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RESEARCH ARTICLE

Analysis of risks factors associated with construction projects in urban wetlands ecosystem

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ABSTRACT

Within some developing countries, wetlands have long been regarded as dumping grounds. However, there has been a gradual paradigm shift in societal attitudes towards recognising their importance as landscape features that provide benefits for humans and wildlife. Unfortunately, construction activities have continually plagued their existence. Therefore, this present research examines the risks factors associated with construction projects in wetlands ecosystem, using Ghana as a case study. A quantitative research strategy leaning towards the positivist paradigm was adopted. A structured survey was developed to collect data from key stakeholders. Purposive sampling was employed to recruit construction experts in the Kumasi Metropolis, with a total of 78 experts agreeing to participate. Relative Importance Index (RII), Mean Score Ranking and a One-Sample T-Test were used to analyse primary data collected. The findings revealed that the key driving forces spurring construction projects in wetlands were rapid urbanisation; high rate of migration; and scarcity of land for development. Critical risks factors associated with construction projects in wetlands were identified as cost overruns; exploitation of biological resources; and water pollution. Finally, the findings also showed that the most critical detrimental effects of construction projects in wetlands were the destruction of aquatic and terrestrial lives; loss of flood control capability; and deterioration of wetland water quality. The study recommends the protection and conservation of wetlands environments through systematized enactment and enforcement of environmental protection regulations by government and non-governmental institutions. This would ensure the preservation of important biodiversity and aid with pollution control and flood protection.

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1. Introduction

Wetlands provide vital sources of water and environmental wildlife havens around the globe yet, have been quickly diminishing because of anthropogenic activity (Wang et al. 2020). Urban and rural growth, as well as agriculture, are examples of human activities that have contributed towards the degradation or complete loss of wetlands (Taillardat et al. 2020). These land use changes have indirectly impacted upon surrounding wetlands by affecting hydrology in the watershed through increased runoff or water withdrawals (Li et al. 2020). Much of this loss happens in freshwater wetlands, with natural processes mostly affecting coastal wetlands, particularly estuarine and marine wetlands, which are naturally affected by high-energy events like land erosion and consequential inundation from sea level rises and storms (Wang et al. 2020). The impacts of these processes may be magnified by climate change and shoreline armoring (Wang et al. 2020). Sadly, in many developing nations wetlands have long been regarded as dumping grounds, but now public attitudes are changing to view them as important landscape features that provide a wide range of palpable benefits for humans and wildlife alike (Xu et al. 2019). Protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters and maintaining surface water flow during dry periods are just a few of the beneficial services or functions provided by wetlands (*ibid*). Moreover, wetlands contribute to the national and local economies by producing resources, enabling recreational activities, and providing other benefits, such as pollution control and flood protection (Hu et al. 2017). Estimating the economic value provided by a single wetland is problematic but evaluating the range of services provided by all wetlands and assign a dollar value is more feasible (Bera et al. 2021). Because

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of the large loss of wetlands and the consequences that this brings, restoration and construction of wetlands have become prioritized environmental measures (Ye and Qiu 2021).

Despite these palpable benefits, developers are still building structures, for religious activities, residential facilities and service stations, without considering the effects that these constructed buildings have on the ecosystem (Hailu et al. 2020). Darnell (1976) discusses four key consequences of construction on wetlands, with the most impactful being the loss of wetland habitat. In strengthening the foundation to withhold structural loads and make it water-tight, it requires the draining, filling, leveeing, damming and channelizing of the wetland. These activities inevitably disturb the ecosystem in which these wetlands animals live and thrive (Hailu et al. 2020). Other consequences include the increase in suspended and sedimented materials which are brought about through the addition of enormous quantities of suspended solids to wetlands environments, the alteration of wetland stream flow patterns and wetlands pollution through increased human activities (Darnell 1976). These risks pinpoint the important ecological functions performed by wetlands. Construction activities that are carried out within such riparian environments affects the ability of the wetlands to perform their ecological functions. Within the Ghanaian context, although several studies have been conducted on risk assessment and management in the construction industry (e.g. Chileshe and Yirenkyi-Fianko 2012; Awuni 2019; Adinyira et al. 2020; Boateng et al. 2020), none have investigated the potential risks associated with construction in urban wetlands. This present study therefore seeks to examine the risks factors associated with construction projects in wetlands' ecosystems. Specifically, the research evaluates the driving forces leading to the emergence of construction projects in wetlands; examines the risks factors associated with construction projects in these wetlands; and assesses the detrimental effects of these construction projects on wetlands and the environment. The study contributes to advancing the existing body of knowledge by assessing risks and effects associated with Ghanaian urban wetlands construction projects, where hitherto scant discourse currently exists. Additionally, the study benefits academia by setting the foundation for future academic inquiry on the environmental performance and consciousness of construction projects in Ghana and developing countries at large. Such work delineated constitutes the first attempt in Ghana to investigate the risks factors associated with construction projects in urban wetlands which will hopefully inform more stringent regulations and oversight by stakeholders such as governmental agencies and practitioners within the construction industry. In doing so, this work provides enabling research that seeks to preserve Ghana's rich biodiversity and heritage for future generations to benefit from.

2. Driving forces leading to the emergence of construction projects in wetlands

A key driving force spurring the degradation and decline of wetlands has been sprawling urbanisation to meet population growth as postulated by studies such as Zhao et al. (2004), Zorrilla-Miras et al. (2014), Gaglio et al. (2017) and Hailu et al. (2020). In turn, urban expansion has been accomplished by draining, infilling and increasing impervious areas (Gaglio et al. 2017). Consequently, ecosystems have become increasingly fragmented and unconnected, increasing their ecological fragility (Mao et al. 2018; Huang et al. 2019). For example, Assefa et al. (2021) investigated the decline of wetlands in Bahir Dar city located in the northwest of Ethiopia and found that since the city became the capital of the Amhara National Regional State, it has seen a significant increase of the built areas. The overall number of housing units in Bahir Dar City increased from 19,808 in 1994 to 45,501 in 2007 to cater for the city's rapid population growth. Wetlands, cultivated land, water bodies, vegetation and grazing areas were replaced by construction of infrastructures, social services and other marketplaces in line with residential dwellings. This unmanaged urban expansion has had devastating effects on supply of ground water, which is crucial to sustaining farming and food production. Several studies have similarly shown that rapid urbanisation has resulted in the conversion of wetlands into built-up regions, which negatively alters the ecosystems (Anteneh et al. 2018; Degife et al. 2019; Hailu et al. 2020).

Rapid urbanisation at the expense of wetland ecosystems, according to Lee et al. (2006), poses ecological risks such as changes in hydrological and sedimentation regimes, as well as the dynamics of nutrients and pollutants. Consequently, the ecological functions that urban wetlands provide have been jeopardised (Lee et al. 2006). Rapid migration to urban centers and population growth have also increased demand for housing and accommodation (Degife et al. 2019; Hailu et al. 2020). However, land for construction purposes is in short supply in metropolitan areas (Sithole and Goredema 2013) and traditional African society often rejects the notion of constructing high-rise development (preferring instead to pursue a policy of low-rise urban sprawl). Consequently, property outside the wetlands' buffer zone is used to compensate for land scarcity for infrastructure development. Rapid urbanisation and urban growth, according to Sithole and Goredema (2013) and Hailu et al. (2020) has resulted in the construction of housing units and other structures on wetlands to meet the requirements of the rising population.

2.1 Risks factors associated with construction projects in wetlands

Risks are synonymous with construction projects and have thus been studied and dissected extensively to understand root causes and ways to minimize and managed their effects (Bahamid et al. 2019). Risk identification, which is the first essential step in risk management, is the process of recognizing and recording information about the associated risks (Chatterjee et al. 2018). In such projects, strategies such as productive risk management have been employed to manage and minimize these risks (Bahamid and Doh 2017). Although it is difficult to control all potential hazards and risks in a construction project, it is important to identify, prioritize and mitigate the most critical (as far as is reasonably practicable), as these can have the most detrimental effects. Construction projects within wetlands are influenced by a number of risk variables (Bahamid and Doh 2017), mainly emanating from ensuring the buildings' structural integrity due to the soil topography in wetlands, ensuring proper drainage and protection from water permeation into the structure. The high water-table in wetlands can engender rapid surges which can exert hydrostatic pressure on the foundations and walls resulting in dampness, leakages and cracks in buildings' foundations (Amo et al. 2017; Huang et al. 2019). Failure to adequately consider these risks and plan properly can compromise a building's quality, result in cost overruns and cause significant changes and/or delays to the project schedule. Another risk factor is minimising the project's environmental impact on the wetland's ecosystem by ensuring proper protection of wetland habitats and ensuring minimal disturbance to the water table and stream patterns (Amo et al. 2017). Although it is important to understand that successful projects are defined by their completion time frame, cost, ability to stay within budget and quality, when constructing in wetlands, the project's environmental consciousness and performance should also be considered (Iyer and Jha 2006; Ismail et al. 2013). Despite these construction risks, wetlands continue to be threatened by development projects such as road construction, thermal power plants, transmission lines, oil and petrochemicals and factories (Anteneh et al. 2018). Construction companies must therefore take necessary precautions and efforts over time to guarantee that their operations are not detrimental to the environment. Most of these precautionary initiatives are driven by a desire to safeguard the natural environment or to meet the minimum acceptable environmental performance requirements set forth in both local and international regulations (Onubi et al. 2019). However, historically these construction companies' efforts have produced inconsistent results (Ardito and Dangelico 2018). In some projects, organisations were able to attain excellent environmental performance (cf. Onubi et al. 2019), while in others they were unable to do so (cf. Onubi et al. 2019). The diverse results in terms of environmental performance have been linked to varying degrees of complexity in construction projects and construction managers using the same procedures, processes and techniques to manage them despite unique project circumstances (Chan and Chan 2004).

Moreover, it is vital to eliminate ecological threats that affect wetlands to conserve and manage them in a sustainable manner before any construction can proceed. Ecosystem-based management is the best strategy to using ecological risk management (ERA) in wetland investigations. The Shadegan Wetland study (Xu et al. 2019) illustrates that stresses imposed on the wetland's environment have negative consequences for the wetland's characteristics. The main stresses were: changes in natural habitats; changes in the water balance of the wetland; water pollution; overexploitation of biological resources; and drought (Xu et al. 2019). Furthermore, the study (*ibid*) suggests that all these elements are interconnected, and that separating the effects and consequences of these factors is challenging due to the complexity of wetland ecosystems. Hydrologic alterations are a common human activity that causes degradation (Huang et al. 2019). When hydrologic conditions lead the water table to saturate or inundate the soil for a period of time each year, the characteristics of a wetland evolve (Xu et al. 2019). Any change in hydrology has the potential to drastically affect soil chemistry as well as plant and animal ecosystems. Common hydrologic alterations in wetland areas include: deposition of fill material for development; drainage for development; farming; mosquito control; dredging and stream channelization for navigation; development and flood control (including diking and damming to form ponds and lakes); and diversion of flow to or from wetlands (Wang et al. 2020; Xu et al. 2019).

2.2 Detrimental effects of construction projects in wetlands and their effects on sustainable performance of wetlands

Wetlands, which provide the most environmental services per unit area, are critical for human survival and long-term development (Malekmohammadi and Blouchi 2014). Wetlands store roughly 20–30% of total organic carbon globally, making them a significant carbon bank for terrestrial ecosystems; carbon balance concerns are intimately linked to climate change (Costanza et al. 1997). According to survey results of key wetlands in China by, 95.2% of wetlands were threatened by human activity, with 30.3% being reclaimed or transformed at random, 26.1% being affected by pollution, 24.0% being affected by excessive biological resource use, 8.0%

being degraded by soil and water loss and sediment deposition, and 6.6% being degraded by unreasonable water resource use (Wang et al. 2020). There are two types of human-induced wetlands disturbances: direct and indirect. Indirect disturbances are more linked to natural impacts such as fragmentation of a wetland from a contiguous wetland complex, increase in flooding and erosion due to rise in sea levels, and loss of recharge area, or changes in local drainage patterns due to climate change (Ficken et al. 2019). Sporadic movement of sediment in and out of wetlands is a disturbance that also occurs in the absence of human activities (Wang et al. 2020).

Examples of direct disturbances include reclamation and human activities within the scope of wetlands, such as wetlands tourism, excessive use of biological resources (bird eggs, fish, reeds etc.), and harvesting of water resources from wetlands for irrigation (Wang et al. 2020). The distribution of settlements (multi-level central places, e.g., cities, towns and villages), which are spatially aggregated areas of human activity, is also related to the direct influence of human activity (Ficken et al. 2019). People usually leave a certain settlement site for a specific wetland location to obtain access to natural resources, to view/enjoy the wetlands and to reclaim underused land (Wang et al. 2020). Hence, settlement patterns may have an impact on the environment of nearby wetlands (Wang et al. 2020). When the grade of the central site is higher, the intensity of human activities and the extent of their services tend to be greater, and vice versa (Wang et al. 2020). Damage probability and risk grade inflicted on regional ecosystems will be greater for central sites at a higher level. Infrastructure facility construction may entail a comparable set of operations such as site preparation, layout, excavation, substructure construction, superstructure construction, mechanical and electrical installation, and finishing (Dadao 2002). The actions involved in the development of these facilities may have detrimental repercussions for wetlands, which must be conserved for these natural resources to be sustainable (Amo et al. 2017). Long-term moisture, fissures, and other faults can compromise the structural integrity of structures erected on wetlands, which can lead to continuous costly maintenance or building failure.

According to Sithole and Goredema (2013), the number of people living in wetlands is increasing, and residents of wetlands face a variety of issues, including structural breakdown of their dwelling units. Construction activities may pollute the wetlands' aquatic and terrestrial life, resulting in their extinction. According to Amo et al. (2017), around 1% of the world's recorded species have been lost, with human activities accounting for about 75% of the loss. When hazardous and poisonous compounds from building activities reach wetlands, they are likely to harm the wetlands' species. These pollutants degrade the environment that allow aquatic and terrestrial organisms to live and thrive, resulting in their extinction (*ibid*). Changes in atmospheric pressure are also caused by the degradation of wetlands (Sithole and Goredema 2013). Wetland vegetation serves to manage the amount of air pressure in the surrounding environment. According to Amo et al. (2017) terrestrial and marine ecosystems play a critical role in climate regulation by absorbing nearly half of all man-made carbon emissions. Because most of the regions within urban centers are either tarred or bare, vegetation in cities and urban centers is typically scarce and limited to wetlands. Therefore, when the wetlands' vegetation is destroyed, the atmosphere's control is compromised, influencing atmospheric pressure. Numerous studies in medical meteorology show that sudden daily fluctuations in atmospheric pressure have negative consequences on health and various types of human activities (Danso and Manu 2013; Dotse 2018). Wetlands also extract and store greenhouse gases from the atmosphere, therefore their demise may contribute to global warming (Sithole and Goredema 2013). Wetlands degradation can also cause a fall in atmospheric oxygen levels. Through its gaseous exchange, vegetation aids in the regulation of oxygen in the environment. The level of pollution in metropolitan areas is extremely significant due to emissions from automobiles and other industrial devices. When the vegetation of wetlands is destroyed by construction activities, the chemical processes of green plants are also harmed, affecting their gaseous exchange (Amo et al. 2017).

3. Research framework and data collection

The study adopted a positivist and empiricist epistemological philosophy, which emphasizes empirical methods designed to yield pure data and facts uninfluenced by human interpretation or bias (Owusu-Manu et al. 2018; Edwards et al. 2020). A deductive research approach was adopted in this study to test theories about the phenomena under investigation using empirical data (Creswell and Creswell ; Ahmed et al. 2021). The research also adopted the quantitative strategy, which involved the use of surveys to gather primary data from experts within the construction industry. A quantitative approach places emphasis on measurement and quantification and thus, a Likert scale was used in seeking expert opinions. The Likert scale grading system has the advantage of minimizing central tendency challenges normally associated with ordinal data (Creswell and Creswell). Contextually, this study focused on examining the risk factors associated with construction projects in wetlands. This included examining the driving forces spurring construction projects in urban wetlands ecosystem and examining the detrimental effects of these projects on the environment. Geographically, the study was limited to the Kumasi Metropolis, which is the capital city of one of the largest regions in Ghana. The region is also strategic because over ten suburbs in Kumasi are wetlands, making it an important study area. Finally, the proximity to the researchers enabled ease of collecting data.

In designing the survey to collect data, a thorough review and synthesis of the literature was undertaken regarding construction in wetlands – the results of which subsequently informed scales formulated. The designed survey comprised two main parts, part one sort to collect the respondent's demographic data. Part two contained three sub-sections that accrued data on 1) the driving forces spurring construction projects in wetlands ecosystem; 2) the risks associated with projects on wetlands; and 3) the detrimental effects of these projects on the environment. Respondents were to rate the identified factors on a Likert scale of 1 to 5, from strongly disagree to strongly agree. The survey data collection instrument was first piloted using two project managers, as well as two site engineers to check the validity of the research instrument. These individuals were chosen due to their in-depth knowledge and experience in the development of wetlands, with each having a minimum of three years of experience. This pilot study provided useful feedback which helped in restructuring the survey before full deployment (e.g., clarity of the questions/scales posed, layout of the instrument and additional areas to be investigated).

Purposive sampling (also known as judgment sampling) was adopted to select respondents based on their knowledge and experience, which was critical in ensuring rigor of information obtained (Etikan and Bala 2017). Respondents were therefore required to have at least three years of experience and in-depth knowledge of wetlands development. Identified respondents who agreed to participate were then required to fill out the survey either virtually by email or in person. As part of stringent ethical considerations governing this research, all respondents were assured that: their identities would remain strictly confidential and would not be divulged nor disseminated without written informed consent; data would be presented in aggregate form and that the findings would be freely available post analysis and publication; and that all data would be held in a secure cloud-based server and securely destroyed post publication (cf. Fisher et al. 2018). In all, a total of 78 questionnaires were retrieved out of the 100 target respondents accounting for 78% response rate. The high response rate of 78% was due to the intensive follow-up by calling, emailing, and meeting respondents in person.

3.1 Data analysis

Data was analyzed using the Statistical Packages for Social Sciences (SPSS) version 24. The statistical analysis used included mean score ranking, one-sample t-test and Relative Importance Index (RII). RII and mean score ranking were used to determine the central tendency of the driving forces, risk factors as well as the effects of construction project on urban wetlands. A one-sample t-test was also used to ascertain the statistical significance of the mean values.

4. Analyses and discussion of results

Cronbach's Alpha co-efficient was used to check the internal consistency of the variables and reliability of the scale designed for the study. A scale is considered reliable if the Cronbach Alpha co-efficiency >0.700 (Owusu-Manu et al. 2022; Quaigrain et al. 2022). The Cronbach's Alpha coefficient was determined to be 0.813, which is significantly higher than the required threshold of 0.70. Therefore, it can be determined that the survey designed to collect the data was highly reliable.

4.1 Socio-demographic data

Demographic data was used as an indicator to access the suitability of participating respondents to ensure the required scientific rigor of the data collected. With regards to qualifications, 46.2% were Construction Managers (f = 36), 17.9% were Quantity Surveyors (f = 14) and 10.3% were Project Managers (f = 8). The remaining 25.6% had other professional backgrounds (f = 20). Regarding years of experience, most respondents had 6–10 years of experience representing 51.3% (f = 40), with 35.8% having above 11 years of experience (f = 28). The remaining 12.8% had below 5 years of experience (f = 10). Finally, regarding educational level, 58.8% of respondents had bachelor's degree (f = 42) with the remaining 46.2% had obtained at least a Masters (f = 36). It can be deduced from these demographics that all respondents are well versed and knowledgeable and thus ensures the accuracy and rigor of the data provided

4.2 Driving forces leading to the emergence of construction projects in wetlands

To understand the rationale behind construction activities on urban wetlands, the study assessed the driving forces leading to the emergence of construction projects in wetlands. The prevalence of these characteristics (as defined through literature synthesis) was ranked and analysed using RII, in addition to their mean scores and standard deviation. Table 1 summarises these values. One-sample t-test was also

Table 1. Driving forces leading to the development of wetlands.

Driving forces	Mean	SD	RII	Ranking	Literature Sources
Rapid urbanisation	4.36	0.837	0.872	1	Sithole and Goredema (2013); Zhao et al. (2004); Huang et al. (2019); Assefa et al. (2021); Hailu et al. (2020)
High rate of migration to the urban centers	4.28	0.851	0.856	2	Hailu et al. (2020); Assefa et al. (2021); Degife et al. (2019)
High cost and scarcity of land for development	4.23	0.979	0.846	3	Mao et al. (2018); Degife et al. (2019)
Rapid population growth	4.15	0.839	0.830	4	Sithole and Goredema (2013); Huang et al. (2019); Assefa et al. (2021)
High demand for alternative land uses	4.08	0.894	0.815	5	Huang et al. (2019); Assefa et al. (2021)
Wetlands cheaply leased out	3.95	1.161	0.789	6	Mao et al. (2018); Sithole and Goredema (2013)
Expansion of built-up area	3.82	1.041	0.764	7	Assefa et al. (2021); Huang et al. (2019)
Scarcity of lands for construction purposes	3.77	1.104	0.754	8	Sithole and Goredema (2013)
Proximity of wetlands to economic activities	3.56	0.988	0.713	9	Assefa et al. (2021); Hailu et al. (2020)
Unprecedented land reclamation	3.41	1.012	0.682	10	Sithole and Goredema (2013)
Closeness of wetlands to social amenities	3.29	1.012	0.651	11	Assefa et al. (2021); Hailu et al. (2020)
Farming practices	3.08	1.148	0.615	12	Assefa et al. (2021)

conducted to compare the means of the various variables and establish how different they were from the hypothesized mean which was 3.5. The null hypothesis (Ho) states, 'the mean value is not a statistically relevant driving force,' and the alternative hypothesis (Ha) states, 'the mean value is a statistically significant driving force'. The analysis presented in Table 2 shows that only eight of the assessed driving forces had mean scores considerably > the hypothesised mean, with their p-values < 0.05. The remaining four, which were ranked as the least critical driving forces either had p-values > 0.05 or mean scores lower than the hypothesized mean. Conclusively, the study's null hypothesis is disproven for those eight driving forces, and thus these are significant driving forces which lead to the development of urban wetlands.

In discussing the three most critical driving forces from the analysis in Tables 1 and 2, '*rapid urbanisation*' was rated as the most important contributory factor with a mean score of 4.36 and an RII of 0.872. This implies that respondents strongly agreed that rapid urbanisation is a significant driving force leading to the development of construction projects on urban wetlands. This finding was also echoed by Sithole and Goredema (2013) and Huang et al. (2019) who stipulated that increasing urbanisation places an undue demand on urban infrastructures leading to the commissioning of more projects to meet those demand. Thus, urbanisation plays a crucial role in the use of wetlands for construction as land available for such becomes scarce. Assefa et al. (2021) also concurred that rapid urbanisation inevitably increases the demand for housing and other facilities in these urban areas. With most urban areas already facing a problem of land scarcity and limited housing, authorities such as municipal governments and other stakeholders in charge of physical development are being enticed to encroach on wetlands to increase land available for the development of housing and other facilities to accommodate the rapidly increasing population. In addressing land scarcity conundrum, countries like Japan and Singapore have resorted to developing vertical cities (Wong, 2004), a solution Ghana needs to fully capitalise on in order to overcome a cultural desire for sprawling low-rise development.

Similarly, *'high rate of migration to urban centers'* very closely linked with urbanisation was ranked as the second most critical driving force with a mean score of 4.28 and an RII of 0.856. From this, it can be concluded that respondents strongly agreed that high rate of migration is a key factor influencing the development of construction projects in urban wetlands. As more people migrate to urban areas, this exponentially leads to rapid increases in population resulting in increased housing shortages, urban congestion, strains on the provision of water and energy and environmental degradation. As postulated by Hailu et al. (2020) the movement of people from other areas of a country to urban centers for economic pursuits puts undue pressure on land demand because of increasing demand for housing facilities and other services. Because of these strains, municipal government and developers resort to claiming lands occupied by water bodies and other ecological wetlands to placate the growing pressure on the limited lands and housing facilities.

The third most critical factor driving the development of construction projects on wetlands in urban areas was linked to the '*high cost and scarcity of land for development in these urban areas*', with a mean score of 4.23 and an RII of 0.846. Respondents strongly agreed that the high cost of land in urban centers is one of the factors fueling the development of construction

Table 2. Driving forces leading to the development of wetlands one sample T-Test.

Test Value = 3.5						
					95% Confidence	
Driving forces	t	df	Sig. (2 tailed)	Mean difference	Lower	Upper
Rapid urbanization	9.063	78	.000	0.859	0.67	1.05
High rate of migration to the urban centers	8.114	78	.000	0.782	0.59	0,97
High cost and scarcity of Land for development	6.886	78	.000	0.731	0.51	0.95
Rapid population growth	6.590	78	.000	0.654	0.46	0.84
High demand for alternative land uses	5.700	78	.000	0.577	0.38	0.78
Wetlands cheaply leased out	3.413	78	.001	0.449	0.19	0.71
Expansion of built-up area	2.718	78	.008	0.321	0.090	0.56
Scarcity of lands for construction purposes	2.154	78	.34	0.269	0.02	0.52
Proximity of wetlands to economic activities	0.573	78	0.568	0.064	−0.16	0.29
Unprecedented land reclamation	−0.783	78	0.436	−0.090	−0.32	0.14
Closeness of wetlands to social amenities	−2.126	78	0.037	−0.244	−0.47	−0.02
Farming practices	−3.254	78	0.02	−0.423	−0.68	−0.16

projects on wetlands in urban areas. Due to high demand and limited supply of available lands in urban centers, prices of the limited available lands can be expensive (Sithole and Goredema 2013). Because of this high level of prices, developers opt to reclaim lands occupied by wetlands and other aquatic features to undertake construction and other developmental projects to avoid high costs. According to Mao et al. (2018), this is key driving factor leading to the reclamation of wetlands, which are leased out significantly for less. However, the ecological functions of wetlands cannot be overlooked in lieu of infrastructure development. Considering their ecological and economic benefits, Ghana must reconsider the reclaiming of such lands if it hopes to drive more sustainable development.

Regarding other assessed factors, '*rapid population growth*' and *'demand for alternative land uses'* were ranked 4th and 5th key drivers with mean scores of 4.15 and 4.08 respectively. From these mean scores it can be deduced that respondents strongly agreed that these are important factors which drive the utilisation of wetlands for construction projects. Population most especially in the urban areas is witnessing an increase and this is creating unsustainable demand for housing and other facilities. To satisfy these increasing demands, more land which may include wetlands and other water bodies are converted and utilized to create more facilities to house the increasing population. Respondents generally agreed with all the other variables as factors that drive the utilization of wetlands for construction projects since they all had means ranging between 3.0 and 3.99. Conversely, *'unprecedented land reclamation'* with a mean score of 3.14, *'closeness of wetlands to social amenities'* with a mean score of 3.26 and *'farming practices'* with a mean score of 3.08 were rated as the least important driving factors. By implication, although studies like Huang et al. (2019) have postulated the importance of land reclamation activities, and agricultural practices contributing to the development and loss of essential wetlands, within the Ghanaian context, these factors are not seen as critical driving forces. Further research is required to understand why this perception prevails.

4.3 Risk factors associated with construction in wetlands

An analysis of risk factors associated with construction projects in wetlands (defined through a methodical synthesis of literature) is outlined Table 3. Risk factors were analysed using RII, in addition to their mean scores and standard deviation. A one-sample t-test was also conducted to further analyze the distinction between the means of the assessed risked factors, with the hypothesized mean of 3.5. The null hypothesis (Ho) states, 'the mean value is not a statistically relevant risk factor', and the alternative hypothesis (Ha) states, 'the mean value is a statistically significant risk factor.' The analysis shown in Table 4 indicated all but one of the assessed driving risk factors had mean scores considerably > the hypothesised mean, with their p-values < 0.05. '*Non-profitability of project*' which was ranked as the least important risk factor had a p-value > 0.05. Conclusively, the study's null hypothesis is rejected for those nine risk factors.

Discussing the three key risk factors, from the analysis shown in Tables 3 and 4, *'cost overruns'* was deemed the most critical risk factor with a mean score of 4.18 and an RII of 0.836. By implication respondents strongly concurred that cost overruns is one of the key risks associated with construction projects on wetlands. Construction in wetlands comes with certain challenges which may be unpredictable at the start of the project, and these may lead to changes in design and project schedule, resulting

Table 3. Risk factors associated with construction in wetlands.

Risk Factors	Mean	SD	RII	Ranking	Literature Sources
Cost overruns	4.18	0.908	0.836	1	Chatterjee et al. (2018); Ellis et al. (2021; Onengiyeo Fori (2016)
Exploitation of biological resources	4.15	0.740	0.831	2	Anku (2006); Verhoeven et al. (2006); Xu et al. (2019)
Water pollution	4.10	0.988	0.821	3	Xu et al. (2019)
Building quality challenges	4.03	0.925	0.805	4	Huang et al. (2019); Amo et al. (2017)
Alteration in natural habitats	3.97	0.772	0.795	5	Xu et al. (2019)
Risk of structural collapse	3.95	0.881	0.790	6	Huang et al. (2019); Amo et al. (2017)
Risk of drought	3.92	0.894	0.785	7	Xu et al. (2019)
Changes in water levels	3.90	0.934	0.779	8	Xu et al. (2019)
Project schedule delays	3.90	0.988	0.779	9	Amo et al. (2017)
Non-profitability of project	3.69	0.997	0.738	10	Onengiyeo Fori (2016)

Table 4. Risk factors associated with construction in wetlands one sample T-Test.

Test Value = 3.5

Risk Factors	t	df	Sig. (2 tailed)	Mean difference	95% Confidence Lower	95% Confidence Upper
Cost overruns	6.609	78	.000	0.679	0.47	0.73
Exploitation of biological resources	7.805	78	.000	0.654	0.49	0.82
Water pollution	5.386	78	.000	0.603	0.38	0.83
Building quality challenges	5.016	78	.000	0.526	0.32	0.73
Alteration in natural habitats	5.423	78	.000	0.474	0.30	0.65
Risk of structural collapse	4.497	78	.000	0.449	0.25	0.65
Risk of drought	4.180	78	.000	0.423	0.22	0.62
Changes in water levels	3.758	78	.000	0.397	0.19	0.61
Project schedule delays	3.552	78	.000	0.397	0.17	0.62
Non-profitability of project	1.703	78	.093	0.192	−0.03	0.42

in financial troubles during construction (cf. Chatterjee et al. 2018). This has the potential of straining the project budget and leading to cost overruns (Ellis et al. 2021; Shoar et al. 2022). According to Onengiyeo Fori (2016) to address and manage these cost overruns, it is important to identify what the root causes are. While specific events such as extreme weather conditions can cause delays or damage which may result in cost overruns, they are often the result of more complex project management issues that can be difficult to untangle, such as technicalities in building on wetlands. Implementing a sustainable risk management strategy can significantly help to circumvent the damaging repercussions of environmental risks and overruns. It is important to note that these costs are not limited to only the construction stage, as building on wetlands can lead to long-term battles with water surges and higher potential of flooding (Amo et al. 2017).

The second most rated risk factor associated with construction in urban wetlands was deemed to be the *'exploitation of biological resources'* with a mean score of 4.15 and an RII of 0.831. With the emergence of construction projects in wetlands, biological resources are being exploited and destroyed at a greater rate than they are being replaced (Xu et al. 2019). Also, some activities conducted during construction may be detrimental to these resources and hence, lead to their damage. The importance of preserving the biological integrity of wetlands cannot be overstated. Wetlands provide significant ecological benefits to the environment's health. They aid in the filtering and removal of pollutants from the ecosystem, such as sediments and hazardous compounds (Anku 2006).

'Water pollution' with a mean score of 4.10 and an RII of 0.821 was found to be the third most rated risk factor. Construction projects especially those in wetlands possess a high risk of polluting water bodies since they involve the use of a lot of hazardous chemicals and materials. This is in cognisance with Xu et al. (2019) who agreed that construction activities in wetland environments can significantly alter and pollute water stream flow patterns. This can result in reduced flow through water loss, reduced flow during critical low water seasons, reduction of peak flow, reduction of floodplain flooding and modification of seasonal flow regimes. The downstream effects of flow pattern alterations may severely damage the natural ecosystems of streams; riparian wetlands; coastal marshes, swamps, and estuaries; and ocean beaches. Additionally, construction activities also generate voluminous waste which possess the tendency and capability of damaging water bodies if not adequately controlled and managed.

Regarding the other assessed risk factors, *'building quality challenges', 'alteration in natural habitats', 'risk of structural collapse'* and *'drought'* were rated as the 4th, 5th, 6th and 7th most key risks associated with constructing in wetlands with mean scores of 4.03 3.97, 3.95 and 3.92 respectively. As discussed, projects in wetlands cause immense changes to habitats and other residents who depend on these fragile ecosystems. Facilities constructed on wetland environments also risk structural failures since the soils and other conditions may not be suitable enough to hold the structural loads. Another risk posed is drought, in that construction in wetlands may put areas at a risk of experiencing droughts since these projects can lead to the alteration and reduction in water flow and its regeneration capabilities. Regards the least critical potential risks, 'changes in water levels', 'inability to complete project on schedule' and the 'non-profitability of projects' were deemed by respondents as the least impactful and thus lower on the priority scale with mean score values of 3.90, 3.90 and 3.69 respectively. Many of these risk factors are interrelated and thus, although these have been rated lowest within this study, more research is needed to ascertain the relationship and effects of these factors on overall project performance.

4.4 Detrimental effects of construction projects in wetlands

The study finally assessed the detrimental effects of construction projects in urban wetlands in Ghana. Analysis of these effects are summarised in Table 5. A one-sample t-test was also conducted at a 95% confidence level using a hypothesized mean of 3.5. Similarly, the null hypothesis (Ho) states, 'the mean value is not a statistically relevant effect', and the alternative hypothesis (Ha) states, 'the mean value is a statistically relevant effect.' The analysis presented in Table 6 indicated that all eleven of the effects had mean scores significantly > the hypothesised mean, with their p-values < 0.05. Overwhelmingly, the study's null hypothesis is rejected for all assessed effects and thus, these are significant detrimental effects of constructing on urban wetlands.

Analysing the three key detrimental effects as shown in Tables 5 and 6, *'destruction of aquatic and terrestrial lives'* and *'loss of flood control capability'* was overwhelmingly ranked as the most critical damaging effects of construction projects in urban wetlands with mean scores of 4.18 and RII of 0.836. The execution of infrastructure projects on wetlands inevitably involves activities which can be negatively impact the lives of aquatic and terrestrial habitats which may reside in these wetlands. Activities like excavations may disturb, endanger, or bring about the extinction of habitats that depend on such wetland for survival. Bahamid et al. (2019) concurred that construction activities like draining, excavation, filling which are essential in stabilising wetlands to ensure structural integrity of the structure are also unfortunately destructive activities which lead to the loss of wetland inhabitants and wetland spatial extent.

Regarding the *'loss of flood control ability'* it can be concluded that respondents agreed very strongly that loss of flood control is a significant harmful effect which can be cause or aggravated by the commissioning of construction projects in wetland environment. This is in cognisance with Moomaw et al. (2018) and Xu et al. (2019) who stated that wetlands help to control flooding by regulating the flow of water by providing surface water storage during periods of high rainfall. From this, it can be deduced that construction projects on wetlands can result in the loss of flood control capability performed by these wetlands. This is because the process of executing a construction

Table 5. detrimental effects of construction projects in wetlands.

Detrimental Effects	Mean	SD	RII	Ranking	Literature Sources
Destruction of aquatic and terrestrial lives of the wetlands	4.18	0.679	0.836	1	Bahamid et al. (2019); Xu et al. (2019); Mulligan et al. (2012); Amo et al. (2017)
Loss of flood control capability	4.18	0.879	0.836	2	Xu et al. (2019); Moomaw et al. (2018); Mbala et al. (2019)
Deterioration of wetland water quality	4.15	0.740	0.831	3	Mbala et al. (2019); Houser and Pruess (2006); Mulligan et al. (2012)
Loss of erosion control and sediment-trapping capability	4.08	0.864	0.815	4	Xu et al. (2019); Moomaw et al. (2018); Mbala et al. (2019)
Loss of flood plain land and flood plain protection	4.05	0.788	0.810	5	Xu et al. (2019); Moomaw et al. (2018); Mbala et al. (2019); Mulligan et al. (2012)
Changes in the atmospheric pressure	4.00	0.645	0.800	6	Wang et al., (2020); Amo et al. (2017); Sithole and Goredema (2013)
Reduction in water supply and storage	3.97	0.805	0.795	7	Xu et al. (2019); Moomaw et al. (2018); Mbala et al. (2019)
Destruction of wetlands contributing to global warming	3.90	0.847	0.779	8	Mulligan et al., (2012); Amo et al. (2017); Wang et al. (2020)
Reduction in the amount of oxygen in the atmosphere	3.87	0.795	0.774	9	Mulligan et al., (2012); Amo et al. (2017); Sithole and Goredema (2013)
Increased sedimentation	3.85	0.807	0.769	10	Mulligan et al., (2012); Li et al. (2020)
Reduced recreational opportunities	3.70	0.827	0.759	11	Xu et al. (2019); Hu et al. (2017)

Table 6. Determent Effects of construction project on wetlands one sample T-Test.

Test Value = 3.5						
					95% Confidence	
Detrimental Effects	t	df	Sig. (2 tailed)	Mean difference	Lower	Upper
Destruction of aquatic and terrestrial lives of the wetlands	8.840	78	.000	0.679	0.53	0.83
Loss of flood control capability	6.828	78	.000	0.679	0.48	0.88
Deterioration of wetland water quality	7.805	78	.000	0.654	0.49	0.82
Loss of erosion control and sediment-trapping capability	5.894	78	.000	0.577	0.38	0.77
Loss of flood plain land and flood plain protection	6.180	78	.000	0.551	0.37	0.73
Changes in the atmospheric pressure	6.850	78	.000	0.500	0.35	0.65
Reduction in water supply and storage	5.202	78	.000	0.474	0.29	0.66
Destruction of wetlands contributing to global warming	4.146	78	.000	0.397	0.21	0.59
Reduction in the amount of oxygen in the atmosphere	4.128	78	.000	0.372	0.19	0.55
Increased sedimentation	3.788	78	.000	0.346	0.16	0.53
Reduced recreational opportunities	3.147	78	.002	0.295	0.11	0.48

project can lead to the high likelihood of destroying these wetlands permanently or changing their nature and rendering them unable to perform this key function (Mbala et al. 2019; Xu et al. 2019). This only goes to emphasize the importance of proper planning within urban areas and conservation of important wetlands.

The third most critical harmful effect was deemed to be the *'deterioration in wetland water quality"* with a mean score of 4.15 and an RII of 0.831. Implicitly, it can be deduced that constructing on wetlands creates an imbalance in the wetlands that also compromises the quality of water bodies (wetlands can act as natural filtration barriers). Mbala et al. (2019) established that water pollution is a significant effect of construction projects on the environment. Houser and Pruess (2006) further argued that construction activities lead to the development of sediments, and sediments are the largest causes of polluted water. Therefore, as previously established it can be the concluded that construction activities in wetlands can seriously jeopardise the quality of water, further emphasizing the important role that wetland plays within the ecosystem.

Regarding the other assessed factors, *'loss of erosion control and sediment-trapping capability'*, *'loss of flood plain land and flood plain production'* and *'changes in the atmospheric pressure'* ranked 4th, 5th, and 6th most important effects with mean scores of 4.08, 4.05 and 4.00. However, *'increased sedimentation'* and *'reduced range of recreational opportunities'* were ranked as the least damaging effects of construction activities with mean scores of 3.85 and 3.79. From this it can be deduced that urban wetland is a crucial component of the urban ecosystem, providing a variety of ecological services that cannot be replaced by other ecosystems in the city. It is said to be the most effective means of utilizing the terrestrial ecology (Ye and Qiu 2021). However, as urbanisation and thus construction projects have accelerated, wetlands have been severely damaged, reducing wetland support for economic and social sustainable development. Thus, a clear understanding of wetland service functions, as well as the protection and restoration of urban wetlands, is an important issue that municipal governments within Ghana and other project stakeholders must prioritise.

4.5 Implication of findings

Theoretically, this study adds to the growing body of knowledge on the importance of wetlands' conservation in urban environments, the risk factors associated with construction projects in wetlands ecosystem and the detrimental effects associated with construction projects in wetlands ecosystem. The research contributes to the prevailing discourse on advancing a collective environmental consciousness amongst project stakeholders and their responsibility for construction projects regarding construction on, and destruction of essential wetlands. Such work serves as a reference benchmark for the industry and researchers and strives to engender much needed polemic debate. The study's findings provide stakeholders, particularly planning and development government agencies and the construction industry alike the necessary empirical insights into the potential risks factors associated with construction within urban wetlands, its effects on ecosystem as well as some critical driving factors spurring the destruction of existing essential wetlands. The empirical data analysis presented will hopefully lead to the enactment of more stringent and sustainable planning and construction practices, municipally and nationally, with the aim of conserving indispensable urban wetlands which are fast depleting. The findings also outlined key economic driving factors spurring expansion of urban infrastructure, such as urbanisation and population growth. Knowledge of these key driving forces will hopefully provide agencies with the amount needed to address these factors with the aim of minimizing the destruction and deterioration of urban wetlands.

Practically, the study recommends the protection and conservation of wetlands entailing the stringent and systematic collection of necessary data to inform the regulation and monitoring of construction and planning activities, and implementation of sustainability standards by both government and non-governmental institutions within Ghana. Additionally, the study also advocates for government to be more committed to the restoration and protection of wetlands through enforcement of strict standards and education on the importance of wetlands. The geographical limitation of the study to the Kumasi Metropolis limits the generalisation of the results, therefore parallel studies nationwide are recommended. Also, the study did not investigate the benefits of wetlands, therefore the study recommends that exploration of the benefits of urban wetlands ecosystem to the social, environment and economic development of Ghana and investigate strategic measures for preventing and minimizing the usage of wetlands for construction activities.

5. Conclusion

The study examined the risks factors associated with construction projects in wetlands' ecosystems in Ghana. Specifically, the study identified critical driving forces leading to the emergence of construction projects in wetlands and also assessed key risk factors associated with construction projects on wetlands. The findings emphasised *'rapid urbanisation'* as the most critical driving force, closely, followed was *'high rate of migration to urban areas'* and *'scarcity of land for development'*. By implication, within the Ghanaian context, rapid urbanisation, high migration rates to urban areas and scarcity of land for development are key measures spurring the development on urban wetlands. Similarly, *'cost overruns'* was found to be the most critical risk factor to consider when developing on wetlands. This is followed by *'exploitation of biological resources'*, and *'water pollution'* which were ranked by respondents' as the second and third most important risk factor to consider. From these findings, it is imperative for construction industry and professionals and government officials to critically examine the feasibility of construction on wetlands and the detrimental effects it would have upon project success and the environment. In further understanding the effects of such construction project on the environment, the study investigated the effects of construction on wetlands. The findings pinpointed '*destruction of aquatic and terrestrial lives*' as a significant harmful effect of construction projects. Similarly, 'loss of flood control capability', *and 'deterioration of wetland water quality'* were also rated as key detrimental effects. From these findings, its is clear that although the emergence of the sustainable development within Ghana has created more awareness on environmental protection during construction, environmental performance should be regarded as a key criterion for assessing project performance to ensure construction companies prioritize environmental protection just as they do other project factors. Harmony between the built and natural environment must be a priority on project stakeholders henceforth, to protect natural biodiversity and mankind who reply so heavily upon it. Mankind will ruin the environment at the expense of our own demise.

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