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# Quantitative Analysis of the Effects of Variations in Public Building Projects

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**Abstract** Effects of variations in building projects have continued to be a worldwide chronic problem. It is imperative to uncover and understand detrimental effects of variations that lead to poor performance of building projects. Poor performance has led to difficult in achieving value for money in those projects. This study endeavoured to identify and evaluate detrimental effects of variations in public building projects in Tanzania. Pertinent literature was reviewed coupled with structured questionnaires administered to architects, engineers, quantity surveyors and procurement officers to get individual perception with regard to negative effects of variations. A total of 7 detrimental effects of variations were identified from literature and provided the basis for the formation of the questionnaire. Descriptive statistics, frequencies, Cronbach's alpha reliability test and t-test were used to analyse and synthese data collected from questionnaires. This implies that, a quantitative research with regard to detrimental effects of variations was conducted for the collection of numerical data that was interpreted, analysed and explained statistically. The study finding indicates that the most five significant detrimental effects of variations were cost overruns, time overruns, dispute among project parties, rework and demolition and, productivity degradation in the development of building projects. The agreement among respondents in rating and ranking the factors of the detrimental effects of variations was found to be significant. It is recommended that: team work spirit among project parties; proper procurement of consultants and contractors; proper feasibility study of the project; sufficient time for design; inclusive design and; proper change control mechanisms would be beneficial and effective ways of mitigating detrimental effects of variations in public building projects. Findings from this study should help professionals, academicians, researchers and policy makers to improve construction performance.

**Keywords** Detrimental effects, Public building projects, Value for money, Variations, Tanzania

## 1. Introduction

Adverse effects of variations in construction projects such as cost overruns, time overruns, project abandonment, rework, disruption and conflicts continue to be a chronic problem worldwide and the situation is getting worse, particularly in developing countries. Tanzania being a developing country has problems related to detrimental effects of variations in developing its public building projects [1]. In the context of Tanzania construction sector, it is observed that, instead of a project taking two years it takes more than three years with its cost doubling [2]. This unfavourable circumstance resulting from the adverse impacts of variations tends to raise concern on infrastructure facilities developed through meager public resources that fail to provide value for money. It is argued that, to achieve project objectives one would expect the project to be completed within the initially anticipated cost, time and quality, but reality takes the opposite direction [3]. As a result of adverse effects of variations, many cases of poor quality, late completion and cost overruns are being reported in many construction projects in Tanzania and some of these projects have not been successfully implemented as expected [4].

Arain and Pheng [5] affirm that a detrimental variation is one that negatively impacts the project performance. In fact, detrimental effects of variations pessimistically impact various aspects of the project performance. For instance, it is argued that the cost of rework in a construction project can be as high as 10 to 15% of the original contract value [6]. The projects handled by consultant reveal that the total initial contract sum was 11,490,077.17 United States Dollar (USD) and the final cost was 14,396,353.67 USD, representing approximate cost overruns of 25.29% [7]. Likewise, the research carried out on projects indicates an increase in the duration of the projects from 178 months to 226.5 months, representing an average of 27.25% time overruns [6]. This implies that, adverse effects of variations inflict substantial adjustment to the contract sum and duration of the project.

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So far, detrimental effects of variations on the performance of construction projects were observed by many researchers. However, most of these researchers were too general with little emphasis on public building projects. Additionally, these researchers have inadequately documented the prevalence and severity of the detrimental effects of variations. For instance, Sunday [7] found that the impact of variations has greater significant impact on the projects handled by consultants than the in-house project staff irrespective of the type and size of the projects. Oladapo [8] and Ismail et al. [9] managed to outline few detrimental effects of variations in the construction industries of Nigeria and Iran respectively which inevitably fuel the need to look comparatively the experience of negative impacts of variations in other construction industries. Moreover, the researchers identified this area of study as deserving attention since none of the studies highlighted addressed the detrimental effects of variations on the performance of public building projects in Tanzania.

This study attempts to find out the major adverse effects of variations in construction projects. Specifically this study was carried out to identify, evaluate and document the major detrimental effects of variations in public building projects in Tanzania. The study was achieved through a detailed literature review coupled with questionnaire survey employed to obtain views from professionals with regard to detrimental effects of variations in public building projects. Questionnaire survey has been used successfully in many studies such as those by Megha and Rajiv [10] and Park and Papadopoulou [11] in generalizing results into other contexts. By the help of Statistical Package for Social Sciences (SPSS) software, the statistical analysis was used to syntheses and analyse data. The major detrimental effects of variations were identified, evaluated and ranked according to their importance and occurrence. This study seeks to contribute towards finding solutions for minimising detrimental effects of variations in public building projects. It is hoped that, results from this study should benefit construction stakeholders such as policy makers, construction practitioners and academicians to improve construction performance. The rest of the article is organised as follows: first, the literature on variations and their attached major detrimental effects were reviewed. This is followed by a description of research methods and data analysis techniques used for the study. Results of the study are then discussed. The paper concludes with discussion of theoretical, practical and managerial implications and directions for future research. Lastly, the study findings could provide useful awareness and insights in engendering managerial efficiencies and effectiveness towards successful performance improvement in construction projects.

## 2. Literature Review

### 2.1. The Concept of Variations in Construction

Variations with their attached adverse effects in construction projects are a global phenomenon [12, 9]. Variations are caused by various factors that often cause disputes and dissatisfactions among the parties involved in construction projects [13]. It is stated that construction process is subject to many variables and unpredictable factors resulting from many sources [10]. Variations are one of these variables and unpredictable factors related to the project participants with the consequence of changes in the scope of work. These changes can lead to deviations from the sum stipulated in the contract [11]. Great concern has been expressed in recent years regarding the adverse impacts of variations in the construction projects [12]. However, most building projects are liable to variations that might be caused by change of mind of the clients, consultants or any unforeseen scope of the project raised by one of the project participants. Keane et al. [14] argue that the causes of variations could originate from client, consultant, contractor and non-party-related causes. Moreover, Murdoch and Hughes [15] insist that variations may originate from three ways: (i) clients may change their minds about what they asked for before the work is complete; (ii) designers may not have finished all of the design and specification work before awarding the contract; and (iii) changes in legislation and other external factors may force changes upon the project team.

Entrust Group [16] defines variation as the change, modification, alteration, revision or amendment to the original intent of the contract and /or its works. It may involve the alteration of kind or standard of any materials to be used in the works [17]. Additionally, it is an area of research in the construction industry that still needs to be researched, as it has received limited attention. It is argued that there is a very limited research work addressing the change management issues specifically within the construction project management context [18]. Moreover, it is affirmed that most construction projects especially in developing countries, usually suffer from cost and time overruns due to variations in project plans with the consequence of stagnating economic development [9, 19]. Thus, with this scenario, it is imperative to examine to what extent building projects have suffered the adverse effects of variations and suggest the possible mitigation measures for improvement.

### 2.2. Detrimental Effects of Variations

Detrimental effects of variations in building projects normally occur due to several human and non-human factors often leading to poor performance of construction projects. Arain and Pheng [5] assert that a detrimental variation is one that negatively impacts the project performance. To date, several studies have been carried out on the detrimental effects of variations in construction projects. However, these researches have inadequately documented their prevalence and severity. These studies include those by Sunday [7] who concluded that the impact of variations has greater significant impact on the projects. Others are Oladapo [8] and Ismail et al. [9] who managed to establish the detrimental effects of variations scenarios in Nigeria and Iran respectively which inevitably fuel the need to look comparatively the experience of negative impacts of variations from other parts of the world. Moreover, Kassim and Long [20] reveal that few formal studies have been carried out to analyse the causes and effects of variations in construction projects. Hence, this study intends to fill that lacunae and heed Kassim and Long [20] plea for pioneers to carry extensive study on the effects of variations in construction projects. In this case, the thorough review of literature was carried out to identify the inter-related detrimental effects of variations in public building projects in Tanzania.

From review and syntheses of previous studies, a total of 7 major detrimental effects of variations were identified. These effects of variations from some parts of the world are cost overruns and productivity degradation [21] in Uganda; time overruns [22] in Sri Lanka; dispute among parties [23] in the United Kingdom construction industry; rework and demolition [24] in South Africa; decrease in quality of work and poor safety conditions [5] in Singapore, as discussed here under.

#### 2.2.1. Cost Overruns

Cost overruns denote the increase in the amount of money required to construct a project over and above the original budgeted amount [21]. Although in every construction project there is a contingency sum usually allocated to cater for possible variations in the project while upholding the overall project cost, there is still substantial cost overruns in many construction projects. It is argued that hardly few projects get completed within costs as stipulated in their original contracts [25]. Researches to date have tended to focus on the technical aspects of managing costs in construction projects in the attainment of client objectives [26]. However, there are several causes of cost overruns in construction projects. These include under estimation of original project cost, poor field investigation, delays in procurement and payment, changes in scope of work, inadequate resources supply and additional payments for the contractor. In fact, causes of cost overruns can originate from different sources at any stage of the project [18].

For instance, procurement delays can be frequently due to variations that require substantial amount of money, new expertise, new materials and specialized equipment. Further, problems related to procurement systems might be caused by numerous variation orders [27]. The Public Procurement Act (PPA) 2011 of the United Republic of Tanzania (URT) requires cost of variations to be approved by the Procuring Entity's (PE's) Tender Board (TB) before its implementation. The approval procedure depends on the amount of cost imposed by variations during construction. Nonetheless, variations endorsement process as per PPA sometimes consumes more time such that the progress of the project is hindered. In this context, a procurement delay is a common effect of variations which adversely affect the cost of the project. Relatively, additional payments for the contractor can be a potential effect of variations in construction projects. It is reported that variations result into price escalation and day works [22] that provide additional payments for the contractor. Thus, variations effect of cost overrun in public projects consequently leads to lack of public services due to high demand of outlay.

#### 2.2.2. Time Overruns

Time overruns mean the actual delay of construction beyond stipulated date of completion [22]. The actual measure of time overruns means the difference between the actual completion periods minus planned completion periods [22]. The detrimental effects of time overruns have resulted into several claims for Extension of Time (EoT) in many construction projects, and continue to be a worldwide chronic problem that needs to be addressed. Timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants [26]. However, many construction projects worldwide have suffered delays due to variations such that their value for money has been jeopardized. Thus, it can be concluded that variations result in requirement of additional time to complete the job [22].

#### 2.2.3. Disputes among Parties

Disputes among parties are potential adverse effect of frequent variations in construction projects. Variations in construction projects may cause conflicts and disputes, which can lead to the disruption of construction schedules, increased project costs, and even adversely affect the relationships between project participants [28]. Moreover, disputes and misunderstandings are still encountered when variations arise, often causing disruptions to the smooth running of projects [17]. Relatively, changes in the requirements and conditions of contracts constitute disputes in construction projects [23]. In fact, minimization of scope changes could be fundamental to disputes mitigation. It is argued that whenever conflicts arise, the parties involved should always go back to the project mission, and try to make agreement that is consistent with the project goals and objectives [29]. However, frequent communication and strong coordination can assist in eliminating poor relations and disputes among project parties.

#### 2.2.4. Rework and Demolition

Rework and demolition are potential adverse effects of variations in the construction project. Rework arises from changes due to poor communication between design consultants and clients [24]. Normally rework and demolition occur due to variations at the construction phase. It is argued that rework is accompanied by the demolition of what has already built [18]. Rework and demolition are a very inefficient practice and often lead to multiple cost implications in a particular construction project [30]. Moreover, in regard to the presence of rework in public projects, the government bears the responsibility for maintaining constructed facilities and, inherently, the burden of rectifying quality failures following completion [31]. Therefore, changes or variations have something in common, namely additions or deletions to the scope of work, which consequently create rework and possibly schedule resequencing, acceleration, delay or suspension [32].

#### 2.2.5. Productivity Degradation

Productivity has been generally defined as the ratio of outputs to inputs [33]. Arguably, loss in productivity implies loss of time and subsequent delays. Productivity is the key to a greater competitiveness, as it is critical to the profitability of projects [34]. However, construction works that are associated with variations have a negative impact on both plant and labour productivity. For example, changes or variations may impair labour productivity such that, direct labour costs of the project may then increase and slow project progress with the consequences of elongating the schedule and increasing overhead costs.

#### 2.2.6. Decrease in Quality of Work

Variations can influence the quality of any work included in the contract [16]. Good quality of work is the practical measure of “value for money” of any particular construction project. However, the quality of work may become poor because of frequent variations occurring during the construction phase of a project. Additionally, quality may be compromised as contractors try to compensate for losses they are not optimistic about recovering. Variation orders not only affect project performance in terms of time and cost but also adversely affect the quality of work [5].

#### 2.2.7. Poor Safety Conditions

Poor safety conditions in many construction sites jeopardise employees’ ability to efficiently discharge their duties. In fact, construction in general involves dangerous operations which require utmost care. Construction projects comprise of series of physical activities to be performed by people. It is argued that construction work is extremely hazardous and the exposure to health and safety is enormous [35]. Thus, variations in technology, works, materials, construction methods and equipment may substantially require additional health and safety measures in a construction site [5]. Failure to fulfill the need of appropriate health and safety measures imposed by variations leads to poor health and safety conditions to people at construction sites. Furthermore, workplace safety is a core consideration for all types of organizations that are accountable for protecting and optimizing the functionality of human resources [36].

## 3. Research Methodology

### 3.1. Research Design

There are five research styles: experiment, survey, action research, ethnographic research and case study [34]. Ying [37] considers that there are five common research strategies in the social sciences: surveys, experiments, histories, epidemiologic research and case studies. However, the adoption of the appropriate research design depends on the logic that links the data collected and data analysis to yield results that give answers to the main research questions being investigated. In this case, the survey method was adopted for the study. Fellows and Liu [38] stipulate that surveys operate on the basis of statistical sampling; only extremely rarely are full population surveys possible, practical or desirable. Furthermore, Fellows and Liu [38] clarify that, commonly, samples are surveyed through questionnaires or interviews. Specifically, the survey method using questionnaire was adopted for the study. It is argued that, the principles of statistical sampling – to secure a representative sample – are employed for economy and speed [38]. Evidently, interview approach is time-consuming, inconsistency and expensive in terms of cost as compared to questionnaire survey. Alshenqeeti [39] reveals that interviews are time-consuming with regard to both data collection and analysis because they need to be transcribed, coded and possibly translated. As a result of limited resources in terms of time and money, the study was designed to obtain views from architects, engineers, quantity surveyors and procurement officers with regard to detrimental effects of variations in public building projects using a questionnaire survey. Impliedly, a quantitative research was conducted for the collection of numerical data that were interpreted, analysed and explained statistically.

### 3.2. Study Population

The population of the study comprised of engineers registered by Engineers Registration Board (ERB), architects and quantity surveyors registered by Architects and Quantity Surveyors Registration Board (AQRB) and, procurement and supplies officers registered by Professionals and Technicians Board (PSPTB) in Tanzania.

### 3.3. Questionnaire Design

The aim and purpose of the questionnaire was to obtain views from construction practitioners with regard to detrimental effects of variations in public building projects. The questionnaire was divided into two main sections. Section 1 solicited general information about the respondents. Section 2 rated significant detrimental effects of variations related to projects performance. In section 1 of the questionnaire, the respondent was asked to fill in the space provided with the appropriate respondent’s general information. In section 2 the respondent was asked to rate the detrimental effects of variations variables using five-point Likert scale viz-a-viz: strongly disagree = 1; disagree = 2; neutral = 3; agree = 4 and strongly agree = 5. Likert scale rating system has been used successfully by many researchers such as Mohammad et al. [40] and Mizanur et al. [41] in their studies.

### 3.4. Pilot Study

A pilot study was carried out to find out if the questionnaire was able to measure what was supposed to be measured; the wording was clear; if all questions were interpreted in the same way by respondents; what responses were provided; and if there was any research bias. It is argued that, to ensure the effectiveness of a questionnaire, a pre-test should be carried out by piloting the questionnaire with a small representative sample [42]. Furthermore, a pilot study helps to refine data collection plans with respect to both the content of the data and the procedure to be followed [37]. A judgment sample of 18 respondents with good spread of respondent characteristics was chosen for the preliminary testing of the questionnaire. The questionnaires were administered to professionals (architects, engineers, quantity surveyors and procurement officers) contacted in person. Nevertheless, only 9 respondents were able to return the filled questionnaire forms. Based on their feedback, corrections were made to improve the format, layout, questions and the overall content of the questionnaire. Through this process, the questionnaire was validated and provided the authors with improvement opportunity prior to main survey.

### 3.5. Sampling Technique

Given the wide distribution of public building projects and their heterogeneous nature around Tanzania, the purposive sampling method was used in this study. Purposive sampling involves searching for cases or individuals who meet a certain criterion [43]. Also, researchers' sample must be tied to their objectives [43]. It is argued that, purposive sampling is a technique widely used in research for the identification and selection of information-rich cases for the most effective use of limited resources [44]. Furthermore, purposive sampling technique, also called judgment sampling, is a deliberate choice of an informant due to the qualities that the informant possesses [45].

### 3.6. Sample Size and Selection

The primary data for this study was collected from multiple construction professionals around Tanzania. These include architects, engineers, quantity surveyors and procurement officers. In this case, a total of 183 questionnaires were purposively administered to 36 architects, 90 engineers, 42 quantity surveyors and 15 procurement officers contacted in person to get individual perceptions. Telephone call and Short Message System (SMS) reminders were used to remind respondents to fill the questionnaire form. Results in Table 1 illustrate that 143 valid responses were received from the respondents constituting 78 percent of response which is considered adequate for data analysis.

### 3.7. Data Analysis

Data from the questionnaire were encoded using the Statistical Package for Social Sciences (SPSS) version 17. Thereafter, data were carefully analysed and synthesized using descriptive statistics, frequencies, Cronbach's alpha reliability test and t-test. The descriptive statistics and frequencies were used to rank the potential detrimental effects of variations. Relatively, Cronbach's alpha reliability test was used to ascertain whether the questionnaire was capable of yielding similar scores if the respondents used it twice. Additionally, a one sample t-test analysis was performed to test for the significance of the ratings of the variables. The Spearman's rank correlation coefficient was used to measure the degree of agreement between the different parties.

## 4. Results and Discussion

### 4.1. Reliability Testing

Reliability test was carried out to determine whether the questionnaire was capable of yielding similar scores if the respondents have used it twice. The test was conducted using SPSS. The determined Cronbach's alpha coefficient value for the rated 7 items of the questionnaire was 0.740. This value indicates that the questionnaire items form a scale that has reasonable internal consistency reliability. Impliedly, the survey instrument used was reliable and acceptable and that an agreement exists between construction industry practitioners in rating the factors of variations accordingly. Reynolds and Santos specify that an alpha greater than 0.7 implies the instrument is acceptable [46].

**Table 1.** Distribution of the Respondents

| Registration Board | Participants Category | Questionnaires sent (Sample size) | Response | Response rate (%) |
|---|---|---|---|---|
| AQRB | Architects | 36 | 12 | 33.3 |
| ERB | Engineers | 90 | 84 | 93.3 |
| AQRB | Quantity surveyors | 42 | 35 | 83.3 |
| PSPTB | Procurement officers | 15 | 12 | 80.00 |
| | Total | 183 | 143 | 78.00 |

**Table 2.** Demographic of Respondents

| Characteristics | Frequency | Percentage | Cumulative Percentage |
|---|---|---|---|
| **Type of Organisation** | | | |
| Client | 79 | 55 | 55 |
| Consultant | 39 | 27 | 87 |
| Contractor | 25 | 18 | 100 |
| Total | 143 | 100 | |
| **Sex** | | | |
| Male | 118 | 83 | 83 |
| Female | 25 | 17 | 100 |
| Total | 143 | 100 | |
| **Education Level** | | | |
| Undergraduate Degree | 110 | 77 | 77 |
| Master Degree | 32 | 22 | 99 |
| PhD | 1 | 1 | 100 |
| Total | 143 | 100 | |
| **Work Experience** | | | |
| 0 – 5 years | 43 | 30 | 30 |
| 6 – 10 years | 37 | 26 | 56 |
| 11 – 15 years | 19 | 13 | 69 |
| 16 – 20 years | 17 | 12 | 81 |
| 21 – 25 years | 9 | 6 | 87 |
| More than 25 years | 18 | 13 | 100 |
| Total | 143 | 100 | |

## 4.2. Information of the Respondents

Table 2 indicates that 79 (55.2%) respondents were from government, 39 (27.3%) were from consultants and 25 (17.5%) were from contractors. These statistics affirm that the majority of participants were from government. Furthermore, 118 (83%) respondents were male and 25 (17%) were female which implies that male participants were the majority. In the case of education level, about 110 (77%) respondents were undergraduates possessing first degree, 32 (22%) were master degree holders and 1(1%) respondent was a doctoral degree (PhD) holder. Relatively, 43 (30%) respondents have work experience ranging between 0-5 years, 37 (26%) have work experience between 6-10 years, 19 (13%) between 11-15 years, 17 (12%) from 16-20 years, 9 (6%) have work experience between 21-25 years and, 18 (13%) have work experience more than 25 years. The determined average of 15 years of professional work experience of respondents was considered suitable and that they have acquired adequate experiences from the construction industry such that, based on this argument, the responses given by those professionals are reliable and trustworthy.

## 4.3. Effects of Variations

Result in Table 3 indicates the overall top five highly ranked detrimental effects of variations as cost overruns ranked 1st, time overruns ranked 2nd, dispute among project parties ranked 3rd, rework and demolition ranked 4th and productivity degradation ranked in the 5th position. In principal, the respondents agreed that the first five factors were the predominant effects of variations in building projects since their means range between 3 and 5. This implies that, these effects are the most significant and occur more commonly at construction as agreed in the overall viewpoints. However, these findings are more less the same as those observed by researchers in other countries. For example, Megha and Rajiv [10] and Asamaoh and Offei-Nyako [47] observed delay in completion schedule, increase in project cost and disputes between parties as the first three most important effects of variations in South of Iran and Ghana respectively. However, the least ranked detrimental effects of variations were decrease in quality of work ranked 6th and poor safety conditions ranked in 7th position. Apparently, decrease in quality of work and poor safety conditions are relatively not the most important effects of variations since their means are below 3. The following sub-sections discuss the ranking of detrimental effects of variations from the perspectives of the overall, clients, consultants, contractors, architects, engineers, quantity surveyors and procurement officers.

### 4.3.1 Cost Overruns

From Tables 4 and 5 the cost overruns in projects as the result of detrimental variations were ranked in the 1st position from all viewpoints. However, it seems that, consultants (Mean = 4.7436) were more conscious with the problem of cost overruns because consultants have a big role to keep the cost of the project within the clients' budget. Furthermore, it is not surprising to see that the factor of cost overruns was the most important one for procurement officers (Mean = 4.8553). Arguably, this is because procurement officers on behalf of the client have the obligation of fund budgeting for the project. However, this agreement in ranking from all viewpoints indicates that the problem of cost overruns is substantial in public building projects in Tanzania. Thus, researchers and practitioners of construction should put more effort on the technical aspects of managing costs on construction projects. Overall, these results agree with Ndihokubwalo and Haupt [48] who found that cost overruns are the major outcome of variations in the South African construction projects. Similarly, cost overruns have also been identified as the most significant effect occurred due to variations in Malaysian construction projects [13].

#### 4.3.2. Time Overruns

Table 4 demonstrates that time overrun was ranked 2nd in the overall, clients, consultants and contractors groups of respondents. However, it can be inferred that contractors (Mean = 4.6400) were more conscious with the problem of time overruns in construction projects. Presumably, from contractors' perspective, delayed project can erode profits and prevent resources from being deployed elsewhere. Likewise, in Table 5 time overrun was ranked 2nd in the overall, architects, engineers, quantity surveyors and procurement officers groups of respondents. It is likely that, time overrun was the most important one for procurement officers (Mean = 4.8553). Ideally, procurement officers are interested to see the owner uses the finished product as soon as practical so that he or she may enjoy the benefits of the investment. However, the agreement between all groups of respondents implies that the problem of time overrun in public building projects continues to be a chronic problem and needs to be addressed. The result is slightly not in agreement with Ndihokubwalo and Haupt [48] and Ismail et al. [9] who found that time overrun is a major problem and ranked it first. This might be because of different reasons, depending on the nature of the problem in a particular country. It is argued that timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants [26].

#### 4.3.3. Disputes among Project Parties

Result in Tables 4 and 5 shows that, disputes among project parties have been ranked by clients, architects, engineers and procurement officers in the 3rd position. However, this detrimental effect of variations has been ranked by the consultants, contractors and quantity surveyors in the 4th position. Arguably, this effect is more important to clients, architects, engineers and procurement officers. This might be due to the roles they play in realizing project objectives. Nevertheless, the perception of the clients, architects, engineers and procurement officers groups of respondents are in agreement with those by Ndihokubwalo and Haupt [48] and Ismail et al. [9] who ranked disputes among project parties in the 3rd position. It is argued that, whenever conflicts arise in a project, the parties involved should always go back to the project mission, and try to make agreement that is consistent with the project goals and objectives [29].

#### 4.3.4. Rework and Demolition

Rework and demolition in Tables 4 and 5 had been ranked 4th in the overall, clients, engineers and procurement officers groups of respondents. However, consultants, contractors, architects and quantity surveyors ranked rework and demolition in the 3rd position. In this case, it seems that rework and demolition is an important detrimental effect of variations to consultants, contractors, architects and quantity surveyors. This implies that, consultants and contractors have big role to play in minimizing rework and demolition in construction projects. Additionally, from the contractors' perspective, it is the question of whether would be paid for the rework [24]. Furthermore, it is not surprising to find out rework and demolition is an important one for architects and quantity surveyors as it affects cost performance and quality of the projects. However, to date there is no proper mechanism in place for quantity surveyors in capturing the rework cost on site [24]. It is argued that, rework is a quality failure attribute that contributes to waste and value losses in building design and construction [31]. Furthermore, rework is usually a pure waste and should be avoided as much as possible. The only requirement for handling rework is to perform all necessary correction activities to guarantee the conformance of the "as-built" to the "as designed", which is more or less obvious [18]. However, the decision of rework is a difficult one since rework is normally accompanied by the demolition of what has already built [18].

#### 4.3.5. Productivity Degradation

Results in Tables 4 and 5 reveal that the overall, clients, and quantity surveyors groups of respondents ranked productivity degradation in the 5th position. However, consultants, contractors, architects, engineers and procurement officers ranked productivity degradation in 6th position. In fact, the conflict in ranking is good, because it articulates the unbiased ranking of the negative impacts of variations. However, these rankings are not in line with those by Msallam et al. [49] who ranked productivity degradation in 12th position. It is argued that, variation orders often associated with interruption, delays and modification of work do have a negative impact on labour productivity [17].

#### 4.3.6. Decrease in Quality of Work

Decrease in quality of work in Tables 4 and 5 has been ranked 6th in the overall, clients and quantity surveyors groups of respondents. However, on one hand, consultants, contractors, engineers and procurement officers ranked decrease in quality of work in the 5th position. On the other hand, architects ranked decrease in quality of work to the 4th position. In this case, decrease in quality of work is an important one for architects as they have the responsibility to ensure the conformance of the “as-built” to the “as designed”. However, decrease in quality of work has been identified in Southern Iran as detrimental effect of variations and ranked 5th from all viewpoints except contractors who ranked it in the 4th position [9]. Interestingly, in the South African construction industry, decrease in quality of work was placed in the 9th position [48]. Despite the similarity and dissimilarity in ranking, decrease in quality of work due to variations is the suffering of many construction projects in various parts of the world.

#### 4.3.7. Poor Safety Condition

From Table 4 poor safety conditions were ranked 7th from all viewpoints. Similarly, in Table 5 results indicate that poor safety conditions were ranked 7th from all viewpoints except architects ranked it in the 5th position. One can infer that architects were more conscious to issues of safety in the construction sites. However, poor safety conditions had been the least ranked among the seven major detrimental effects of variations. This implies that, poor safety condition is not the most important detrimental effect of variations. These rankings do not align with those by Ndihokubwalo and Haupt [48] who placed issues of health and safety in the 11th position. However, the ranking in Table 4 is in line with those by Msallam et al. [49] who ranked poor safety conditions in the 7th position in the Jordan construction industry.

### 4.4. Degree of Agreement

#### 4.4.1. Spearman’s Rank Correlation Coefficient

The Spearman’s rank correlation coefficient is used to measure the degree of agreement between the different parties or factors. The value of the spearman rank correlation coefficient ranges from +1 (perfect positive correlation), through 0 (no correlation at all) to -1 (perfect negative correlation). In this research, SPSS software version 17 was used to conduct Spearman’s rank correlation coefficient analysis to determine the relationship between parties (clients, consultants and contractors). Result in Table 6 suggests that there was negative correlation between clients and contractors, which was statistically significant at the 0.01 confidence level ($r_s$ = -0.225, $\rho$ = 0.002 < 0.01). Moreover, there was positive correlation between consultants and contractors, which was statistically significant at the 0.05 confidence level ($r_s$ = 0.196, $\rho$ = 0.019 < 0.05). However, there was positive correlation between clients and consultants, which was not statistically significant at the 0.05 confidence level ($r_s$ = 0.058, $\rho$ = 0.490 > 0.05). Thus, this result suggests that there was a weak divergence (-0.225) of perception between the respondents of clients and contractors, while, there was a weak convergence of perception between the respondents of the consultants and the other two parties’ respondents (0.196 with contractors and 0.058 with clients). Furthermore, these agreements suggest that the ranking of detrimental effects of variations was unbiased such that the study results can be dependable.

**Table 3.** Overall Ranking of the Detrimental Effects of Variations

| Variation effects | N | Strongly disagree 1 | 2 | 3 | Strongly agree 4 | 5 | Mean | Rank |
|---|---|---|---|---|---|---|---|---|
| 1. Cost overruns | 143 | 1(0.7%) | 0(0%) | 2(1.4%) | 43 (30.1%) | 97 (67.8%) | 4.6434 | 1 |
| 2. Time overruns | 143 | 1(0.7%) | 2(1.4%) | 9(6.3%) | 47(32.9%) | 84(58.7%) | 4.4755 | 2 |
| 3. Disputes among project parties | 143 | 8(5.6%) | 15(10.5%) | 43(30.1%) | 45(31.5%) | 32(22.4%) | 3.5455 | 3 |
| 4. Rework and demolition | 143 | 4(2.8%) | 24(16.8%) | 37(25.9%) | 55(38.5%) | 23(16.1%) | 3.4825 | 4 |
| 5. Productivity degradation | 143 | 11(7.7%) | 35(24.5%) | 36(25.2%) | 50(35.0%) | 11(7.7%) | 3.1049 | 5 |
| 6. Decrease in quality of work | 143 | 21(14.7%) | 32(22.4%) | 34(23.8%) | 39(27.3%) | 17(11.9%) | 2.9930 | 6 |
| 7. Poor safety conditions | 143 | 18(12.6%) | 42(29.4%) | 46(32.2%) | 33(23.1%) | 4(2.8%) | 2.7413 | 7 |

**Table 4.** Overall versus Project Parties Ranking of the Detrimental Effects of Variations

| Variation effects | Overall | | Client | | Consultant | | Contractor | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Rank | Mean | Rank | Mean | Rank | Mean | Rank |
| 1. Cost overruns | 4.6434 | 1 | 4.5823 | 1 | 4.7436 | 1 | 4.6800 | 1 |
| 2. Time overruns | 4.4755 | 2 | 4.3544 | 2 | 4.6154 | 2 | 4.6400 | 2 |
| 3. Disputes among project parties | 3.5455 | 3 | 3.7215 | 3 | 3.3589 | 4 | 3.2800 | 4 |
| 4. Rework and demolition | 3.4825 | 4 | 3.4051 | 4 | 3.4872 | 3 | 3.7200 | 3 |
| 5. Productivity degradation | 3.1049 | 5 | 3.3038 | 5 | 3.0528 | 6 | 2.5600 | 6 |
| 6. Decrease in quality of work | 2.9930 | 6 | 3.0506 | 6 | 3.1025 | 5 | 2.6400 | 5 |
| 7. Poor safety conditions | 2.7413 | 7 | 2.8608 | 7 | 2.7179 | 7 | 2.4000 | 7 |

**Table 5.** Overall Versus Professionals Ranking of the Detrimental Effects of Variations

| Variation effects | Overall | | Architects | | Engineers | | Quantity Surveyors | | Procurement Officers | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Rank | Mean | Rank | Mean | Rank | Mean | Rank | Mean | Rank |
| 1. Cost overruns | 4.6434 | 1 | 4.6667 | 1 | 4.5357 | 1 | 4.8286 | 1 | 4.8553 | 1 |
| 2. Time overruns | 4.4755 | 2 | 4.5000 | 2 | 4.2976 | 2 | 4.7714 | 2 | 4.8333 | 2 |
| 3. Disputes among project parties | 3.5455 | 3 | 3.2500 | 3 | 3.6071 | 3 | 3.4000 | 4 | 3.8333 | 3 |
| 4. Rework and demolition | 3.4825 | 4 | 3.2500 | 3 | 3.4524 | 4 | 3.5714 | 3 | 3.6667 | 4 |
| 5. Productivity degradation | 3.1049 | 5 | 2.4167 | 6 | 3.1429 | 6 | 3.2000 | 5 | 3.2500 | 6 |
| 6. Decrease in quality of work | 2.9930 | 6 | 2.9167 | 4 | 3.9524 | 5 | 3.0000 | 6 | 3.3333 | 5 |
| 7. Poor safety conditions | 2.7413 | 7 | 2.7500 | 5 | 2.7738 | 7 | 2.7429 | 7 | 2.5000 | 7 |

**Table 6.** Spearman Rank Correlation Coefficient Analysis

| | Spearman's Rho | Client | Consultant | Contractor |
|---|---|---|---|---|
| Client | Correlation Coefficient | 1.000 | -.058 | -.255** |
| | Sig. (2-tailed) | . | .490 | .002 |
| Consultant | Correlation Coefficient | -.058 | 1.000 | .196* |
| | Sig. (2-tailed) | .490 | . | .019 |
| Contractor | Correlation Coefficient | -.255** | .196* | 1.000 |
| | Sig. (2-tailed) | .002 | .019 | . |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

**Table 7.** T-Test Analysis for Significance in Ranking Detrimental Effects of Variations

| N = 143 | | Test Value = 3 | df = 142 | | |
|---|---|---|---|---|---|
| | | | | 95% Confidence Interval of the Difference | |
| Effects of Variations | t | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| 1. Cost overruns | 33.518 | .000 | 1.64336 | 1.5464 | 1.7403 |
| 2. Time overruns | 23.859 | .000 | 1.47552 | 1.3533 | 1.5978 |
| 3. Decrease in quality of work | -.067 | .947 | -.00699 | -.2141 | .2002 |
| 4. Rework and demolition | 5.546 | .000 | .48252 | .3105 | .6545 |
| 5. Poor safety conditions | -2.977 | .003 | -.25874 | -.4306 | -.0869 |
| 6. Productivity degradation | 1.142 | .256 | .10490 | -.0767 | .2865 |
| 7. Disputes among project parties | 5.835 | .000 | .54545 | .3607 | .7303 |

#### 4.4.2. One Sample T-Test

One sample t-test was carried out using SPSS software version 17 to test for the significance of the ratings. The test value was set as 3 because the rating scale ranges from 1 to 5 with 3 being a neutral position. Result in Table 7 shows that the five detrimental effects of variations demonstrate significant values less than 0.05. Impliedly, the difference in means was statistically significant at the 0.05 confidence level. However, decrease in quality of work and productivity degradation exhibit higher values than 0.05, suggesting that, the difference in means was statistically not significant at the 0.05 confidence level. Also the 95% interval of difference ($\rho = 0.05$) shows that all rated factors have both the upper and lower limits either below or above zero, meaning that, they were practically significant. Therefore, it can be inferred that, the ratings of the detrimental effects of variations variables were significant.

## 5. Conclusions and Recommendations

### 5.1. Conclusions

Finding of the study shows that public building projects suffered the problem of the adverse effects of variations. Based on the research objective, the significant detrimental effects of variations were identified, evaluated and ranked; and have been concluded as follows:

#### 5.1.1. Cost Overrun

Cost overrun was found to be the most significant effect of variations in construction projects as it was ranked 1st. This implies that more efforts are needed to control detrimental variations in construction projects so that the client’s value or good performance of the project can be realized. Furthermore, researchers and practitioners of construction should put more effort on the technical aspects of managing costs on construction projects.

5.1.2. Time Overrun

Time overrun was found to be the 2nd potential detrimental effect of variations. In fact, this has been a potential problem in public building projects in Tanzania and other parts of the world. It is observed that instead of a project taking two years it takes more than three years with its cost doubling [2].

5.1.3. Dispute among Project Parties

Evidently, dispute among project parties was ranked 3rd detrimental effect of variations followed by the rest detrimental effects. This implies that many construction projects suffered the problem of disputes among project parties in their various stages of the project life cycle.

5.1.4. Degree of Agreement in Ranking

Relatively, different opinions among project participants were conflicting on the ranking of the detrimental effects of variations. However, the conflict in ranking is good, because the agreements suggest that the ranking of detrimental effects of variations was unbiased such that the study results can be dependable.

5.1.5. T-test Analysis

The t-test analysis was used to determine the significance of ratings. In fact, from the test results, it can be inferred that, the ratings of the detrimental effects of variations variables were significant.

5.1.6. Practical and Managerial Implications

It is optimistic that the findings of this study will benefit the professionals, academicians, researchers and policy makers in managing and improving performance of building projects.

### 5.2. Recommendations

Based on the study findings, the researchers recommend the following: team work spirit among project parties, proper procurement of consultants and contractors, proper feasibility study of the project, sufficient time for design, inclusive design, and proper change control mechanisms would be beneficial and effective ways of mitigating detrimental effects of variations in public building projects.

## 6. Limitations

While the research work has generated important findings in the field of Construction Engineering and Management (CEM), its design is not without flaws. Firstly, the study was confined on public building projects in the context of Tanzania. Secondly, in addition to quantitative technique adopted for the study, a qualitative study of the causes of variations should be performed. This could help to maximize the strengths and minimize the limitations of each technique [42]. Thirdly, due to limited resources, the sample size of about 143 participants in this study could be miniature. Arguably, future research should employ a large number of participants. Fourthly, discussion of other relevant adverse effects of variations in construction projects is beyond the scope of this study. Finally, despite those limitations, the findings of this study represent a snapshot of the adverse effects of variations in public building projects in Tanzania.

## 7. Contributions

The findings of the study are very important for monitoring the trends of detrimental effects of variations in construction projects. In this case, the study forms a baseline for future researches in the area of construction in the context of Tanzania. Furthermore, the study findings can form a base for comparison with other construction industries from various parts of the world. More importantly, the study findings could provide useful insights in engendering managerial efficiencies and effectiveness towards successful performance improvement in construction projects delivery.

## 8. Future Research

The findings of this study could be used as input for future studies. Specifically, further research could focus on developing effective mitigation measures to alleviate the deleterious effects of variations in public building projects. Mitigation measures could help policy makers, academicians and professionals of the construction industry to curb the persisting deleterious effects of variations in building projects and improve performance of construction.

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