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Analyzing the Impact of Contract Amendments on Climate Resilient Large Water Supply Project in Nepal

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Abstract

Water supply infrastructure plays a critical role in national development, public health, and climate adaptation of Nepal. Climate resilient water supply projects, specially launched in complex ecological and socio political contexts, demand robust contract management to achieve timely, cost-effective, and high quality results. However, frequent contract amendments particularly Extensions of Time (EoTs) and Variation Orders (VOs) often undermine project outcomes. Despite their significance, some empirical evidence exists on their causes and mitigation in Nepal's water sector.

This study explore the nature, frequency, and determinants of contract amendments across 54 water supply projects managed by the Project Management Office (PMO) under the Climate Resilient Water Supply Project (CRWSP) of Nepal. A mixed methods approach was adopted, using secondary data from project documents, amendment logs, and Bills of Quantities (BoQs), along with primary data from Key Informant Interviews (KIIs) with experienced project managers and engineers.

Resurch findings indicate that 79.63% of the projects experienced at least one amendment, often involving both EoTs and VOs. EoTs were primarily driven by external factors such as pandemics like COVID, extreme weather, political disruptions, and material or labor shortages. VOs resulted largely from design flaults, additional work needs, administrative inefficiencies, and inaccurate BoQs. These issues reflects systemic shortcomings in planning, risk assessment, and stakeholder coordination.

To address these challenges, the study proposes some important strategies including rigorous design reviews, BoQ validation, digital contract management systems, risk registers, and synchronized project scheduling for the mitigation. The findings offer actionable insights for strengthening contract governance and improving delivery of water infrastructure in Nepal.

Keywords: *Climate resilient infrastructure, contract amendments, contract management, Extension of Time (EoT), Variation Orders (VOs)*

1. Introduction

Water supply infrastructure plays a vital role in advancing national development, public health, and climate adaptation in Nepal. In recent years, emphasis has shifted toward the construction of large scale, climate resilient water supply projects to withstand increasing environmental stressors and socio economic demands. These projects, typically implemented in geographically diverse and politically sensitive regions, require robust contract management mechanisms to ensure that quality, cost, and time objectives are achieved. However, in Nepal, the performance of such projects is frequently hampered by contract amendments especially due to Extensions of Time (EoTs) and Variation Orders (VOs) which delays, increase project costs, and diminish overall effectiveness (Bhattarai, 2023).

Successful execution of water infrastructure projects depends on pre construction planning, technical readiness, administrative efficiency, and risk assessment. Contract amendments are often characteristic of underlying systemic issues such as incomplete designs, inaccurate Bills of Quantities (BoQs), weak supervision, and external disruptions including extreme weather events and political interference. These challenges are compounded by Nepal's federal governance structure, where institutional coordination, policy alignment, and local stakeholder engagement are still evolving (Shukla, 2019).

International studies reveal that more than 70% of infrastructure projects globally undergo contract amendments due to site conditions, design errors, administrative delays, or stakeholder pressures (Malatesta & Smith, 2019; Al-Hejji, 2006). Such amendments while legally permissible under instruments like FIDIC and Nepal's Public Procurement Act (PPA, 2007) is poorly managed, leading to disputes and reduced accountability. Literature further suggests that weak contractual governance, in combination with limited capacity at the project level, accelerates cost overruns and timeline extensions in lowand middle income countries (Frederiksen et al., 2021; Harhad, 2018).

In Nepal, delays in water supply infrastructure are frequently linked to low bidding practices, budgetary constraints, environmental disruptions, and insufficient human resources. These issues not only affect short term implementation but also compromise the long term sustainability of the infrastructure. Inadequate systems for tracking and managing contract changes can result in substandard construction, stakeholder dissatisfaction, and reduced resilience of the water supply system (Laryea, 2020).

While several studie's findings address project delays in Nepal, few have systematically analyzed the frequency, nature, and causes of contract amendments particularly in the context of climate resilient water supply projects of Nepal. This study support to fills that gap by conducting indepth examination of 54 projects under the Climate Resilient Water Supply Project (CRWSP), managed by the Project Management Office (PMO) and the Department of Water Supply and Sewerage Management (DWSSM). It uses a combined methods approach involving both document review and qualitative interviews.

This research aims to understand how contract amendments affect key performance indicators such as project duration, cost efficiency, and service quality. It also proposes actionable corrective measures for improving contract management and project governance in Nepal's water supply infrastructure development sector.

Specific Objectives

i. To identify and classify the types and frequencies of contract amendments occurring during the project implementation phase.

ii. To analyze the key factors contributing to contract amendments during the implementation phase.

iii. To recommend effective mitigation measures for minimizing the occurrence and impact of contract amendments.

2. Materials and Methods

2.1 Research Design

This study adopted a mixed methods research design aligned with the three specific research objectives. The research design combined both quantitative and qualitative data to enhance the strength of findings. Quantitative methods support to determine the frequency and patterns of contract amendments, while qualitative methods provided expert insights into their causes and mitigation measures for contract amendments. The approach followed a sequential model starting with document analysis, followed by expert interviews, and then triangulation through literature.

2.2 Methodological Framework

The research framework was structured to explicitly link each research objective with corresponding data sources, collection methods, and analysis strategies. Framework guided the integration of empirical and experiential knowledge.

2.3 Study Area and Scope

The scope of this study includes 54 climateresilient water supply projects implemented under the Department of Water Supply and Sewerage Management . These projects cover the area of the mountain, hill, and Terai regions of Nepal, providing insights into diverse terrain challenges. only the project selection was guided by project expenditure size (over NPR 2 million), geographic spread, and data accessibility.

2.4 Data Sources

2.4.1 Primary Data

Primary data was collected through Key Informant Interviews (KIIs) with engineers, procurement experts, and officials involved in project management. These interviews explored the root causes and mitigation strategies and measures of contract amendments, especially by Extensions of Time (EoTs) and Variation Orders (VOs).

2.4.2 Secondary Data

Secondary data included project contracts, BoQs, amendment logs, audit reports, and progress documents of 54 projects. This data supported to quantify amendment types, frequencies, and patterns.

2.5 Sampling Techniques

Purposive sampling was conducted to identify key respondents to meet the research objectives. Selected projects ensured geographic diversity.

2.6 Data Analysis

Data analysis followed a thematic approach. Secondary data were collected based on amendment type, cause, timing, and impact. Primary data were collected through KII and analyzed for key themes around contract management and mitigation measures for the proble occured. Chart and tables were used to depict amendment distributions and trends.

Table 1: Research Objectives to Methodological Inputs and Outputs

Objective	Data Source	Method	Output
Identify amendment types & frequency	*Project documents*	*Quantitative analysis*	*Classification of EoTs & VOs*
Analyze causes	*Project Document/ Literature review*	*Quantitative analysis/ Thematic coding*	*Root cause patterns*
Recommend mitigation	*KIIs & literature review*	*Qualitative synthesis*	*Practical strategies*

3. Results and Discussion

This chapter presents analysis of both secondary and primary data related to 54 large climate resilient water supply projects of Nepal. Secondary data, sourced from project documents under the Project Management Office (PMO) of the ClimateResilient Water Supply Project (CRWSP), included progress reports, amendment logs, and financial records. Primary data were gathered through Key Informant Interviews with professionals experienced in contract management within DWSSM and CRWSP projects. The analysis addresses the types, causes, and impacts of contract amendmentsEoT and Vo. Results are visually presented using tables, charts, and diagrams for clarity. KII insights complement these findings, offering practical recommendations to reduce amendment frequency and enhance project performance. Together, this mixed methods approach the analytical basis for the discussions.

3.2 Contract Amendment Types and Frequency

Figure 1 illustrates the distribution of contract amendment types and their respective frequencies across the 54 climate-resilient water supply projects reviewed. The data reveal that the highest number of amendments occurred in projects that involved both Extension of Time (EoT) and Variation Orders (VO). A total of 25 projects fall under this dual category, with a cumulative 33 VOs and 65 EoTs recorded. This trend highlights that, most of the cases, changes to both project duration and scope simultaneously while water supply infrastructure development.

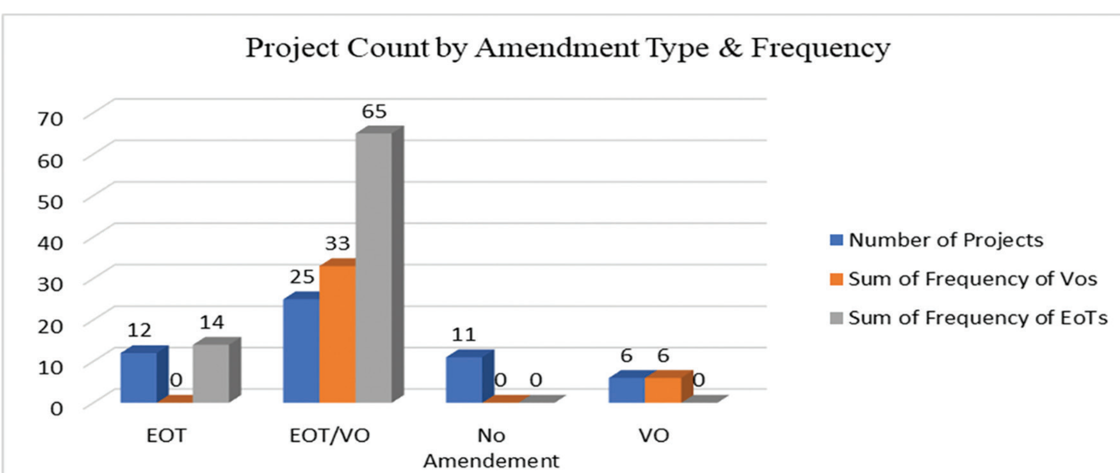

Figure 1: Types & Frequency of amendment

3.2.1 Extension of Time (EoT) Days Analysis

EoT analysis from 54 climate resilient water supply projects explored significant delays, with over 80% of projects experiencing at least one amendment. The most frequent delay range was 180- 269 days (19 numbers of EoTs across 12 projects), indicating moderate-term disruptions. Shorter delays (90- 179 days) appeared in 9 projects, while longer delays of 360- 989+ days affected multiple projects, including two exceeding 1,000 days.

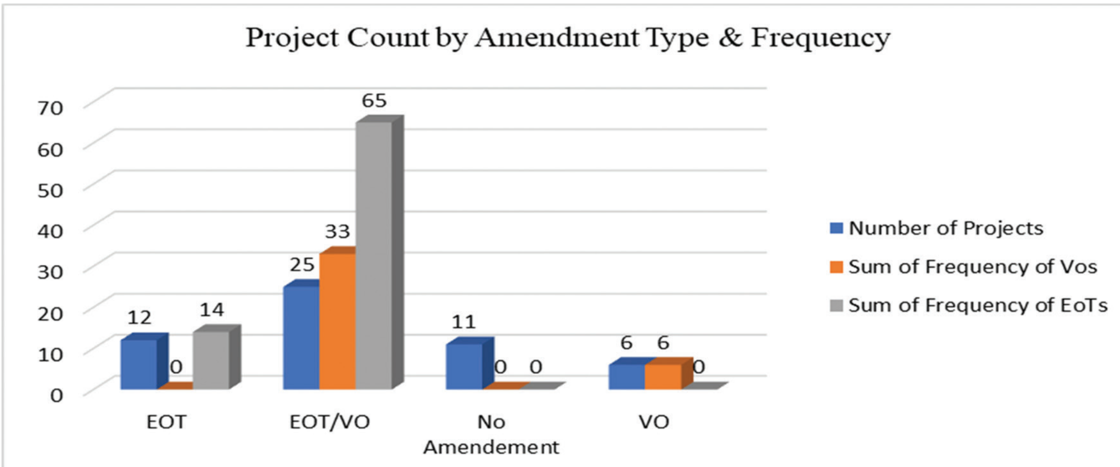

Figure 2: Types & Frequency of amendment

These delays reflect chronic challenges monsoon impacts, design deficiencies, procurement issues, and poor inter-agency coordination consistent with global findings on underperforming infrastructure projects (Flyvbjerg, 2014; World Bank, 2020; Gamil & Alhagar, 2020). Prolonged EoTs further highlight the risk of planning and administrative inefficiencies (Love et al., 2015; Amoatey et al., 2017).

4.2.1 Distribution and Frequency of Variation Order (VOs)

Figure 3 illustrates the distribution of VOs across 54 climate resilient water supply projects. Out of these, 31 projects recorded 39 times of VOs, confirming that scope changes affected over half of all projects. The most common range was 1015% scope change (20 VOs in 14 projects), followed by 5–10% (10 VOs) and 0–5% (8 VOs). One project even reported a negative VO (−5 to 0%), indicating a scope reduction.

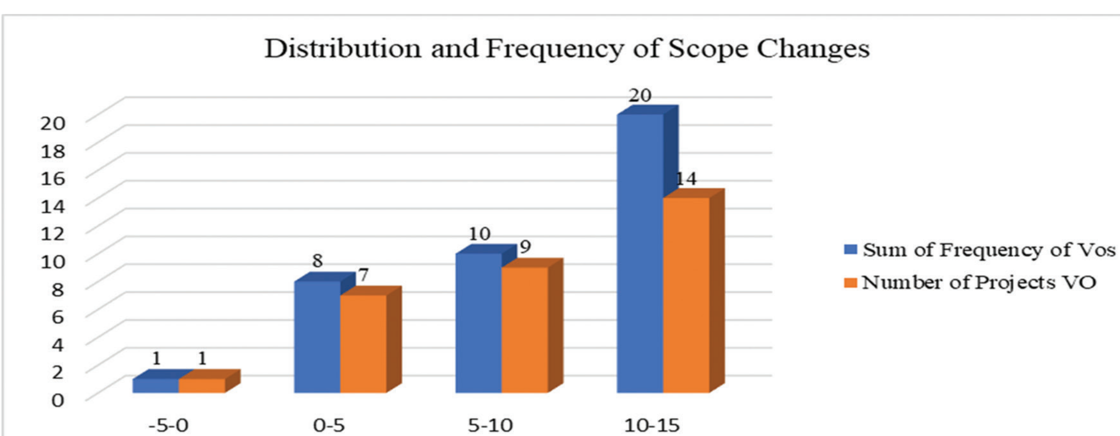

Figure 3: Distribution and Frequency of Scope Changes

These VOs reflect the challenges such as unforeseen site conditions, late design clarifications, and evolving technical needs. While some changes were minor, others had significant cost and time implications. Poorly managed projects VOs exploure the risk of delays, disputes, and cost overruns. This underscores the need for robust planning, stakeholder engagement, accurate designs, and flexible contract clauses to absorb such variations (Arain & Pheng, 2005; Chan & Kumaraswamy, 1997). Effective VO management enhances adaptability, budget control, and overall project success.

4.2.2 Extension of Time (EoT) Days Analysis

Figure 4 shows varied EoT durations across 54 water supply projects. The 180-269 day range was most frequent, with 19 EoTs in 12 projects, indicating moderate delays often driven by monsoon impacts, design revisions, or administrative bottlenecks. The 90-179 day range (10 EoTs) reflects short term issues like mobilization or procurement delays, while longer delays 360-449 days (14 EoTs), 720- 809 days (13 EoTs), and even beyond 990 days point to severe disruptions, including site complexity, institutional lag, or external shocks.

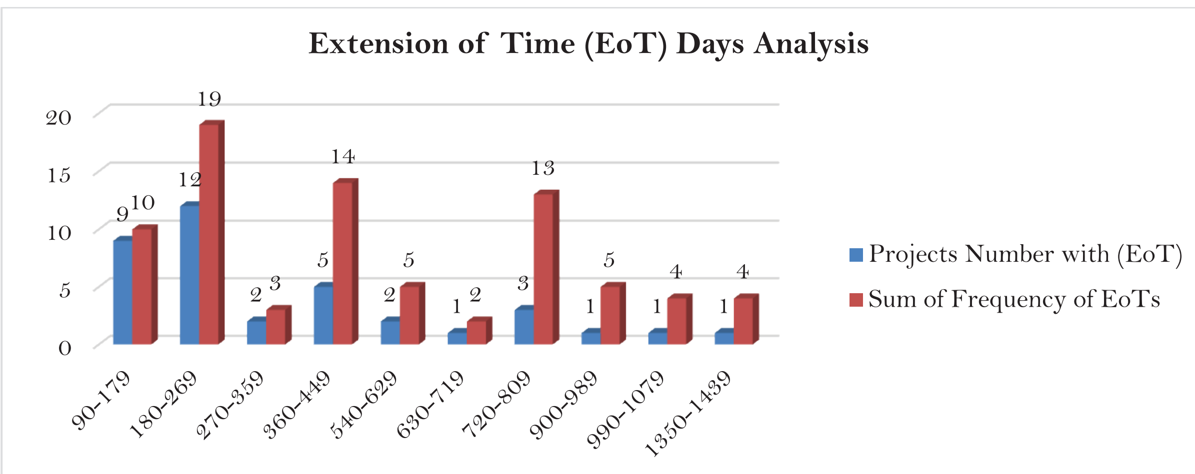

Figure 4: Extension of Time (EoT)

These findings emphasize the need for realistic scheduling, comprehensive risk assessments, and flexible contract provisions (FIDIC, 2017). While moderate delays are common, some projects face prolonged setbacks, highlighting gaps in planning, coordination, and responsiveness. Strengthened contract management and early stage mitigation planning.

4.2.3 Relationship Between EoTs and VOs

Figure 5 illustrates the interplay between Extension of Time (EoT) and Variation Orders (VOs) across 54 climate resilient water supply projects. The most frequent category EoTs caused by VOs was found in 18 projects (33%), indicating that one third of delays were directly linked to scope modifications, often due to inadequate design, evolving technical needs, or stakeholder revisions. 12 projects (22%) had EoTs unrelated to VOs, reflecting delays from weather events, procurement lags, or contractor inefficiencies.

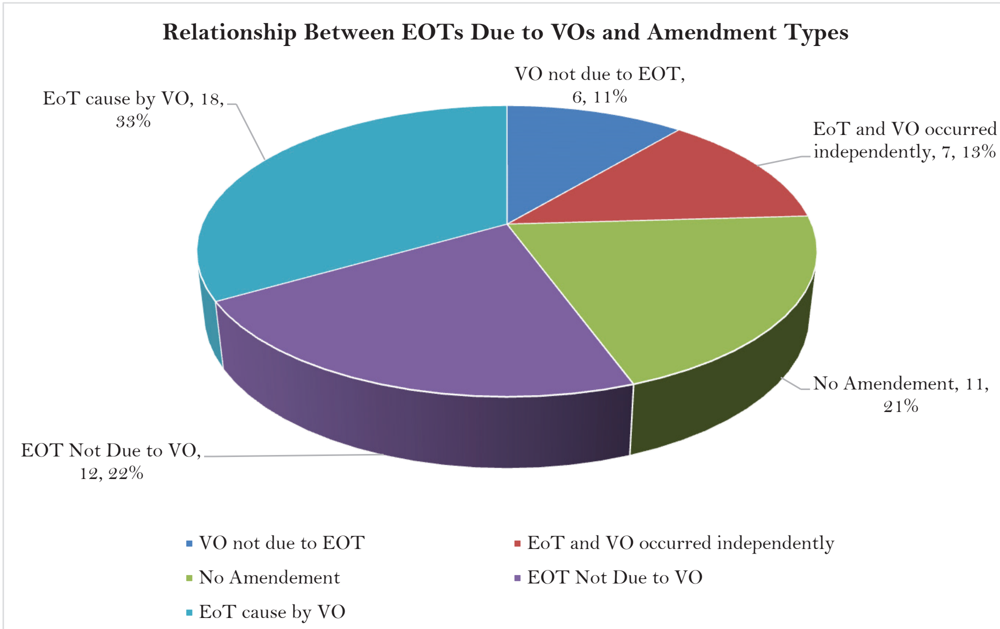

Figure 5: Relationship Between EOTs Due to VOs and Amendment Types

Interestingly, 11 projects (21%) had no amendments,. Meanwhile, 6 projects (11%) experienced VOs without EoTs.. Another 7 projects (13%) recorded both VOs and EoTs independently. 56% of projects had at least one amendment, and 33% exhibited a direct link between scope change and schedule delay affirming the global trend that poorly managed VOs are a significant contributor to project overruns (Olawale & Sun, 2010)..

4.3 Factors Contributing Variation Orders (VOs)

Figure 6 illustrates that the leading cause of VOs was design related issues (36 cases), including errors, omissions, and unforeseen site conditions. This was followed by additional requirements (21 cases) and missing BoQ items (16 cases), indicating gaps in planning and scope definition.

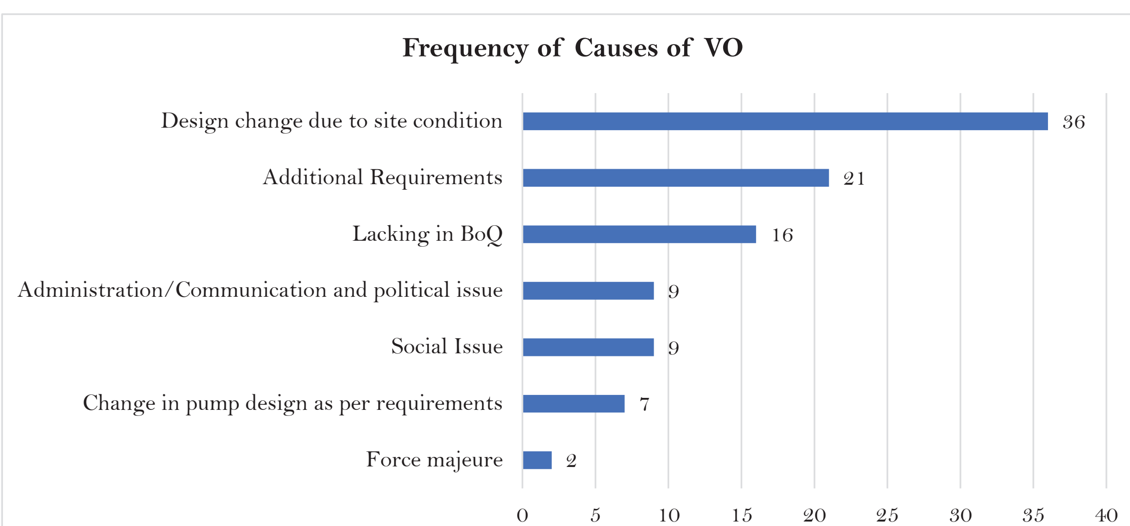

Figure 6: Frequency of causes of Variation Order

Other contributing factors included administrative/political delays (9), social issues (9), pump design revisions (7), and force majeure events (2). These findings underscore the importance of robust design, risk assessment, and stakeholder engagement.

4.3.1 Frequency of Sub-Causes for VOs due to Design Change

Figure 7 highlights the key sub causes of design related VOs. The most frequent was quantity adjustments due to site conditions (11 cases), followed by anchorage/support block requirements (10) and protective structure additions (7). Other causes included pipeline extensions (3), unclear drawings (2), pipe alignment changes (2), and sump well revisions (1). These findings reflect shortcomings in initial design, planning, and site assessment. .

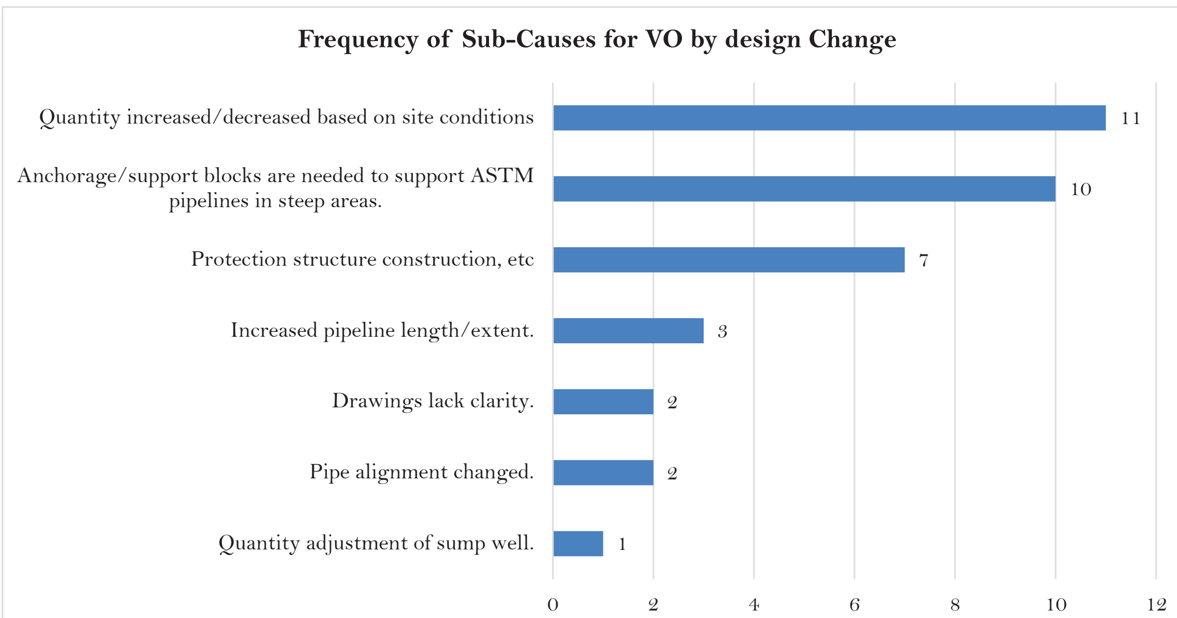

Figure 7: Frequency of Sub-Causes for VO by design Change

4.3.2 Frequency of Sub-Causes for VOs due to Additional Requirements

Figure 8 shows that the most frequent sub causes of VOs due to additional requirements were extra landscaping works, pipe network extensions, and sump well adjustments, each occurring 4 times. These were caused by guard house additions (3) and office buildings (2). Less frequent additions included toilets, electromechanical components, and new structural types (e.g., gabion walls, ferro-cement tanks).

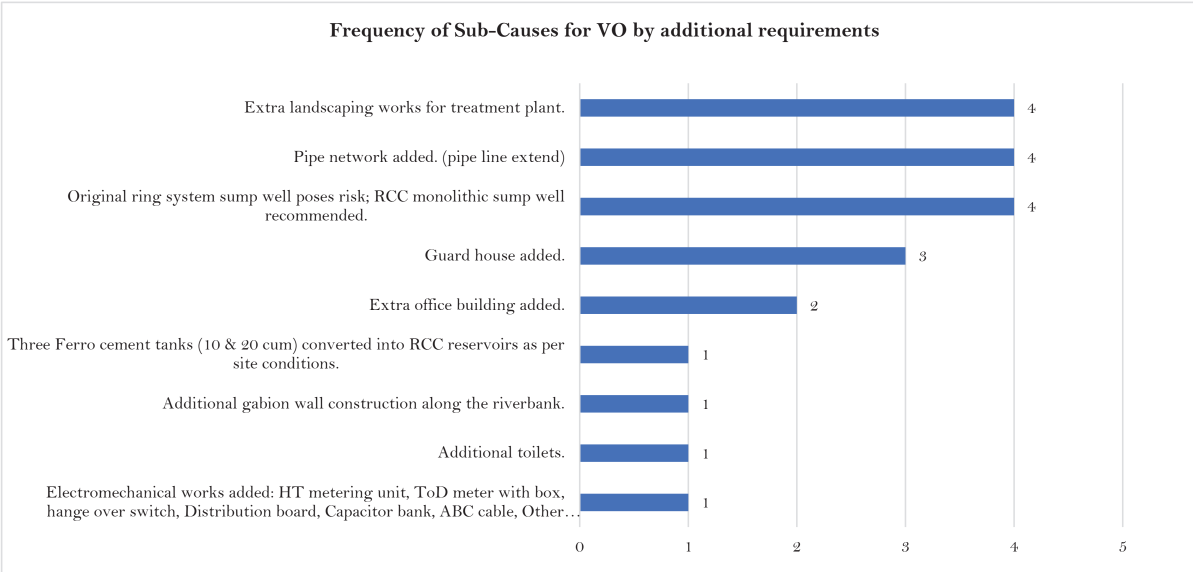

Figure 8: Frequency of Sub-Causes for VO due to additional requirements

These findings reflects on site needs and stakeholder demands not fully captured during initial planning. To reduce such VOs, early need assessments and comprehensive stakeholder consultations are also essential.

4.3.3 Frequency of Sub-Causes for VOs Due to Lacking in BoQ

Figure 9 highlights that the most frequent BoQ related cause of VOs was due to missing items in design and BoQ (8 cases), indicating systemic lapses in early project documentation. Other issues included missing washout items in RVT structures (4), fitting variations for pumps (2), and omission of soak pits and fencing (1 each).

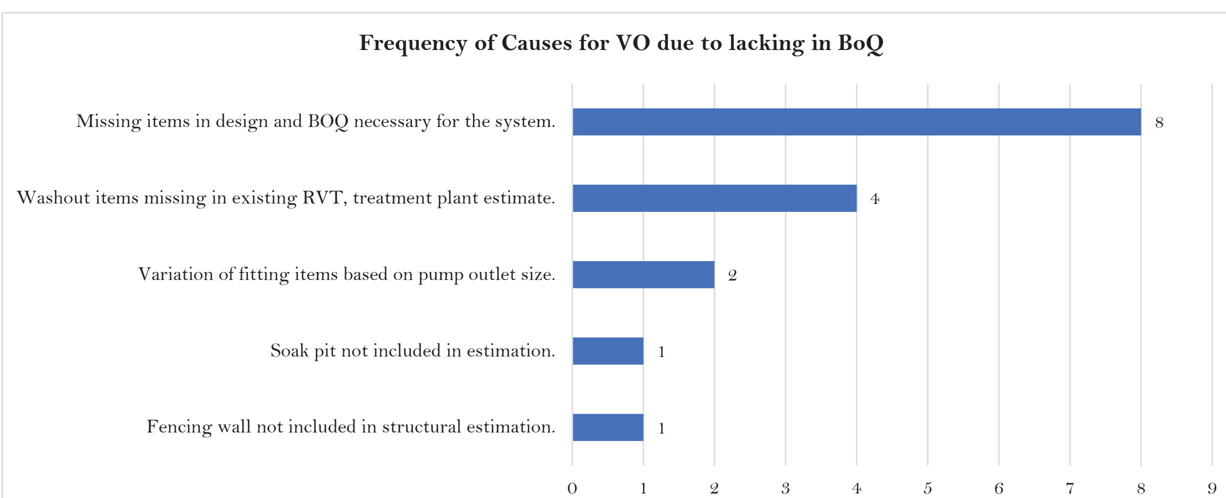

Figure 9: Frequency of Sub-Causes for VO due to lacking in BoQ

These findings underscore the need for site soecific BoQ preparation, cross disciplinary design checks, and quality assurance. Use of standardized BoQ templates, third party reviews, and digital design tools like BIM can support to identify omissions early, reducing contract amendments and enhancing delivery performance.

4.3.4 Sub-Causes for VOs due to Administration, Communication, and Political Issues

Figure 10 shows that 13 projects faced VOs due to administrative or political directives most notably from the Nepal Electricity Authority (NEA), which instructed changes such as replacing standard lines with insulated ACSR conductors. These externally driven changes, affecting 24% of projects.

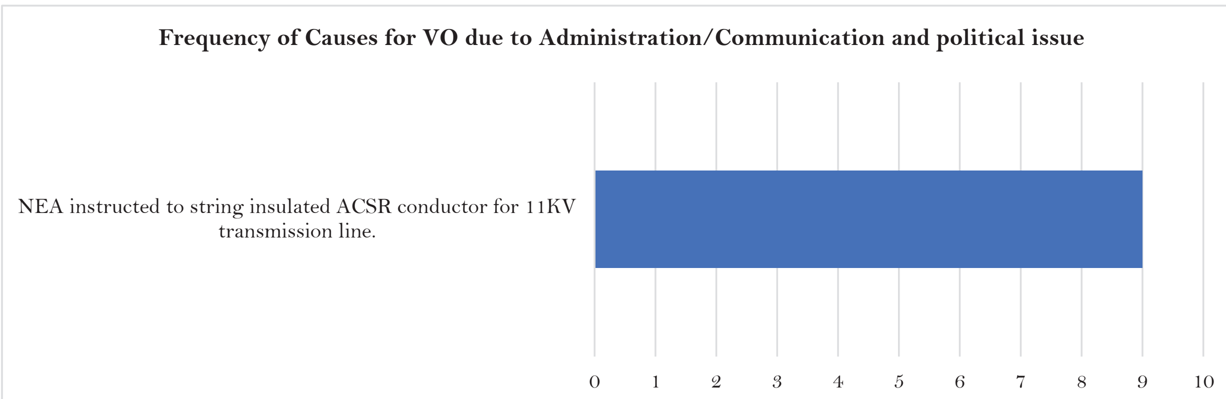

Figure 10: Sub-Causes of VO due to Administration/Communication and political issue

Such VOs underscore the need for early regulatory coordination, flexible contract clauses, and well-documented stakeholder engagement..

4.3.5 Frequency of Sub-Causes for VOs Due to Social Issues

Figure 11 shows that the most frequent social related VO cause was pipe alignment changes (4 cases), often due to land disputes or local resistance. Other causes included pipeline extensions (2), social tensions (2), and construction material shortages (1).

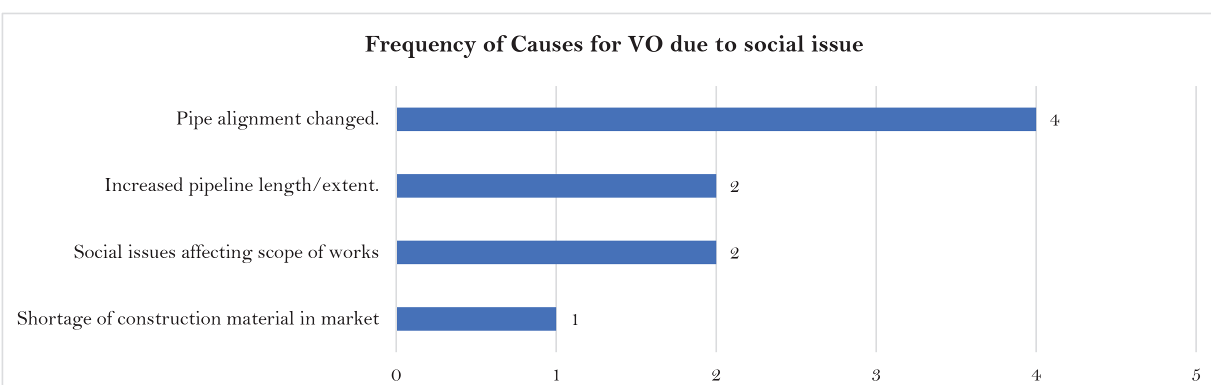

Figure 11: Frequency of Sub-Causes for VO due to social issue

These findings highlight the role of sociocultural factors in shaping project scope and timelines..

4.3.6 Frequency of Sub-Causes for VOs due to Change in Pump Design

Figure 12 shows that the most frequent pump related VO cause was redesign due to head and discharge differences (4 cases), indicating inadequate hydraulic planning. Other causes included electromechanical component changes (2) and full system redesigns (1).

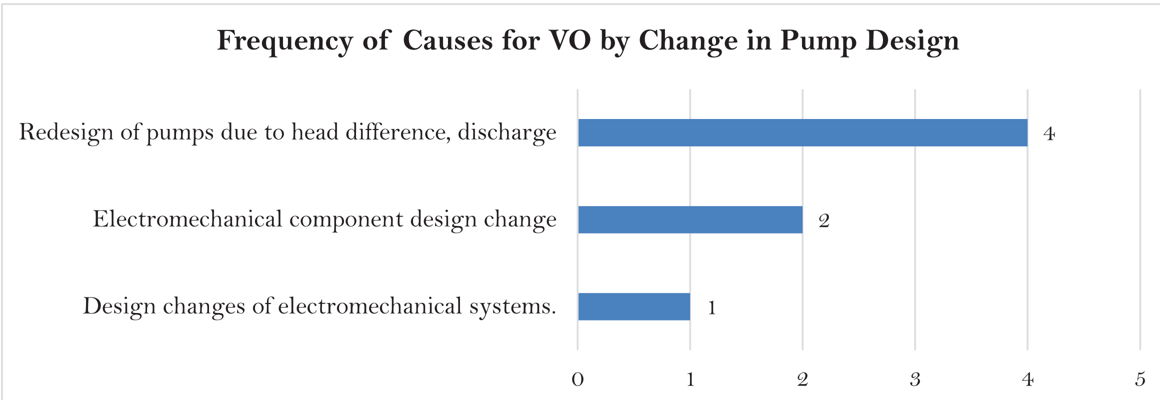

Figure 12: Frequency of Causes for VO due to Change in Pump Design

These issues emphasize the need of hydraulic modeling, multi disciplinary coordination, and early validation of electromechanical specifications..

4.3.7 Frequency of Causes for VOs Due to force Majeure

As shown in Figure 13, only one VO was caused by a force majeure event flooding. However, its impact was significant, requiring major design changes including a 200 m³ RVT, RCC dam, guard house, and extensive site protection works.

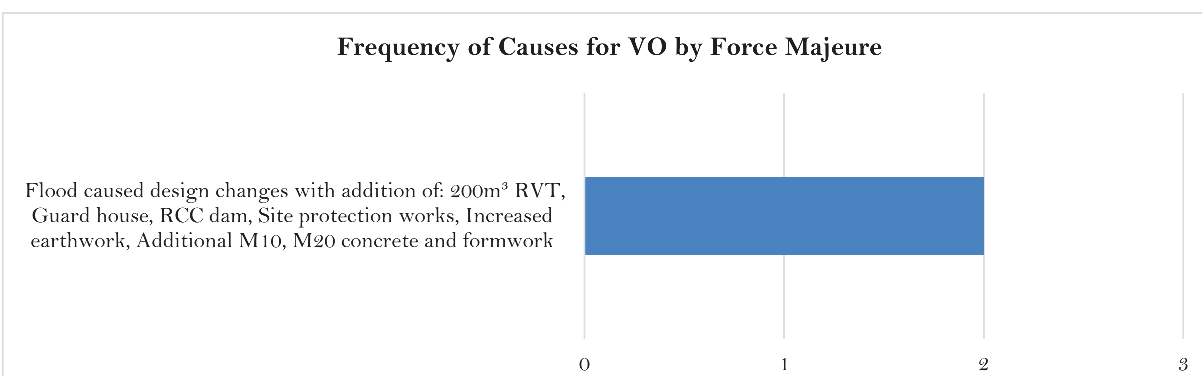

Figure 13: Frequency of Causes for VO by Force Majeure

Though rare, such events highlight the vulnerability of infrastructure to extreme climate risks..

4.3.8 Triangulated Analysis of Causes of Variation Orders

Triangulated findings indicate that design changes due to site conditions is the majour cause of Variation Orders (VOs), confirming misalignment between design assumptions and field realities. This is followed by additional stakeholder demands, BoQ omissions, and administrative or political interference. Less frequent but impactful causes include social obstacles, pump redesigns, and force majeure.

Table 1: Triangulated Discussion with Literature-Based Causes of Variation Orders (VOs)

S.N.	Cause Category	Literature Support Causes	Key Supporting source References
1	Design Issues	- Errors and omissions in design - Design changes during implementation - Inadequate/poor working drawings - Inadequate scope definition - Design complexity - Inaccurate or copied BoQs - Consultant design reviews mid-project	(Kandel, 2025), (Pokharel & Joshi2, 2020), (Hashim, Bilal, Sohail, & Shail, 2014), (Mishra, Korala, Dhungana, Pokharel, & Khadka, 2021)
2	Additional Work Requirements/ Client-Initiated Changes	- Change of plan/scope by owner - Substitution of materials - Additional work requests - Poor project objectives - Financial constraints or delays - Impediments in decision-making	(Kandel, 2025), (Enshassi, Arain, & Al-Raee, 2010), (Mishra, Korala, Dhungana, Pokharel, & Khadka, 2021)
3	Administrative/ Political/ Communication	- Lack of competent project/ construction manager - Defective workmanship - Financial difficulties - Poor planning and strategic control - Insufficient manpower/equipment - Political pressure - Delay in decision-making - Poor contract management - Coordination issues	(Kandel, 2025), (Oyewobi, Jimoh, Ganiyu, & Shittu, 2016) (Enshassi, Arain, & Al-Raee, 2010)
4	Lacking Items in BoQ	- Errors in BoQ - Omissions in design - Inadequate working drawings - Inadequate estimation	(Kandel, 2025), (Pokharel & Joshi2, 2020), (Mishra, Korala, Dhungana, Pokharel, & Khadka, 2021)
5	Social Issues	- Obstacles from local residents - Social resistance - Land disputes - Socio-cultural barriers	(Kandel, 2025), (Ghimire, Bohara, & Awasthi, 2023), (Mishra, Korala, Dhungana, Pokharel, & Khadka, 2021), (Mohammad & Ani, 2010)

The analysis aligns with literature that identifies poor planning, design flaws, client-initiated changes, weak governance, and inadequate stakeholder engagement as major VO drivers (Kandel, 2025; Enshassi et al., 2010; Oyewobi et al., 2016; Ghimire et al., 2023). Table 1 summarizes literature-supported causes across categories.

4.4 Factors Contributing to Extensions of Time (EoT)

Delays in climate resilient water supply projects arise from interlinked external shocks and internal inefficiencies (Figure 14). Epidemics and force majeure (38 cases) is the most frequently occurring factor, notably COVID-19 and natural disasters. Socio-cultural issues (31 cases) stemmed from land disputes, local customs, and community resistance are also the factors affecting EoT, highlighting early engagement and cultural sensitivity. Variation in work (24 cases) is one of the majour cause findings from the study.

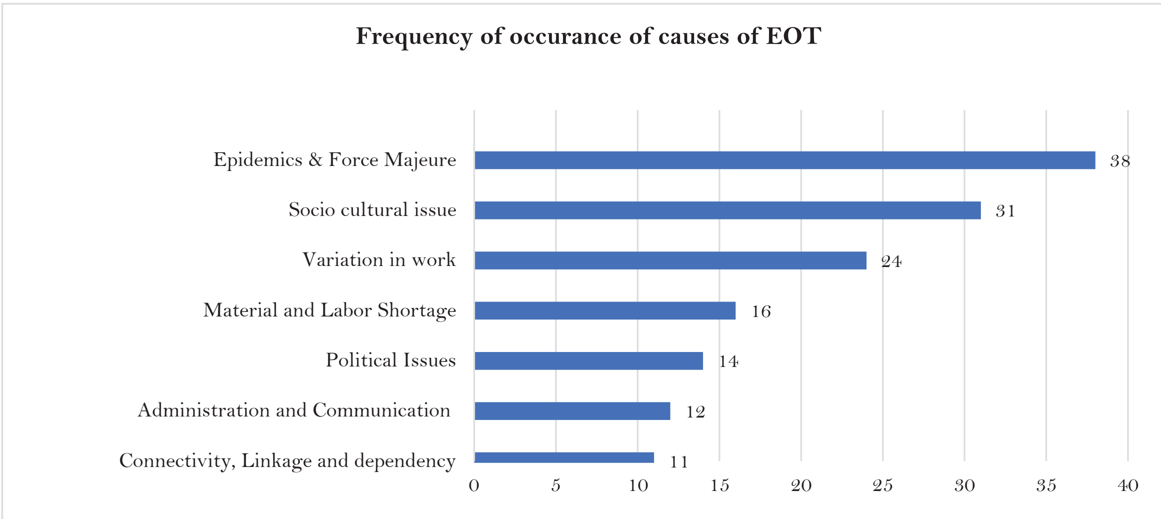

Figure 14: Factors Contributing to Extensions of Time (EoT)

Material/labor shortages (16 cases) revealed supply chain vulnerabilities, while political (14), administrative/ communication (12), and dependency delays (11) further extended timelines. Findings for integrated risk management, socio-cultural analysis, contractual flexibility, scope clarity, and cross agency coordination. Consistent with global evidence (Olawale & Sun, 2010; Love et al., 2016), EoTs in Nepal caused through multi dimensional, demanding adaptive.

4.4.1 Sub-Causes of EoT Due to Epidemics and Force Majeure

Epidemics and force majeure were major contributors to delays (Figure 15). COVID-19's first, second, and third waves caused 20 delays, disrupting labor, supply chains, and site access under nationwide lockdowns. Hydro meteorological events also had significant impacts: heavy rainfall and flooding (8 cases), monsoon induced landslides/road blockages (6), the Hewa Khola flood (2), flood-induced intake damage (1), and snowfall-related work stoppages (1).

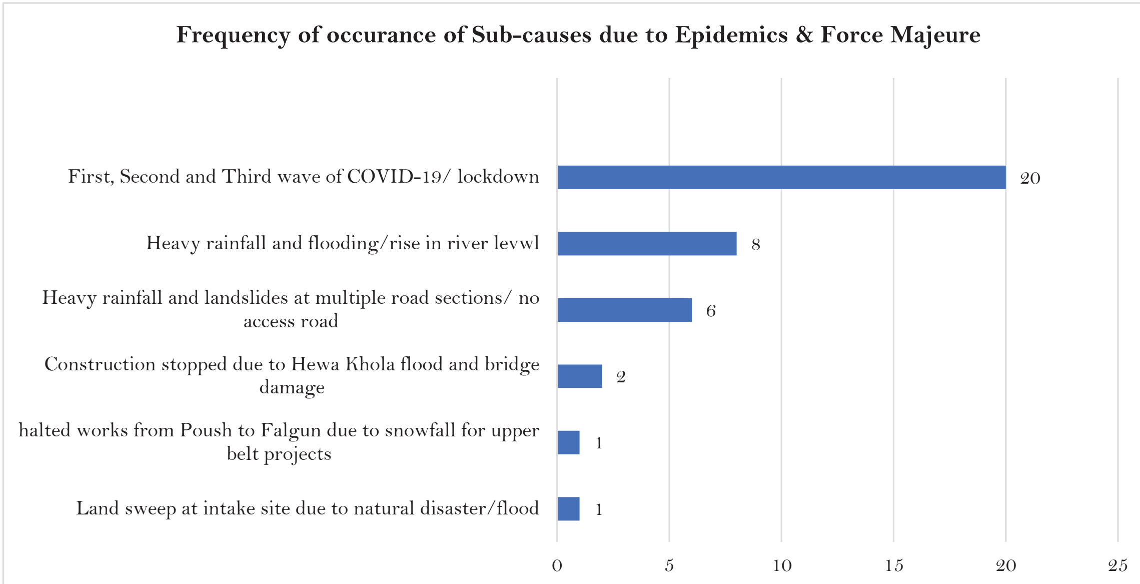

Figure 15: Occurrence of sub causes due to Epidemics & Force Majeure

The fndings indicate that the mitigation requires integrating climate risk profiling, pre-monsoon contingency measures, all weather access, and flexible contractual provisions (e.g., FIDIC 2017)..

4.4.2 Socio-Cultural Sub-Causes of EoT

Socio cultural issues significantly delayed projects (Figure 16). The most frequent cause was unavailability of land for structures (10 cases), , inheritance conflicts. Community disputes (6), . Other causes included inaccurate household data (5), boundary conflicts (4), and household connection complications (3). Local festivals (2) and delayed user committee evaluations (1) also contributed. Study exploures the participatory planning, transparent land management, accurate pre-construction data verification, and culturally sensitive scheduling would be the mitigation measures of contract ammendments.

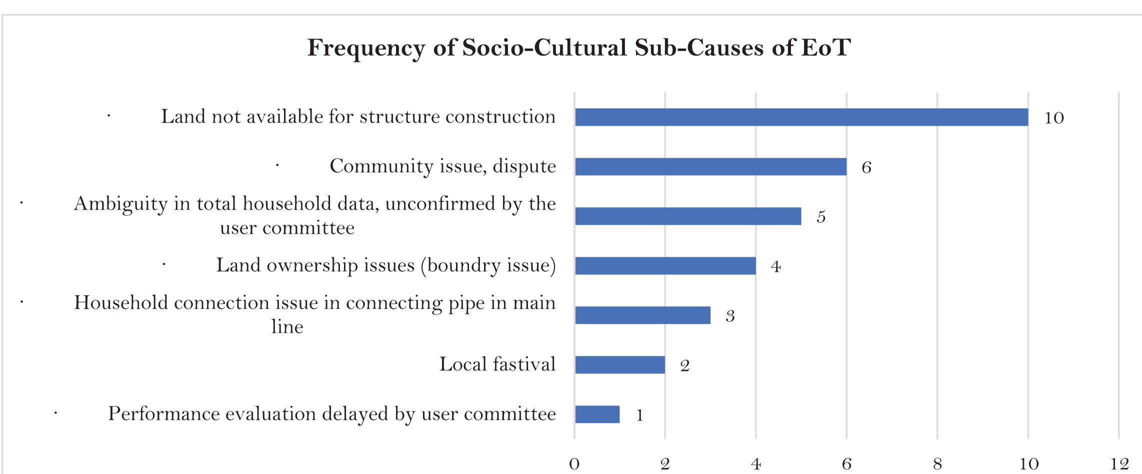

Figure 16: Frequency of Socio-cultural sub-causes of EOT

4.4.3 Variation order Sub-Causes of EoT

Variation Orders (VOs) contributed significantly to EoT delays (Figure 17). The most frequent sub cause was extra works under VO (8 cases),. VO approval delays (5) and alignment or pipeline length changes (5) reflected administrative bottlenecks and evolving scope,. Pump design changes (4) indicated gaps in hydraulic and electromechanical coordination. Isolated cases included pipeline rerouting due to RVT relocation (1) and insufficient design details (1).

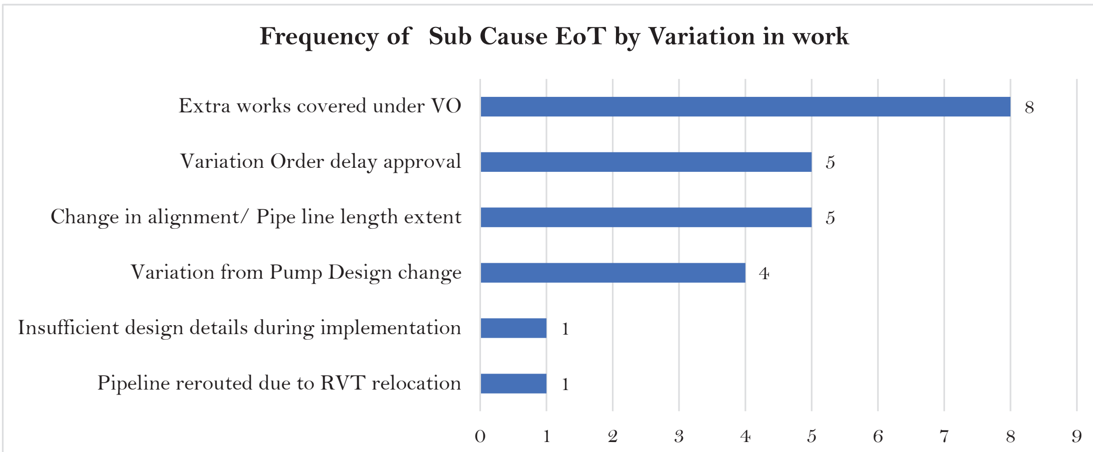

Figure 17: Frequency of sub causes of EOT by VO

4.4.4 Material and Labor Sub-Causes of EoT

Material and labor shortages were key contributors to EoT delays (Figure 18). Labor unavailability during federal and provincial elections (7 cases) was the most frequent sub-cause, reflecting the influence of socio-political cycles on project execution. Crusher union strikes halting aggregate supply (4) highlighted supply chain fragility, while FCAAN protests and filter media shortages (2 each) further disrupted continuity. One delay was linked to a contractor's failure to procure materials.

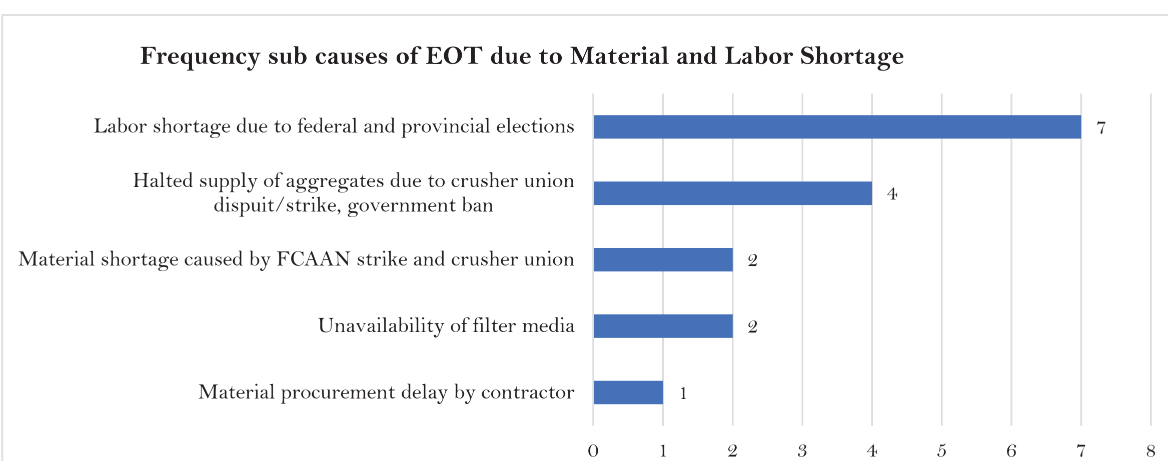

Figure 18: Frequency of Sub causes of EOT due to Material & Labour Shortage

4.4.5 Political Factors Influencing EoT

Political factors notably contributed to EoT in climate-resilient water supply projects (Figure 19). Elections at central and local levels (8 cases) delayed decision making and field activities due to staff deployment. Crusher organization strikes (3 cases) disrupted aggregate supply, while a single case of government restructuring under federalism caused approval delays.

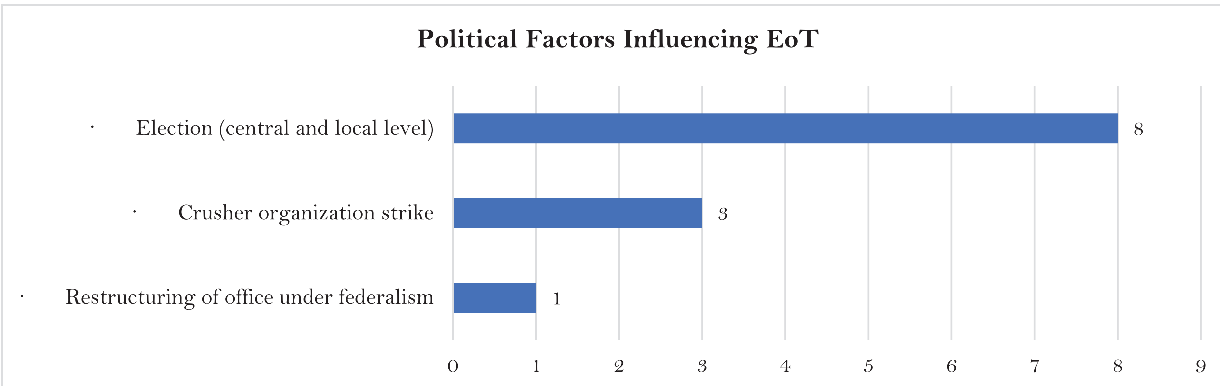

Figure 19: Frequency of Sub-Causes of EOT due to Political Factor

These findings highlight the need for election- aware scheduling, contingency supply chain planning, and alternative approval mechanisms.

4.4.6 Administrative and Communication Sub-Causes of EoT

Administrative and communication issues contributed notably to EoT (Figure 20). Frequent policy amendments (4 cases) disrupted project continuity, while poor coordination and communication (3 cases) caused misaligned responsibilities and scheduling conflicts.

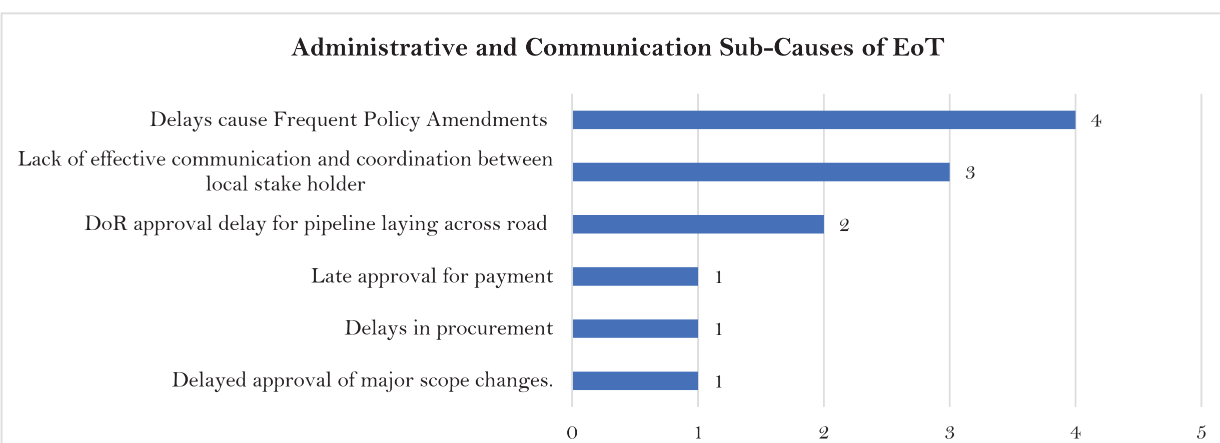

Figure 20: Administrative & Communication Sub Causes of EOT

Approval delays for pipeline crossings by the Department of Roads (2 cases) and isolated incidents of late payments, delayed procurement, and postponed scope change approvals further hindered progress..

4.4.7 Connectivity, Linkage and dependency Sub-Causes of EoT

As shown in Figure 21, insufficient technical manpower (6 cases) was the leading sub cause, slowing supervision, decision-making, and on-site problem resolution. Delays in Department of Roads approvals and contractor declared construction holidays (2 cases each) further impacted the schedules. One case of Nepal Electricity Authority delay in providing electrical connections also illustrates the risks of third-party dependencies.

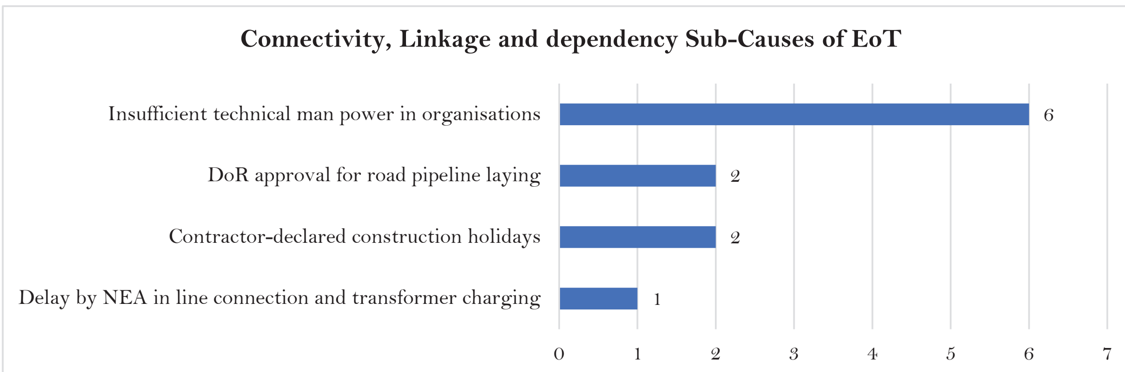

Figure 21: Procedural and Coordination Sub-Causes of EoT

4.4.8 Triangulated Analysis of Causes of Extension of Time (EoT)

Epidemics and force majeure (38 cases) were the most frequent EoT drivers, mainly COVID-19, monsoon disruptions, and natural disasters. Socio-cultural issues (31) involved land disputes, community resistance, and festivals. Variation in work (24) arise from design changes and evolving user needs, while material and labor shortages (16) were linked to supply chain disruptions and seasonal migration. Political issues (14) stemmed from elections, strikes, and federal restructuring. Administrative and communication delays (12) reflected slow approvals and poor coordination, and connectivity dependencies (11) involved delayed third-party infrastructure.

Table 2: Triangulated discussion with Literature-Based Causes of Extension of Time (EoT)

S.N.	Cause Category	Key Issues	Sources
1	Epidemics & Force Majeure	- Natural disasters, pandemics, - severe weather, - site inaccessibility	(Koirala & Shahi, 2024), (Musarat & Inderyas, 2019), (Subedi & Joshi, 2020), (Bhattarai, 2023)
2	Socio-Cultural Issues	- Community resistance, - land disputes, strikes, - public holidays	(Mishra A. K., October 2020) (Bhattarai, 2023), (Subedi & Joshi, 2020)
3	Variation in Work	- Design changes, - poor initial scope definition, - variation orders	(Mishra A. K., October 2020), (Bhattarai, 2023), (Koirala & Shahi, 2024)
4	Material & Labor Shortages	- Late Procurement, - Labour shortage due to election, - Labour migration, - Supply chain distrubution	(Bhattarai, 2023)
5	Political Issues	- Election (central and local level), - Crusher organization strike, - political instability, - Restructuring of office under federalism	(Mishra A. K., October 2020), (Bhattarai, 2023)
6	Administration and Communication	- Lack of effective communication and coordination, - slow approvals, - lack of clear responsibilities	(Subedi & Joshi, 2020), (Acharya, Kim, & Lee, 2004)
7	Connectivity, Linkage, and Dependency Factors	- Delayed utility relocation, - dependency on third-party infrastructure, - lack of preliminary coordination	(Kandel, 2025), (Subedi & Joshi, 2020)

Literature corroborates these findings, linking epidemic/weather events (Koirala & Shahi, 2024; Bhattarai, 2023), socio-cultural barriers (Mishra, 2020; Subedi & Joshi, 2020), design variations (Mishra, 2020; Ghimire et al., 2023), material/labor shortages (Musarat & Inderyas, 2019), political instability (Kadiri & Shittu, 2015), and governance bottlenecks (Acharya et al., 2004; Kandel, 2025). This triangulation confirms EoTs result from both uncontrollable externalities and preventable governance/planning gaps, requiring integrated risk management, capacity building, and coordinated stakeholder action.

4.5 Mitigation Measures

Mitigation strategies were formulated from Key Informant Interviews (KIIs) with experienced CRWSP-PMO project managers and engineers, and triangulated with established literature to address the most recurrent and high-impact causes of EoT and VOs. Recommendations include:

4.5.2 Mitigation Measures for Variation Orders: KII Insights and Literature Validation

An integrated review of Key Informant Interview (KII) insights and literature highlights five priority areas for mitigating Variation Orders (VOs) in climate-resilient water supply projects.

Table 3: Integrated Mitigation Measures for Variation Orders

S n.	Main Cause from Finding	Mitigation Focus Areas	KII-Based Strategies	Literature-Based Strategies	Sources
1	Design Issues	Technical	Conduct multi-disciplinary design reviews. Integrate geotechnical studies during design, Engage contractors during final design phase	Freeze design stages to avoid late changes Maintain design change register Evaluate change impact before approval	(Olawale & Sun, 2010), (Berihu, Grum, Tariku, & Abebe, 2023), (Arantes & Ferreira, 2020)
2	Additional Work Requirements	Scope Management	Clarify scope with contractors during pre-construction Develop rigorous scope management plans	Clarify contractual risks/responsibilities Use flexible clauses for controlled changes without renegotiation	(Asiedu, Adaku, & Owusu-Manu, 2017), (Mhando, Mlinga, & Alinaitwe, 2017)
3	Administrative Issues	Governance	Streamline VO approval processes with workflows Establish fast-track decision-making protocols	variation order procedures within contract documents Enhance contract administration and managerial oversight	(Mhando, Mlinga, & Alinaitwe, 2017), (Wepari, Donkor, & Kusi, 2024)
4	Missing in BOQ Items	Documentation	Conduct cross-checks between BoQ and design Ensure comprehensive BoQ review prior to tender	Improve consistency between BoQ and drawings Accurate feasibility and design documentation	(Berihu, Grum, Tariku, & Abebe, 2023), (Zou, Zhang, & Wang, 2007)
5	Social Issues	Community	Conduct early social risk assessments Establish community liaison committees	Hold stakeholder meetings during planning Clarify roles and streamline expectations	(Asiedu, Adaku, & Owusu-Manu, 2017), (Mhando, Mlinga, & Alinaitwe, 2017)

4.5.4 Mitigation Measures for Extension of Time: KII Insights and Literature Validation

Table 4 summarizes seven primary EoT causes epidemics/force majeure, socio-cultural issues, variation in work, material and labor shortages, political disruptions, administrative gaps, and connectivity dependencies along with KII-derived strategies and literature-supported measures. Triangulation shows that while some delays are unavoidable, most can be mitigated through contingency planning, design freeze, early stakeholder engagement, supplier prequalification, dependency risk assessment, and strengthened governance and coordination mechanisms.

Table 4:

Rank	Cause of EoT	KII-Based Mitigation Measures	Literature-Supported Measures	Key Sources
1	Epidemics & Force Majeure	Develop contingency plans; incorporate flexible scheduling clauses	Prepare risk registers; buffer time; promote contract flexibility	Olawale & Sun (2010); Asiedu et al. (2021); Berihu et al. (2023)
2	Socio-Cultural Issues	Community liaison committees; early stakeholder engagement	Regular consultations; establish dispute resolution frameworks	Mhando et al. (2021); Arantes & Ferreira (2020)
3	Variation in Work	Design reviews before bidding; contractor input during design	Freeze designs early; maintain change logs; adopt structured change order procedures	Olawale & Sun (2010); Berihu et al. (2023)
4	Material & Labor Shortages	Secure alternate suppliers; build buffer stock; workforce mobilization	Prequalify contractors; effective logistics; engage local labor pools	Wepari et al. (2024); Arantes & Ferreira (2020)
5	Political Issues	Align schedule with election cycles; develop political risk mitigation plans	Use flexible clauses; early stakeholder risk mapping	Asiedu et al. (2021); Zou et al. (2007)
6	Administration & Communication Problems	Establish communication protocols; regular inter-agency meetings	Define clear roles; implement project tracking tools (CPM, EVM); strong leadership	Zou et al. (2007); Olawale & Sun (2010); Berihu et al. (2023)
7	Connectivity & Interdependency Issues	Inter-agency scheduling coordination; third-party utility mapping	Early relocation plans; dependency risk assessments	Mhando et al. (2021); Asiedu et al. (2021); Zou et al. (2007)

4. Conclusions

This study examined 54 climate-resilient water supply projects in Nepal to assess the prevalence, causes, and mitigation of contract amendments, focusing on Extension of Time (EoT) and Variation Orders (VOs). Amendments observed in 79.6% of projects among the 54 projects, combination of EoT and VO (46.3%), underscoring the interlinked nature of time and scope changes. Many causes were preventable through stronger planning, coordination, and well governance system, as shown through the triangulated evidence from the primary and secondary data, Key Informant Interviews (KIIs), and literature.

Types and frequency: Combination of EoT and VO was most frequent in the projects shown by the result, EoT only and VO only, with only 1/5th of projects free from amendments which shows the projects amendments through VO and EoT is most common in the climate resilient water supply projects in Nepal.

Causes of VOs: Design related issues like design faults, design change, followed by additional administrative/political delays, BoQ gaps, social conflicts, and force majeure are the majour cause shown by the study.

Causes of EoTs: Predominantly epidemics/force majeure, socio cultural issues, scope variations, resource shortages, political instability, administrative problems, and project dependency to other agencies are explored from the study.

Mitigation: Priorities design audits and planning stage of the project, early contractor involvement to know the project site and BoQ details, clear scope management, contingency planning, political risk assessment and scheduling, and streamlined governance with strong inter agency coordination are recommended to reduce the trend of contract ammendments due to EoT and VOs.

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