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# A Systematic Review of The Causes and Effects of Variation Orders in Sustainable Construction in Developing Countries

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**Abstract**

Variation orders are a frequent occurrence in construction. It is inevitable, but it can be controlled to minimise the cost, time overrun, and enhance the quality of work. This systemic review compiles more than 80 articles of various constructions between period of 2009 to 2022, with a focus on the similarities and differences in variation orders between developing and developed countries' insight towards sustainable construction projects. A review of the existing literature identified that the common cause of variation order from twelve countries is the owner originated variations, change in design by consultant, error and omission in design, and lack of coordination between consultant and contractor. Out of the listed thirty causes of variation order the effects lead to affected work progress, increase in project cost, and delay in payment. The developing countries face different challenges due to economic and political instability and lack of resources, skills and experience. Even though the unbalance ratio between stakeholders could bring biased to overall findings, this review provides useful directions to construction professionals and policymakers. These findings not only will reduce the unfavourable effects but also by suggesting the intention of restoring factors of environment, economic and social sustainability in the construction industry.

## 1. Introduction

The construction industry is the primary source of economic growth and acts as the backbone of any country. Similar to other industries, this sector is subject to risk and uncertainty because of the nature of its operating environment, which may affect overall performance towards achieving goals [1]. Implementation of sustainable development for developing countries relies on the construction industry [2]. According to the Department of Statistics Malaysia, the Malaysian construction industry contracted by 12.9% in the fourth quarter of 2021,

contributing to RM 27.6 billion [3]. The disruption caused by the lockdown extended to June 2021 due to the COVID-19 pandemic. In this case, it certainly delays the project completion time which can be a significant issue in variation orders. Further, the Real Estate and Housing Developers' Association Malaysia revealed that 82% of their respondents face payment issues for human resources and management expenses. Their reinvestment plan in land banking and future projects was badly affected. The impact on 88% of respondents reported that decrement in the profit could be seen around 40% to 44% compared to 2019. Therefore, the effect and cause of variation orders will be further discussed in this review [4].

## 1.1 Variations Orders

Variation can be defined as slightly different from the usual arrangement [5]. The International Federation of Consulting Engineers (FIDIC) [6] explained that 'variation' is any substitute to the work either directed or approved. Similarly, the Standard Contract Book for Construction Projects [7] clarifies variation orders as any changes in the works that are instructed or validated as a variation under the provisions of Chapter Thirteen revised in the year 2013. In general, variation can be considered a change, substitution, modification, alteration and amendment to the original objectives or contract. However, Mahasneh [8] defined variation as an agreement bound to the original contract; hence, a variation order is a revised agreement based on the written contract through the amendments clause and sealed by the contracting official. Noruwa et al. [9] described variation order as the replacement of material, design, scope, or method as amended from the specifications in the initial contract. Variation orders in construction occur when an alteration in the pre-existing work area is made at any construction phase. During the design phase, the effect of variation is less than that in the construction phase. Any changes during the construction phase due to design or material modifications initiated by the consultant or the owner require the demolition of the structure. This controversial issue is inevitable, but variation orders should be minimized [10]. If a variation order cannot be avoided, then the outcome of the variation order will affect the cost, time and quality of the project [11]. As a result of the lack of management and inability to reduce the cost and time overrun, the affected company will face failure [12].

Sustainable options are crucial to gather into the construction industry these days. Hence, stakeholders and regulators are starting to focus on significant strategies, policies and practices to shift the construction practices towards sustainable ways. Typically, developed nations have sustainable and environmentally friendly advancements in place in the construction industry with various policies, rules and prescription, and modern methods of construction. Together, this industry is equitably concerned with the usage of sustainable resource management and providing high-quality sustainable construction projects. However, the construction industry's success is hindered by a lack of understanding among clients about sustainable construction approaches. Even though the construction industry in developed countries is promoting eco-friendly construction, a lack of demand from clients is causing problems [13].

As a result, this industry needs to adapt to new technology by implementing Industrial Revolution 4.0 [14]. The IR 4.0 introduces augmented reality, virtual reality, cloud computing, Internet of Things, simulation, and Building Information Modelling (BIM) [15], [16] which can be implemented in construction. IR 4.0 is known as intelligent and advanced technology that influences safety management performance. For example, BIM is applied to expand 2D and 3D approaches in computer-aided design [17]. All design team members can characterise the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories and project schedule [18]. It will ensure effective collaboration to adjust the design according to project specifications before installation.

## 1.2 Variation Orders Associated to Developing Countries

The construction process is categorized into six phases: project conception, design and planning, building permits, pre-construction, procurement and post-construction. During these phases, many resolutions need to be decided according to assumptions, incomplete information and professional experiences [19]. Change of orders can occur at any phase; hence, the original plan can have any addition, deletion and modification. Variation orders are inevitable even for developed countries which possess high technology, knowledge and experienced manpower. In Saudi Arabia, less than 10% of time and cost overrun seems to cause project failure due to variation orders [20]. The severe cause of variation orders in Saudi Arabia were identified as design error, lack of coordination, differing site conditions, owner's additional work and financial problems [21]. Mohammad et al. [22] revealed that the owner's change of scope, material and specification are the main reasons for time and cost overrun in Malaysia's construction. In China, An & Ma [23] agreed that project cost is affected by changes in orders. Although delay in completion is 50%–80% likely to happen, they still accelerate in construction industries because owners closely watch the project progress so that the end-product could be launched early in the market. In addition, the high interest rate of bank loans forces developers to pay strong attention to a project's duration.

Other developing countries face similar problems. A study conducted in Palestine found that owners are the top cause of variations, because owners tend to change their minds [19]. Moreover, non-compliant design by the

architect or insufficient budget can be main reasons. Regardless of the cause of variation, most of them have trouble with changes in economic conditions and new regulations in the country. Economic instability is highly related to political pressure. Several developing countries such as Palestine [19], Iraq [24], Congo [25], Sri Lanka [26] and Pakistan [27] deal with these problems. Owing to unstable economy, building material prices, labour wages and machinery hire rates increase, thereby resulting in project cost overruns [2], [28].

Thus, this study focuses on the causes and effects of variation orders related to sustainable construction. Several cases from developing and developed countries were compiled from the literature reviews, and the similarities and differences in variation orders from these countries are discussed. Furthermore, the impacts of post-COVID-19 related to construction and the stakeholders associated with the variation orders are included in this review.

## 2. Causes of Variation Orders Associated to Sustainable Construction

Various authors discussed the causes of variation orders in all types of construction such as building [29], roadway [26], [30], terrace housing [22], and public construction [31]. Previous studies categorized the cause of variation order into four sources: (i) owner/client, (ii) consultant, (iii) contractor and (iv) other causes [9], [10], [29]. It will be further discussed via the stakeholders' link to the variation orders.

Environmental degradation due to the enormous construction industry has led to the pursuit of sustainable construction. Renewable materials such as bamboo [32], eco-friendly particle board [33], pre-cast concrete slabs [34], recycled plastics, rubbers or steels [35], prefabricated sandwich panel [36], crushed sand [37], straw bales [38], and plant-based foam [39] have been used in previous construction projects. Cost constraints in sustainable construction are due to the owners' financial state. Ultimately, owners have the right to choose between eco-friendly or conventional materials. Using environmentally friendly materials may entail high cost at the beginning of construction, which is known as 'green cost premium' [40]. However, repairing and maintenance of conventional infrastructure can be higher than that of sustainable materials [41]. Russ et al. [42] defined the green cost premium as an extra cost related to sustainable building elements. A previous study divided the construction cost into four parts: initial cost, resource cost, replacement cost and operation and maintenance cost [43]. The scarcity of sustainable materials requires special orders and manufacture [44]. In Malaysia, sustainable materials need to be imported, which is one of the causes of project delays and poor implementation in construction [45].

A previous study identified 30 causes of variation orders on the basis of three techniques: a literature review, a questionnaire administered to professionals in the road construction industry in Sri Lanka and a case study analysis focused on 11 road construction projects [26]. Usually, questionnaire surveys can be analysed using the Relative Importance Index, Importance Index and Relative Importance Weight to rank the various causes. Appendix 1 shows the 30 causes of variation orders which affected developed and developing countries. According to Human Development Index (HDI) 2022 [46], most developed countries have a score of more than 0.80. The HDI is set from 0 to 1 on the basis of education, health and life expectancy. Developed countries have higher HDI; hence, they can offer their residents a better quality of life. Developed countries discussed in this study are Malaysia, Saudi Arabia, Qatar and United Arab Emirates (UAE). Memon et al. [10] found that the major causes of variation order according to Malaysian Department of Work were design complexity, poor workmanship and unavailability of equipment.

In housing projects in Malaysia, the most significant cause is change in design by consultants and change in scope, materials and specifications by the owner [22]. This finding is supported by Khalifa & Mahamid [21], who discussed contractors' views and reported that additional work from the owner, owner's financial constraints, errors and omission in design, defective workmanship and lack of coordination between construction parties cause change of orders. Although Senouci et al. [47] agreed that owners are usually the major cause of variation orders, they found that contractors' lack of experience and different site conditions contribute to variations. Thus, owners are recommended to appoint experienced and qualified teams and involve professionals at the early stage of projects. In addition, contractors need to conduct thorough risk analysis, immediately inform the consultant of design mistakes and remember to visit the project site before bidding to assess the site conditions properly.

The causes of variation orders indicate the different patterns between developing and developed countries (Appendix 1). Developing countries face different orders such as political pressure, new government regulations/changes in economic condition, shortage of materials, workmanship or materials not meeting the specifications, unavailability of required tools and equipment, poor investigations, unforeseen site conditions, poorly defined scope of work for the contractor, delay in approval and consultant's lack of judgement and experience [24], [25], [27]. The challenges and constraints in these countries affect the construction industry, where construction is done either by paid labour or by self-help in the informal sector [48]. Severe conditions of uncertainty and risks in developing countries force communities to become involved in illegal activities that are disguised to avoid taxes, registration and other necessary processes. However, the informal sector provides low-income jobs, maintains economic activity and indirectly provides better distribution of wealth. Clearly, less developed countries experience minimum growth in construction. Alaloul et al. [2] believed in the strong

relationship between the construction industry, as well as related industries (building material, labour wages, machinery hires and consultation fees) to increase the gross domestic product. Thus, a stable construction is necessary to obtain a balanced economy. Changes in economic conditions usually happen because of unstable politics.

Similar to developed countries, developing countries such as Palestine [19], Congo [25], Sri Lanka [26], Pakistan [27], Iraq [24], [49], and Iran [50] face challenges in construction because clients pose a major change of orders. Owners initiate variations due to money constraints, which require their consultant to change the design, thereby delaying the construction process. Halwatura & Ranasinghe [26] suggested that consultants must ensure that the specifications of the design fall within the approved budget, and the budget team should participate in the design process. By contrast, a recent study reported that the contractor is the most important factor that leads to construction delays, inadequate tools and lack of cooperation among workers [51]. A total of 30 causes of variations were collected from the literature review (Appendix 1), and the most common one discussed below:

- Unrealistic contract duration imposed by owner - Dealing with a difficult owner who is dishonest, arrogant, stingy and indecisive may stress other parties. This reason was ranked 8th place in the questionnaire analysis in Sri Lanka [26]. The inabilities of the owner to modify changes by either removing or adding new materials in the construction contribute to delaying the completion date [24]. When faced with purchasing new materials during the construction phase, certain parts of the project are put on hold until the materials arrive, which results in cost overruns. Besides, the lack of understanding from contractors during the construction may occur if they are not involved in the design phase.
- Financial constraints of the owner - Khalifa & Mahamid [21] reported that the owner's financial ability was ranked in the top five causes of variation orders on the basis of contractors' and consultants' perspectives. Financial difficulties can affect the progress and quality of construction. Another reason to suspend a project is when the economic crisis in the country affects the owner [49]. To make the project feasible, the owner usually lowers the budget by opting for low-cost materials or changing the design specifications.
- Owner-initiated variations - Most of the literature reviews agreed that the owner's modification of the project is a top 10 occurrence either in developing or developed countries [21], [22], [47], [52]. Initially, the owner needs to establish the objectives, scope of work and the required quality standards. As revealed by Staiti et al. [19] the owner may possibly be uninvolved in the project or did not understand the design. Later on, the possibility of the owner initiating variation orders is high if the design changes during the construction or the owner is dissatisfied with the design/material. At the end, it will increase the initial cost and become over budget for the owner to pay. Variations require new design, material substitution and changes in schedule and scope of work [53]. These effects lead to major modifications in project planning and procurement activity. Khalifa & Mahamid [21] suggested that owners should prepare comprehensive documents detailing what he/she needs before entering the design phase. Moreover, owners are recommended to recruit well-experienced project staff to provide advice for sound decision-making.
- Poor estimation - A previous study showed that poor estimation is the main cause of variation order in Sri Lanka [26]. This issue occurs when unforeseen site conditions arise during the construction phase due to a lack of investigation by the consultant at the beginning of the design phase. Wali & Saber [24] associated poor cost estimation as the major cause from the owner. It was recorded as top 10 significant cause in Iraq's construction industry.
- Poorly defined scope of work for contractors - Communication and mutual understanding are important between the owner, consultant and contractors throughout the construction. Lack of involvement from the owner in the initial design phase will lead to a change in scope of work for contractors [22].
- New government regulations/changes in economic condition - Most developing countries such as Palestine [19], Congo [25], Pakistan [27], Iraq [24], and Sri Lanka [26] experienced changes in government regulations. Changes related to the economy and government can be due to new regulations or government decisions and politics. In Congo, owners and contractors said that new government/economic regulations were in the top 5 causes of variation orders [25].
- Change in design by consultant/design changes - Commonly, consultants make variation orders when they refine the design. Previous studies reveal that changes in design is one of the 10 most common causes in variation orders [49]. In particular, inexperienced consultants or fresh graduates typically produce major changes. As suggested by Mohammad et al. [22] the owner should hire experienced staff from the beginning of the project. Owing to a lack of coordination between the consultant and the owner from the design phase, the final decision is delayed and affects the collaboration with contractors. However, modifications in the design phase can be minimised with great care and attention to detail [29].
- Weather conditions - Unpredictable weather, which results in project delays, is clearly outside the control of professionals and construction staff. For example, in seasonal countries such as Iraq and Palestine, project timelines need to be rescheduled for several months because of heavy snow and freezing conditions. For countries like Sri Lanka [26], the monsoon season brings heavy rain, which sometimes result in flood. In all cases, contractors are required to prove the reason of project delays for example severe weather conditions

and that they have made efforts to reduce the after-effects and alleviate the delay. This delay is forgivable; hence, extension can be granted to contractors without additional costs.

- Inadequate planning - Planning is important at the early stage so that consultants can prevent a mismatch between the drawing and field conditions. Hence, Muhammad et al. [22] suggested that the owner must avoid appointing inexperienced project managers to determine the final planning of one project. This issue is in the top 10 causes of variation order [24], [26]. Time constraints and consultants' incompetency can be reasons for inadequate planning [51].
- Contractor's financial constraints - Contractors are responsible for workers' wages. To ensure that construction progress is smooth, the contractor must have a stable financial system. Otherwise, it will impact changes in order and project delays. In many Asian and African countries such as Benin, Burkina Faso, Jordan, Egypt, Vietnam and Uganda, financial difficulties fall in the top five causes of project delay [54].
- Lack of coordination between consultant and contractor - Teamwork between consultant and contractor must be good from the design planning until the end of the construction to avoid errors and omissions in construction design. Such errors will lead to building demolition and significant project extension to allow the team to re-do the design [21]. The owner also has the responsibility to ensure that all requirements meet their expectations from the beginning. The scope of work for the contractor must be explained well by the consultant and the owner.
- Unavailability of required tools and equipment - This problem is usually experienced in developing countries [19], [24]. In this case, proper procurement meets the purpose of the project, which is attributed to availability of tools and special types of equipment [25]. Additionally, it can be achieved by recognising the minimum requirements, allowing competitive bid, testing for specification compliance and choosing the lowest possible cost.
- Shortage of skilled manpower - Shortage of skilled labour can affect construction progress. Enough skilled workers must be hired from the start to ensure that construction is not delayed. Additionally, the quality of construction work comes from skilled workmanship. Incorrect plumbing, wrong materials and products installed, and poor concrete compaction indicate poor workmanship. As the result, many issues such as leaking, plumbing, crack in the walls or foundation will arise. Therefore, contractors should hire experienced workers to avoid unnecessary variations [55].
- Value Engineering - Many determinants related to project characteristics and economic situation cannot be interpreted easily. A profitable bid is obtained through involvement and preparation to evaluate and determine the profit margin [56]. Thus, the aim of value engineering is to provide essential function at the lowest cost on the basis of materials, equipment, systems and designed building features.
- Technology change - Changes in technology bring benefits to the construction industry. These benefits include robotics, drones, sustainable materials, the IoT, BIM, virtual meetings and Industrialised Building System. The benefits can be efficient for building designs, saving costs, project safety, faster, and excellent quality control of construction reduces the unskilled workers and construction period [57].
- Unforeseen site conditions - Unexpected site conditions arise when the investigation at the initial stage is inadequate. Site issues can be man-made or natural conditions [58]. Examples of site issues are hazardous materials, groundwater, underground voids or greenery that are protected by the law. In which case, the progress of construction will slow down and variations are required.
- Errors and omissions in design - Almost all developed and developing countries included in the literature review, except UAE [55] face errors and omissions in design. Previous studies [26], [11] revealed that errors and omissions in design are the top five significant occurrences in construction. According to Hanif et al. [27], this variation impacted almost 4.9% of time overrun and 7.7% of cost overrun in the three case studies on hydropower.
- Substitution of material and procedure - Sometimes, the contractor requests for alternative procedures or materials due to the price, availability and suitability. However, variation orders are mostly carried out by the consultant or the owner to change the design or material. If the owner prefers environmentally friendly materials such as bamboo, the cost will increase by up to 10% [42].
- Health and safety considerations - Contractors are advised to avoid increasing working hours and overtime to ensure the health and safety of workers. Hence, the implementation of IR4.0 can contribute to safety management and sustainability practices in the construction industry. Recent technology such as the digital twin can monitor physical processes using smart decisions in real-time communication between sensors, machines and humans [15].

## 3. Variation Orders Associated to Stakeholders

Most studies only highlighted the main stakeholders responsible for changing orders: the owner/client, consultant and contractor [24], [25], [29], [49], [55], [59], [60]. Lat et al. [18] indicated that owners, architects, engineers, contractors, subcontractors and suppliers are equally linked to variation orders. Risk management was analysed

through a survey among owners, consultants and contractors in Pakistan. The results showed that inadequate project management is the crucial factor that reflects on the timeline, rework is due to error effect cost performance, and poor supervision affects the quality of construction projects. Collaboration among stakeholders before the construction phase is vital to ensure that the model is as accurate as possible. Table 1 shows the division of the 67 variation orders identified from the recent literature into four groups of potential stakeholders.

**Table 1** *The stakeholders of owner, consultant, contractor and other factors linked to variation orders*

| **Stakeholders and Causes of Variation Orders** | [29] | [59] | [51] | [49] | [24] | [51] | [25] | [60] |
|---|---|---|---|---|---|---|---|---|
| **Owner** | | | | | | | | |
| Change of plans/ scope by owner | | | | | | | | √ |
| Change of schedule by owner | √ | | | | | | | |
| Owner's financial problems | √ | | | √ | √ | | | |
| Unrealistic contract durations imposed by the owner | | | √ | | √ | | √ | |
| The delay in payment | √ | | | | | | | √ |
| Inadequate project objectives | | | | | | | | |
| Replacement of materials/ procedures | | | | | √ | √ | √ | √ |
| Desire to start early in the project | √ | | | | | | | |
| Lack of owner experience | √ | | | | | | | |
| Owner requirement unclear | √ | | √ | | √ | | | |
| Weakness in project management | √ | | | | | | | |
| Determine of the time is not suitable | √ | | | | | | | |
| Change in the sequence of implementation | √ | | | | | | | |
| Not to hand over the site at the right time for the contractor | √ | | | | | | | |
| Impediment in the prompt decision-making process | | | | | | | | √ |
| Obstinate nature of owner | | | | | | | | √ |
| Change in specifications by owner | | | | | | √ | √ | √ |
| **Consultant** | | | | | | | | |
| Change in design by consultants | | | √ | √ | √ | | √ | √ |
| Delayed in responding to the problems | √ | √ | | | | | | |
| Inflexible consultant personality | √ | √ | | | | | | |
| Errors and omissions in design | | | √ | √ | √ | | √ | |
| Conflicts between contract documents | | | √ | | √ | √ | √ | √ |
| Inadequate scope of work for contractor | | | | | | | | |
| Technology change | | | | | √ | | √ | |
| Value engineering | | √ | | | | | | |
| Lack of coordination | | √ | | | | | | |
| Design complexity | | | | | | | | |
| Inadequate working drawing details | | | | √ | | | | |
| Inadequate shop drawing details | | | | √ | | | | |
| Consultant's lack of judgement and experience | | | √ | √ | √ | | | √ |
| Lack of consultant's knowledge of available materials and equipment | | | | | | | √ | √ |
| Honest wrong belief of consultant | | | | | √ | | | |
| Consultant's lack of required data | | | | | √ | | | |
| Obstinate nature of consultant | | | | | √ | | | |
| Ambiguous design details | | | | | √ | | | |
| Inadequate design | | | | | √ | | | |
| Non-compliances design with government regulations | | | | √ | | | | |
| Non-compliances design with owner's requirement | | | √ | | √ | | √ | |
| Poor estimation | | | | | √ | √ | √ | √ |
| Change in specification by consultant | | | | | √ | √ | | √ |
| Lack of communication | | | | | √ | √ | √ | √ |

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| | | | | | | |
|---|---|---|---|---|---|---|
| **Contractor** | | | | | | |
| Lack of contractor's involvement in design | | √ | √ | | | √ |
| Unavailability of equipment | √ | √ | √ | | √ | √ |
| Unavailability of skills | | | √ | √ | √ | √ |
| Contractor's financial difficulties | | | √ | | √ | √ |
| Contractor's desired profitability | | √ | | | √ | |
| Differing site condition | | | | | | √ |
| Defective workmanship | | | | | | √ |
| Unfamiliarity with local conditions | | | | | | |
| Lack of specialized construction manager | | | | | | √ |
| Fast track construction | | | | | | |
| Poor procurement process | | | | | | √ |
| Lack of communication | | | √ | √ | √ | √ |
| Contractor's lack of judgement and experience | | | | | | √ |
| Long lead procurement | | | | | | √ |
| Honest wrong belief of contractor | | | | | | |
| Complex design and technology | | | | | | |
| Lack of strategic planning | √ | | | | | √ |
| Contractor's lack of required data | | | | | √ | |
| Contractor's obstinate nature | | | | | √ | |
| **Other factors** | | | | | | |
| Weather condition | | | √ | | | |
| Safety considerations | √ | | √ | | | |
| Change in government regulations | | | √ | | √ | |
| Change in economic conditions | | | | √ | | |
| Socio-cultural factors | | | | | √ | |
| Unforeseen problems | | √ | | | √ | |
| Political pressure | | | √ | | | |

## 3.1 The Owner Involvement

Based on the contractor's and consultant's views, Khalifa & Mahamid [21] revealed the owner's additional work as the major cause of variation order during construction. The owner has the benefit to issue any changes to the design or cost as stipulated in the contract [61]. The causes of variation can be related to design, substitution of materials and change of scope and specification [22]. Depends on the circumstances, a variation often relates to a decrease or increase in the quantity of the materials. It can be a blessing or distress to the owner when the materials are undervalued, which end up increasing the quantity. However, this fact is rarely documented, given that the continuity in the construction industry depends on the client and their reputation [26]. As long as it has a good reputation, the construction company is attractive to hire.

Other causes of variation orders related to the owner are the owner's financial problems, lack of experience, ambiguous design, late payment and design changes during the construction phase [52]. According to Chung et al. [62], client delay factors in Malaysia that affect construction performance include the owner's financial constraints, lack of experience and change order. The outcome may not meet the owner's expectations due to a misunderstanding with the consultant. Thus, during the consultation, the designer and contractor must demonstrate sufficient knowledge and understand the owner's preference and objective. This way, delay in construction performance can be avoided and all parties will be satisfied with the outcome.

A previous study showed that 60% of the legal cases dealing with variation from 2009 until 2019 in Malaysia involved contractors and subcontractors, whereas only 30% were between the owner and contractor, in relation to payment disputes, cross claim by alleging defective works, and delayed completion [61]. This finding indicates that only a few cases were filed against the owner to avoid damage to the firm's reputation. Therefore, good documentation or contracts is required to avoid any dispute among professionals. Good communication and understanding of the objectives of the construction are also vital. An & Ma [23] found that contractors initiate the most variation orders as much as owners do. In China, owners' continuous demands for the project, incomplete design, money and time constraints during the design phase are critical factors influencing the occurrence of variation orders [23]. Variations are attributed to owners' obstinate nature [53] and sometimes, their specifications are not feasible. In Portugal, the majority of construction delays are related to the owner because of their lack of understanding and slow decision-making on the variation orders [63]. These shortcomings, in turn,

increase the cost from delayed construction and lowers the profitability. However, in the United Kingdom, unrealistic deadlines set by owners are the major reason for the delay in construction.

As part of sustainability, a sustainable project starts with capital planning that's in agreement with sustainable construction policies and frameworks of the owner. The owner involvement can start with build sustainability into the request for proposal. The owner can work with consultants and contractor teams that can understand good environmental, social performance, and have history of factoring sustainability into their decisions. Also, the owner could aim to appoint a team with whom the firm will be able to develop an effective working relationship, maintain appropriate communication and, ideally a partnership perspective. Selecting the team should not typically based on capital cost solely. The consultant and design team could be incentivised for their design quality at an optimal cost. Appraising the broader range of issues at this phase is likely to result in less variations, delays, disputes, less time-wasting, and thus, minimise risk of sustainability liabilities.

## 3.2 The Consultant Involvement

Variations related to the consultant are usually due to design modification and complexity; technology change; value engineering; lack of knowledge, data and experiences; non-compliant design with the owner's preferences or government regulations; and inadequate or ambiguous design details [53]. Wali & Saber [24] revealed that the most significant causes of variations from consultants in Iraq were quality control, design errors and omission, unrealistic project duration and non-compliance with government regulations. Thus, the owner must choose a consultant with sufficient knowledge and experience in the construction industry to avoid frequent design changes [11].

In the United States, the consultant is the most significant cause related to construction delays [63]. The causes related to the consultant are difficulties in communication and inadequate project coordination by all participants. Hence, good communication between the professionals and the owner starting from the design phase is an advantage in managing variations. The consultant's competency to understand the owner's preferences and objective is the key to minimise change orders [64]. According to Choi et al. [65], responsiveness, empathy, type, assurance and reliability make a competent consultant. In a single case study, Kykyri & Puutio [66] found that the handling of emotions using nonverbal and prosodic behaviours can affect the conversation between consultants and the owner. The study found that prosodic changes volume; the speaker's bodily behaviour, including facial expressions, movements and gestures) had an important role in conflict interaction. Therefore, consultants need to take into consideration meeting the expectations of the design team members and the owner's perspective. This skill significantly affects the service quality and satisfaction of the consulting service.

Besides, professionals should participate at an early stage to identify possible non-compliance with their requirements and clarify the project objectives. Memon et al. [10] suggested that the consultant must use systematic detailing design to avoid repetitive design changes and inadequate working drawing details. An ambiguous and complex design requires a consultant with skilled workmanship and knows special construction methods [67]. Moreover, consultants must be aware of the availability of materials and equipment in case some sustainable materials need to be in a specific size and shape and need to be handled by an experienced worker, for example the prefabricated components. Additionally, if this industry is going to toward better sustainability, greener construction materials, and practices should be incorporated into the initial design. The owner and design team can work together to maximise the asset lifespan and reuse prospect, for example by using life cycle assessment for selecting materials based on the lowest carbon impacts. When sustainability is part of the design and construction heredity, it results in lower maintenance costs, enhances the reuse prospect of construction materials, extending the life of the building, as well as minimize the variation orders.

## 3.3 The Contractor Involvement

Contractors are one of the important sources that can influence the construction project. Related studies discuss the impact of variation orders from contractors' perspectives. Mahmoud & Elshaikh [68] found that the most significant impact of a variation order in Sudan is due to (i) increase in costs, (ii) productivity degradation (workers), (iii) disputes between owners and contractor, (iv) delay in completion schedule, and (v) increase in duration of individual activities. Abidali & Ali [69] stated that the top three major factors affecting contractors' performance in Iraq were cash flows, payment delay, and contractors' experience. Omopariola et al. [70] supported these findings and indicated that positive cash flows can ensure the timely completion of a project.

This study found that insecure financial aid, delay in payment to the contractor and inadequate budgetary control was the most significant cause of cash flow problems. When payment is delayed, contractors tend to abandon the project because of the unnecessary outsourcing of funds, which reduces the profitability and incurs a high interest rate. If contractors face financial problems, then the progress of the project will be affected because workers' wages are not paid, which leads to poor performance and poor quality [10], [71]. The planning and investigation of the site as well as project cost and time baseline must be prepared well from the start. Several studies attribute the cause of variation orders to a lack of involvement in the design phase from contractors [10],

[67]. Changes in materials or design during the construction phase can lead to a dispute between the owner and contractors.

The dispute must be resolved through negotiation and estimation to avoid lawsuits and court proceedings that may suspend the project [68]. Hence, close involvement, respect and trust between contractors, the consultant and the owner from the beginning is necessary. In regard to the contractor's commitment to sustainable building, practices call on construction firms to practice green building on the job site and beyond for instance addressing carbon reduction, construction material selection, job site wellness among workers, and appropriate management of waste and water. Through such collaboration and commitment, the owner's preferences and project objectives can be delivered, and all parties understand their role in the project.

## 4. Effects on Variation Orders Related to Sustainable Constructions.

### 4.1 Work Progress is Affected

Commonly, variations lead to quality degradation without any delay in time completion. However, if the orders come from government regulations, then the project is impossible to complete on time; hence, the complete shutdown of construction works. Recently, due to the COVID-19 pandemic, project delays affecting variation orders have become prevalent worldwide. Many issues related to employee absenteeism were due to quarantine, illness, reduced on-site staffing, shift work due to social distancing requirements, childcare for those with children and the general effects of telecommuting and public transportation. Furthermore, delays in materials transportation affected the construction progress as a result of global manufacturing shutdowns. Lack of material resources required materials to be imported which mostly occurred with sustainable materials [42]. As a result, longer time is needed to obtain materials, thereby delaying the project [45].

### 4.2 Increases in Project Cost

The cost of sustainable construction is expected to increase by up to 12.5% depending on the type of sustainable building such as for commercial, educational, health facilities, office, residential and public buildings [74]. Russ et al. [42] stated that the cost of sustainable buildings is higher at the initial stage of the project. A previous study agreed that an increase in materials' price is the most significant cause leading to delay and cost overrun [75]. An increment of up to 14% of the total cost affected construction of sustainable housing in Malaysia [22]. These costs were categorised into sustainable materials, sustainable equipment, sustainable technology, sustainable design, tendering, contractors' experience and insurance. The research and development of sustainable materials required more testing and code approval, which consume more money. The majority of respondents in Oman identified contractors as the main cause of cost overrun, specifically their poor planning and management [75].

### 4.3 Delays in Payment

Osman et al. [72] revealed that payment delays are relatively correlated with poor professional relations. This issue occurs due to design complexity, design changes and specification, design discrepancies and lack of information, typically due to request from the client. Changes made by the owner or architects contribute to poor relationships among the professionals and team projects. In the case of interim payment, the employer needs to pay within 56 days after the engineers received all the documents following sub-clause 14.7 FIDIC 1999 [16]. However, if the contractors did not receive the payment, then they are entitled to ask for financing charges compounded monthly on the amount unpaid during the period of delay.

### 4.4 Quality Degradation

Quality degradation due to poor workmanship of contractor is related to productivity degradation [53] because of design discrepancies, indefinite design details, design changes and specifications. As productivity degrades, so does quality.

### 4.5 Productivity Degradation

Productivity in the construction industry was reduced by up to 50% during the COVID-19 pandemic [76]. This reduction was influenced by the shortage of manpower, health and safety regulations, mandatory quarantine and restrictions on movement during the pandemic. Nonetheless, teleworking or work-from-home set-up during the lockdown allowed projects to continue, although the lack of physical presence at the construction site may have affected the progress [77].

### 4.6 Rework and Demolition

Rework and demolition occur when there are variations and changes in design during the construction phase. The impact of changes during the construction phase is a major concern because it will delay the project due to the demolition, whereas changes during the design phase do not require rework and demolition. Additional payment for contractors is also needed because of changes in new materials or equipment [78].

### 4.7 Poor Professional Relations

Good communication between engineers, consultants, designers and contractors is a key to completing the construction on time without major issues. Poor professional relationships can cause lack of information, misunderstanding and conflict [79]. As a result, project quality is degraded and leads to cost and time overrun.

### 4.8 Disputes Among Professionals

The relationship between contractors and consultants can be tense if disagreements arise because of variation orders [61]. The demand for an additional claim from contractors when they feel that they are at a disadvantage can cause tension among professionals and the owner.

### 4.9 Additional Payments for The Contractor

Commonly, variations lead to extra work for contractors. In particular, design changes, material substitution, or new specifications require rework and demolition. Therefore, contractors claim for additional payment and sometimes push the owner/client into legal disputes on the basis of variation clauses. The most frequent claims are change orders and delays caused by the owner [80] [81].

### 4.10 Procurement Delay

Variations in construction may be due to the procurement of new materials or equipment which are unavailable in the country. Some materials need to be imported, and the delivery may take a longer time. Certain sustainable materials need to be ordered in advance according to design specifications (size, shape, or colour), and bulk orders take a while to build [82]. The restriction on movement during the COVID-19 pandemic also affected procurement, thereby increasing the time required for shipment.

### 4.11 Completion Schedule Delay

Rachid et al. [83] revealed that owner-related causes are the most important sources of delay. This cause most impacted countries such as Nigeria [58], Malaysia [22], Congo [25], Sulaimani [49], Iran [50], Ethiopia [73], and Kuwait [78]. The reason is mostly that the imported materials need to be ordered and the delivery required a longer period [22]. The slow change orders, unrealistic contract duration, slow variation orders in extra quantities, delays in payment of performed work and ineffective planning and scheduling by contractors were listed as the top five causes of schedule delay in Algeria [83].

Appendix 2 lists the compiled effect of variation orders in developing and developed countries. The collected literature revealed that cost overrun is the most common effect of variation orders even for developed countries [84, 85]. Completion delay is also a top cause of variation in most of the countries except for Palestine [19]. The minor effects of variation orders from the literature are increased overhead expense, logistical delay, slow progress, damage to the firm's reputation, poor safety conditions and poor relationship among professionals.

## 5. Conclusion

This study found that an increase in project cost is the most significant effect of variation order either in developed or developing countries. Given that sustainable construction is widely associated with costly materials, it always increases the initial construction cost. The objective of this study was achieved, as it identified 30 causes of variation orders in 12 countries. However, the ratio between the stakeholders in the previous questionnaire can be a limitation in this study. It can be biased between the owner, consultants, contractors, or engineers during the questionnaire, because the comparison between the studies conducted did not have a similar ratio among the stakeholders. Unlike in developed countries, developing countries mostly experience political pressure, new government regulations/changes in economic condition, shortage of materials, workmanship or material not meeting the required specifications, unavailability of the required tools and equipment, poor investigation, unforeseen site conditions, poorly defined scope of work for the contractor, delay in approval, and consultants' lack of judgement and experience. However, the impact of variation orders cannot be associated with the economic and political stability of countries. The impacts are only affected according to the number of variation orders in the construction industry.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

## Author Contribution

*The authors confirm contribution to the paper as follows:* ***study conception and design:*** *Hafnidar A. Rani and Afizah Ayob;* ***data collection:*** *Nurhadirah Amzafi, Siti Aisyah Ishak, and Mustaqqim Abdul Rahim;* ***analysis and interpretation of results:*** *Tamakhani Syammaun and Afizah Ayob;* ***draft manuscript preparation:*** *Muhammad Harith Amlus and Hamizah Mokhtar. All authors reviewed the results and approved the final version of the manuscript.*

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**Appendix 1** *The cause of variation orders between developing and developed countries*

| **Category of Country** | **Developing countries** | | | | | | | | **Developed Countries** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HDI 2022** | **0.48** | **0.539** | **0.557** | **0.674** | | **0.707** | **0.708** | **0.783** | **0.782** | **0.81** | **0.84** | **0.848** | **0.89** |
| **Cause of Variation Orders** | **Congo** | **Nigeria** | **Pakistan** | **Iraq** | | **Indon-esia** | **Pales -tine** | **Iran** | **Sri Lanka** | **Malay -sia** | **Saudi Arabia** | **Qatar** | **UAE** |
| | [25] | [58] | [27] | [24] | [49] | [51] | [19] | [50] | [26] | [22] | [21] | [47] | [55] |
| Unrealistic contract durations imposed by the owner | √ | | √ | √ | | √ | | | √ | | | | |
| Financial difficulty of the owner | | | √ | √ | √ | | √ | | | | √ | | |
| Owner-initiated variations | √ | | | | | | | | √ | √ | √ | √ | √ |
| Poor estimation | √ | | √ | √ | | | | | √ | | | | √ |
| Political pressure | | | | √ | | | | | √ | | | | |
| Poorly defined scope of work for contractor | | | √ | √ | | √ | √ | | √ | | | | |
| New government regulations/ change in economic condition | √ | | √ | √ | | | √ | | √ | | | | |
| Change in design by consultant/ design changes | √ | | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | |
| Weather conditions | | √ | | √ | | | √ | √ | √ | | | | |
| Inadequate planning | | √ | √ | | | √ | √ | | √ | √ | | | |
| Local residents | | | | √ | | | | | | | | | |
| Shortage of materials | √ | | | | | | √ | | | | | | |
| Consultant lack of judgement and experience | | | | √ | | √ | √ | | | | | | |
| Contractor's financial difficulties | √ | √ | √ | √ | | | √ | √ | | | √ | | |
| Lack of coordination between consultant and contractor | √ | √ | | √ | | | √ | √ | | √ | √ | | √ |
| Unavailability of required tools and equipment | √ | | √ | √ | | √ | √ | | | | | | |
| Shortage of skilled manpower | √ | | √ | √ | | | √ | | | | √ | | √ |
| Value engineering | | √ | | | | | | √ | | √ | | | |
| Technology change | √ | | | √ | | | | | | √ | | √ | |
| Unforeseen site conditions | √ | √ | √ | | √ | | √ | √ | √ | | | √ | |
| Poor investigation | √ | | | | | | | | √ | | | | |
| Natural disasters | | | | | | | | | √ | | | | |
| Errors and omissions in design | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Poor performance of subcontractors | | | | | | | | | √ | | | | √ |
| Delay in approval | | | | | | | √ | | √ | | | | |
| Contractor's desire to improve his financial condition | √ | √ | | | | √ | | | | | √ | | |
| Material not meeting the required specifications | √ | | | | √ | | √ | | | | | | |
| Poor workmanship | | | | √ | | | √ | | | | √ | | |
| Substitution of material and procedure | √ | | | √ | √ | | √ | √ | | √ | | √ | √ |
| Health and safety considerations | | | | | √ | | √ | √ | | | √ | | |

**Appendix 2** *Effect of variation orders in several countries based on the HDI 2022*

| **Country** | **Developing*** | | | | | | | **Developed** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **HDI 2022** | **0.48** | **0.485** | **0.539** | **0.674** | **0.707** | **0.708** | **0.783** | **0.806** | **0.81** | **0.813** |
| **Effect of variation orders** | **Congo** [25] | **Ethiopia** [73] | **Nigeria** [58] | **Iraq** [49] | **Egypt** [81] | **Palestine** [19] | **Iran** [50] | **Kuwait** [78] | **Malaysia** [22] | **Oman** [85] |
| Increases in project cost | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| Progress is affected | | √ | | | | | | √ | | |
| Hiring new professionals | | | | | | | | | | √ |
| Increases in overhead expenses | | √ | | √ | √ | √ | | √ | | |
| Delays in payment | √ | √ | √ | | | √ | √ | | √ | √ |
| Quality degradation | √ | | | √ | | √ | | | | |
| Productivity degradation | √ | | | | | | | | | |
| Procurement delay | √ | √ | | | | | | √ | √ | |
| Rework and demolition | √ | √ | | | | | | | √ | |
| Logistic delays | | √ | | | | √ | | | | |
| Damage to firm's reputation | | | | | | √ | | | | |
| Poor safety conditions | | | | | √ | √ | | | | |
| Poor professional relations | √ | | √ | √ | √ | √ | √ | | | √ |
| Disputes among professionals | √ | √ | √ | | | | √ | | | √ |
| Additional payments for contractor | √ | √ | √ | √ | √ | | √ | √ | √ | √ |
| Completions schedule delay | √ | √ | | | | | | | | |

**The developing countries were ranked in ascending orders based on Human Development Index (HDI) 2022 by the United Nations*