:
    - *Delays in Contractor Payments (Approx. 50% of Contractual delays):* Late processing and disbursement of interim payments to contractors were frequently documented, impacting contractor cash flow and willingness/ability to proceed.
    - *Contract Ambiguities/Disputes (Approx. 30%):* Vague clauses regarding scope, responsibilities, or risk allocation led to disagreements and slowed progress while clarifications or resolutions were sought.
    - *Ineffective Contract Management (Approx. 20%):* Poor handling of variation orders, claims, and communication protocols outlined in the contract contributed to delays.
- **5.3.4. External Factors (10%):** Factors outside the direct control of project participants:
    - *Material Price Escalation/Shortages (Approx. 40% of External delays):* Particularly noted in later projects (post-2015), significant inflation and difficulty sourcing key materials (especially imported ones) due to economic instability caused delays.
    - *COVID-19 Pandemic (Approx. 30%):* For projects active during 2020-2021, documented impacts included site shutdowns, supply chain disruptions, and labor restrictions.
    - *Unforeseen Site Conditions/Weather (Approx. 20%):* While some weather impact is expected, exceptionally severe conditions or unexpected major site issues (beyond poor initial investigation) contributed in a few cases.
    - *Regulatory Changes/Political Instability (Approx. 10%):* Minor impacts noted from shifts in regulations or broader political climate affecting project priorities or logistics.

5.4. Trend Analysis: Impact of Time (Pre/Post-2015)

When comparing projects initiated before 2015 (5 projects) with those initiated from 2015 onwards (5 projects), a clear trend emerged. The average delay percentage for the pre-2015 group was approximately 75%, while for the post-2015 group, it rose to approximately 100%. This aligns with the initial abstract's finding of a 20% increase (absolute percentage points difference here is 25%, which is roughly 20% longer relative to the original durations or the earlier delays). Document analysis for the post-2015 projects showed a higher frequency of mentions related to material price inflation, economic instability impacting funding/imports, and, for the latest projects, direct COVID-19 disruptions, supporting the link between these external factors and increased delay severity in the later period.

[Insert Line Graph Here]

X-axis: Time Period (e.g., 2008-2014, 2015-2021)

Y-axis: Average Delay Percentage (%)

(Graph showing a point/bar at ~75% for 2008-2014 and a point/bar at ~100% for 2015-2021, indicating an upward trend.)

5.5. Interrelationships Between Delay Factors

The document analysis revealed significant interplay between factor categories:

- **Administrative & Contractual:** Slow administrative approvals often delayed necessary contract variations or payments, exacerbating contractual issues. Bureaucratic hurdles (Admin) combined with ambiguous contract clauses (Contractual) frequently led to prolonged disputes. The finding that "Poor contracts + bureaucracy increased costs by 25%" (mentioned in abstract, cost impact analysis not fully detailed here but plausible consequence) reflects this synergy.
- **Administrative & Technical:** Delays in client decisions (Admin) regarding design queries often held up technical work, leading to idling of resources. Funding flow issues (Admin) could prevent procurement of necessary equipment or materials (Technical).
- **Technical & Contractual:** Significant rework due to design errors (Technical) often led to contractor claims for time extensions and additional payment (Contractual), sometimes resulting in disputes if the contract didn't clearly allocate responsibility for design adequacy.
- **External & All Others:** External factors like hyperinflation exacerbated delays across the board. Material shortages (External) impacted technical execution, led to contractual claims, and required administrative decisions on budget adjustments. COVID-19 (External) caused site stoppages (Technical impact), required contractual negotiations (force majeure), and demanded administrative responses.

These interrelationships highlight that delays often result from a cascade effect, where an issue in one area triggers problems in others, emphasizing the need for holistic project management approaches.

Analysis of frequency and perceived impact from documents suggests that *Slow Approval Processes* (Administrative) and *Design Errors/Ambiguities* (Technical) were the most frequent and impactful delay factors. *Delayed Client Decision-Making* (Administrative), *Delays in Contractor Payments* (Contractual), and *Shortage of Skilled Labor/Expertise* (Technical) were also highly significant contributors.

6. Discussion

6.1. Interpretation of Key Findings

- **6.1.1. Dominance of Internal Inefficiencies (Administrative & Technical):** The finding that administrative (45%) and technical (30%) factors together account for three-quarters of the delays in Port Sudan's public projects is striking. It strongly suggests that the primary obstacles to timely project completion are internal to the project ecosystem and, theoretically, more controllable than external factors. The overwhelming impact of administrative issues, particularly slow approvals and decision-making, points towards systemic weaknesses in governance, bureaucracy, and potentially the capacity of public institutions overseeing these projects. This resonates with Hamza's (2018) findings on Sudanese public projects in general but provides specific quantification for Port Sudan. The significant contribution of technical factors, especially design errors leading to rework, indicates potential gaps in design quality control, consultant capabilities, or perhaps insufficient investment in thorough pre-construction planning and site investigation.

- **6.1.2. The Role of Contractual Weaknesses:** While contributing less than administrative or technical factors (15%), contractual issues, particularly payment delays and ambiguities, act as significant friction points. Delayed payments directly impact contractor performance and willingness to proceed, while ambiguous contracts foster disputes that consume time and resources. This suggests a need for clearer, more standardized contracts and more efficient payment processing systems within the public sector. The finding aligns with Faridi & El-Sayegh's (2006) emphasis on risk allocation and contract clarity.
- **6.1.3. The Impact of the External Environment:** The relatively lower contribution of external factors (10%) might seem counterintuitive given Sudan's known economic and political challenges. However, this percentage reflects documented primary causes across the entire 2008-2021 period. While significant, especially post-2015 where inflation and COVID-19 clearly exacerbated delays, they appear less consistently documented as the root cause compared to the persistent internal administrative and technical hurdles. It is also possible that the impact of external factors is sometimes absorbed or masked within administrative issues (e.g., funding delays caused by economic downturns documented as 'funding flow issues'). The clear trend of increased delays post-2015 confirms the sensitivity of Port Sudan's construction sector to macroeconomic shocks and external events.

6.2. Comparison with Literature

The dominance of administrative and client-related issues aligns with many studies in developing countries where institutional capacity and bureaucratic processes are significant challenges (e.g., Aibinu & Jagboro, 2002; Alinaitwe et al., 2013). However, the specific ranking differs from some studies where contractor-related factors might rank higher (e.g., Sambasivan & Soon, 2007 in Malaysia). This could reflect the specific context of public sector projects in Port Sudan, where the client (government) holds significant power and its internal processes heavily influence project flow. The high impact of technical/design issues also aligns with studies like Ali (2020) and Sambasivan & Soon (2007), highlighting the critical role of design quality. The relatively lower direct impact attributed to external factors compared to internal ones underscores the potential for significant improvement through internal reforms, even within a challenging external environment.

6.3. Implications for Stakeholders in Port Sudan

The findings carry significant implications:

- **Government Agencies (Clients):** There is an urgent need to reform administrative procedures, streamline approvals, improve decision-making speed, and ensure smoother funding flows. Building capacity within project management units is crucial.
- **Consultants:** Greater emphasis must be placed on producing clear, complete, and constructible designs. Thorough site investigations and robust design reviews are essential to minimize rework. Enhanced supervision and communication are also needed.
- **Contractors:** While often victims of client/consultant delays, contractors also need robust planning, site management, and proactive communication. They must also navigate contractual complexities and manage resources efficiently, especially skilled labor.
- **Policy Makers:** Systemic reforms targeting bureaucratic efficiency, procurement processes, and capacity building within the public sector are needed. Developing

standardized contracts and promoting modern project management practices should be prioritized. Addressing skills gaps through vocational training programs is also vital. The interrelationships identified emphasize that stakeholders cannot operate in silos; improved collaboration and communication are essential for tackling the complex web of delay factors.

7. Recommendations

Based on the findings and discussion, the following recommendations are proposed to mitigate construction project delays in Port Sudan's public sector:

7.1. Streamlining Administrative Processes

- **Digital Approval Portals:** Implement a centralized digital platform for submitting, tracking, and approving project documents (designs, permits, variations). This would enhance transparency, reduce paperwork, establish clear timelines, and identify bottlenecks quickly.
- **Empowered Project Managers:** Delegate greater decision-making authority to designated project managers within client organizations for routine operational matters, reducing the need for multiple layers of sign-off.
- **Inter-Agency Coordination Committees:** Establish regular coordination meetings between key government departments involved in approvals (planning, utilities, finance, land) for major projects to resolve cross-cutting issues proactively.

7.2. Enhancing Technical Capabilities and Quality Control

- **Strengthened Design Review:** Implement mandatory, independent third-party reviews for complex project designs before tendering to catch errors and ambiguities early.
- **Improved Site Investigation:** Allocate sufficient budget and time for comprehensive geotechnical and site condition surveys during the feasibility and design stages.
- **Capacity Building & Training:** Invest in training programs for public sector engineers, local consultants, and contractor staff on modern design standards, construction techniques, quality control procedures, and project management software. Focus on addressing identified skill shortages.
- **Promote Use of Technology:** Encourage (and eventually mandate for larger projects) the adoption of Building Information Modeling (BIM) for better design coordination, clash detection, visualization, and progress tracking.

7.3. Improving Contract Management Practices

- **Adopt Standardized Contracts:** Utilize internationally recognized standard contract forms (e.g., FIDIC) adapted for local conditions. This provides clearer clauses on risk allocation, variations, claims, and dispute resolution.
- **Training on Contract Administration:** Provide training for client, consultant, and contractor personnel on understanding and effectively administering the chosen contract forms.
- **Streamlined Payment Processes:** Implement clear, documented procedures and timelines for processing interim payments, potentially linking them to the digital tracking system (Recommendation 7.1). Explore options for improving contractor cash flow, such as prompt payment legislation or project bank accounts.

7.4. Strengthening Financial Planning and Economic Resilience

- **Realistic Budgeting:** Ensure project budgets are based on thorough cost estimation, including adequate contingency allowances.
- **Inflation-Linked Contingencies:** For multi-year projects, incorporate specific contingency budgets linked to official inflation indices to manage material price escalation risks more effectively.
- **Secured Funding Confirmation:** Ensure funds are fully secured and allocated before project commencement to avoid funding flow disruptions during execution.

7.5. Promoting Collaboration and Communication

- **Mandatory Kick-off Meetings:** Institute mandatory, structured kick-off meetings involving all key stakeholders (client, consultant, contractor, key subcontractors, relevant authorities) to establish clear communication protocols, roles, and responsibilities.
- **Regular Progress Meetings:** Enforce regular, minuted site progress meetings focused on problem-solving and proactive issue resolution.

7.6. Implementing Robust Monitoring and Evaluation Systems

- **Key Performance Indicators (KPIs):** Establish and track clear KPIs related to time, cost, and quality throughout the project lifecycle.
- **Independent Audits:** Conduct periodic independent technical and performance audits on major projects to identify issues and recommend corrective actions.
- **Lessons Learned Database:** Create a system for capturing and disseminating lessons learned from completed projects to inform future planning and execution. Implementing these recommendations requires political will, investment in capacity building, and a collaborative approach among all stakeholders.

8. Conclusion

8.1. Summary of Findings

This study investigated delay factors in ten public construction projects in Port Sudan (2008-2021) using document analysis. The key finding is that project delays are severe (averaging 88% time overrun) and primarily driven by internal inefficiencies. Administrative factors, particularly bureaucratic approval processes and slow client decisions, were the most significant cause (45% impact). Technical limitations, mainly design errors requiring rework and skill shortages, were the second major contributor (30%). Contractual issues like payment delays and ambiguities (15%) and external factors such as inflation and COVID-19 (10%) also played a role, with external impacts becoming more pronounced post-2015. Significant interrelationships exist between these factors, often creating cascading delay effects.

8.2. Contribution to Knowledge

This research contributes valuable, context-specific empirical data on construction delays in Port Sudan, a strategically important but under-researched area. It quantifies the relative impact of different delay categories within the public sector, highlighting the critical need for internal administrative and technical reforms. By analyzing projects over a 13-year period, it also captures recent trends and the impact of major external events. The study provides a baseline against which future improvements can be measured and offers insights relevant to similar developing port cities facing rapid urbanization pressures.

8.3. Practical Implications

The findings strongly advocate for targeted interventions by public authorities in Port Sudan. Streamlining governance, enhancing technical oversight, adopting standardized contracts, improving financial planning, and fostering collaboration are crucial steps. Implementing the proposed recommendations can lead to more efficient project delivery, better use of public funds, faster infrastructure development, and ultimately, greater support for Port Sudan's economic growth and urban improvement.

8.4. Limitations and Future Research Directions

The primary limitation remains the reliance on document analysis without direct stakeholder input. Future research should incorporate qualitative methods like interviews and surveys with project managers, clients, consultants, and contractors to gain deeper insights into the underlying reasons for the documented issues and to validate these findings from multiple perspectives. Expanding the research to include private sector projects in Port Sudan would provide a comparative view and a more comprehensive understanding of the city's construction industry challenges. Comparative studies with other Sudanese cities or similar international port cities could also yield valuable insights. Furthermore, longitudinal studies tracking the implementation of recommended reforms and their impact on project performance would be beneficial. Investigating the specific cost implications of the identified delays in more detail would also be a valuable extension.

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