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Impact Of Climate Change on Current Drainage Infrastructure in The Salalah Region

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Abstract

This study investigates the influence of climate change on the drainage system in Salalah City, Oman, evaluating its performance and recommending long-term mitigation strategies for flooding. Climate change has greatly increased flooding risks, aggravating the constraints of urban drainage infrastructure and emphasising the need for effective management measures. The study's goal is to deliver practical information to improve the city's flood resilience and protect its infrastructure. A quantitative research methodology was used, with structured surveys disseminated to project managers, engineers, and technicians in Salalah. SPSS was used to analyse the data, with descriptive and inferential statistical methods, as well as multiple regression analysis. These methodologies allowed for the assessment of links between climate change impacts, drainage system performance, and recommended mitigation options. The findings reveal that 97.2% of respondents believe the frequency of flooding in Salalah has increased in recent years due to climate change. Despite this, 94.5% of participants view the current drainage system and mitigation measures as partially effective, though insufficient for handling extreme flooding events. Regression analysis further highlighted that climate change significantly impacts drainage system performance, with a positive regression coefficient ($\beta = 0.314$, $p < 0.01$), indicating its critical role in exacerbating flooding issues. Additionally, mitigation measures such as infrastructure upgrades and sustainable drainage systems were identified as effective solutions, with a significant positive impact on reducing flood risks ($\beta = 0.295$, $p < 0.01$). The study suggests that managing flooding in Salalah requires a multifaceted approach that includes infrastructure improvements, sustainable urban drainage systems, and stakeholder participation. The proposed mitigating methods provide a road map for improving drainage system efficiency and encouraging sustainable urban development. These findings are useful for politicians, engineers, and urban planners in Salalah and other locations facing similar issues, as well as those working globally to adapt to and reduce the effects of climate change.

Keywords: Climate Change, Salalah City, flooding risk, urban drainage, Mitigation Strategies

1. General

The effects of climate change have been more clearly visible in recent years, changing the environment around us in significant and frequently unpredictable ways. Drainage systems is one of the infrastructures that face a noticeable impact. Extreme weather events are occurring increasingly frequently and intensely, and as a result, the demands for drainage systems improvement are growing (Zhou et al. 2018). Generally, cities and towns have been maintained by a sophisticated network of pipes, canals, and basins, but it is now having difficulty adjusting to the shifting climatic trends. Numerous locations across the globe are affected by climate change, which disturbs ecosystems, water cycles, and societies. Increased rainfall trends have been observed globally in a number of places. Oman's Salalah region is among those places most affected by climate change (Andreou et al., 2020). Changes in weather patterns have resulted in more rain and flooding in this area, which have severely damaged the infrastructure and affected daily life for the locals. Major extreme rainfall events have increased in frequency in Oman over the past few years, leading to frequent flash floods and significant economic, social, and environmental losses (Gunawardhana et al., 2018). Urban drainage systems, which collect and carry wastewater and rainwater away from populated regions, have long been an important aspect of city infrastructure. (Yousif et al., 2019). Designing an efficient drainage system continues to be difficult despite advancements over the years. Particularly, effects of urbanisation and climate change have been extensively noted, which might lead to a notable rise in the frequency and intensity of urban floods in several global regions. Climate change effect assessment in metropolitan settings has previously focused on flood risk from river systems or water supply (Herath & Sarukkalige, 2018) rather than storm and wastewater drainage. The Salalah region's current drainage infrastructure is unable to handle the increased rainfall and flooding brought on by climate change. A better drainage system is now required in order to handle the extra water and lessen the effects of flooding. To preserve the security and wellbeing of local citizens as well as to maintain the region's economic activity, an upgraded drainage system is essential. The study will concentrate on the flaws in the current drainage system and offer remedies that can be used to lessen the effects of climate change. The study's conclusions will offer insightful information on the difficulties brought on by climate change and the steps that can be taken to overcome them, which can be helpful to decision-makers, planners of infrastructure, and local citizens.

2. Literature Review

The Impact of Climate Change on Urban Drainage Systems

Climate change has significantly altered rainfall patterns, increasing the intensity and frequency of extreme weather events that overwhelm urban drainage infrastructure. Zhou et al. (2018) highlight that cities worldwide are facing higher flood risks due to changing precipitation patterns, yet many drainage systems remain outdated and unprepared for such variability. Similarly, Gunawardhana et al. (2018) report that Oman has experienced a notable rise in extreme rainfall events, leading to urban flooding, infrastructure damage, and increased economic costs. These findings align with recent studies indicating that traditional drainage designs are no longer sufficient to manage flood risks in arid and semi-arid regions (Hereher et al., 2019). However, a major limitation in existing research is the lack of region-specific assessments. While studies confirm that climate change affects drainage performance globally, there are few empirical investigations that quantify the exact impact on transmission infrastructure in arid environments like Salalah. This study seeks to bridge that gap by analysing how climate-induced rainfall variations specifically influence Salalah’s drainage system, offering critical data to improve flood mitigation planning.

Urbanization and Its Effect on Drainage Infrastructure

Urban expansion has placed additional pressure on existing drainage systems, exacerbating flooding risks in many regions. Zhou et al. (2019) and Mahmoud & Gan (2018) argue that rapid urbanization increases impermeable surfaces, reducing natural infiltration and leading to higher surface runoff. In Oman, urbanization has accelerated significantly over the past two decades, yet little research has examined how population growth, land-use changes, and infrastructure development impact drainage system performance (Andreou et al., 2022). Although previous studies acknowledge urbanization's role in drainage inefficiency, they often focus on general trends rather than quantitative assessments. Few studies have conducted statistical analyses to evaluate the extent to which urban expansion affects flooding frequency. This research aims to fill this gap by using multiple regression analysis to assess the relationship between urban growth, climate change, and drainage system effectiveness, providing policymakers with data-driven insights for sustainable urban planning.

Effectiveness of Existing Drainage Systems and Flood Mitigation Measures

Many global studies have assessed flood mitigation strategies, with a growing emphasis on sustainable urban drainage systems (SUDS), green infrastructure, and smart drainage technologies (Gimenez-Maranges et al., 2020). Advanced flood control solutions, such as real-time monitoring systems and smart drainage networks, have been successfully implemented in Europe and North America (Alves et al., 2020). However, such approaches are underutilized in the Middle East, where most drainage systems still rely on conventional infrastructure that lacks adaptive capacity (Salimi & Al-Ghamdi, 2019). Alves et al. (2020) found that combining green-blue-grey infrastructure can significantly reduce urban flooding while enhancing sustainability. Yet, in Oman, flood mitigation largely depends on structural interventions like stormwater drainage channels, without integrating newer adaptive drainage technologies (Kourtis & Tsihrintzis, 2021). This study critically evaluates whether Salalah's current flood management approach aligns with best practices, identifying key areas where improvements and innovations are required.

Research Gaps and Contribution of This Study

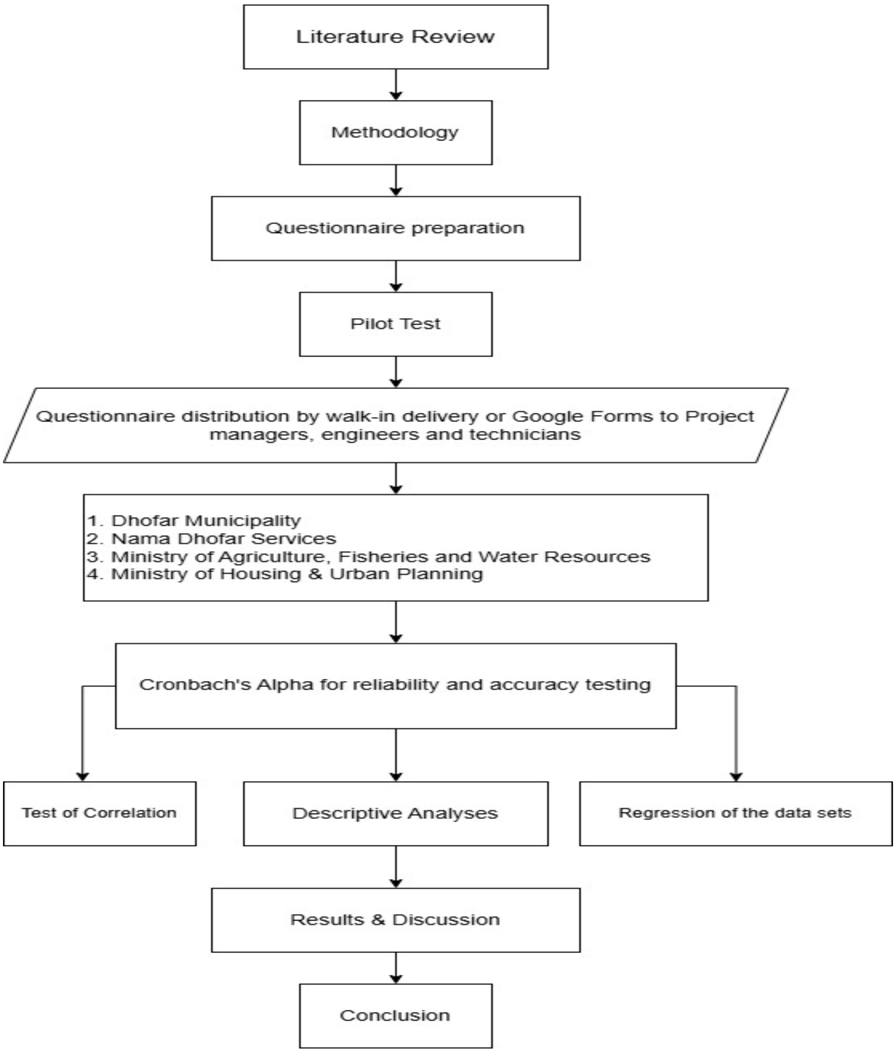
Despite significant research on climate change and urban flooding, several gaps remain in the existing literature:

1. Limited Empirical Data on Climate Change Impacts in Arid Regions – While studies confirm that extreme rainfall events are increasing, few quantify how this affects drainage system efficiency in arid climates like Oman's. This study provides statistical evidence linking climate change to flooding risks in Salalah.
2. Lack of Region-Specific Urban Drainage Assessments – Most existing studies focus on Europe, North America, and Asia, with insufficient research on drainage performance in Gulf countries. This research addresses that gap by analyzing drainage efficiency within the local context of Oman.
3. Insufficient Analysis of Mitigation Strategies – While sustainable drainage solutions are widely discussed, there is little assessment of their practical application in Salalah. This study evaluates existing flood mitigation measures and recommends locally viable solutions tailored to Oman's urban landscape.

3. Methodology

This chapter outlines the methodology, approach, and research plan adopted for the current study. The details and specific methodology employed to address the research objectives is presented in this chapter ensuring a systematic and comprehensive investigation. The Research Methodology acts as a guidance when a researcher is planning for the research. In this study, the Research Onion concept was adopted. It describes the method by segmenting the investigation into "layers." (Melnikovas, 2018). The objective is to assess each layer of an investigation as it is being built, choosing the optimal strategy, the methodologies and ways of thinking that support the research and the methods used for data collection and analysis. The research onion provides an effective method for creating a research technique shown in figure 1.

Flow Chart:



Survey Instrument

A structured questionnaire was designed to collect primary data from professionals involved in drainage system management. The survey was divided into four key sections:

1. Demographic Information – Includes questions about the respondent's job role, organization type, and years of experience in water and wastewater management.

2. Perceptions of Climate Change Impact – Assesses respondents' views on flooding frequency, intensity of rainfall, and the effectiveness of existing drainage infrastructure in Salalah.
3. Effectiveness of Current Drainage System – Evaluates how well the current drainage system performs under extreme weather conditions, with responses rated on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).
4. Mitigation Measures – Examines the use and effectiveness of flood mitigation strategies, such as infrastructure upgrades, sustainable urban drainage systems (SUDS), and smart water management technologies.

Sampling Method

The study employed a purposive sampling method, specifically expert sampling, to ensure responses were collected from relevant professionals with expertise in drainage infrastructure and climate resilience.

Target Population and Sample Selection

The target population consisted of engineers, technicians, and project managers from:

Dhofar Municipality, Ministry of Housing & Urban Planning, Nama Dhofar Services and Ministry of Agriculture, Fisheries, and Water Resources. A total of 109 professionals participated in the study. The sample size was determined based on Yamane's (1967) formula for sample size calculation, ensuring statistical adequacy for reliable inferential analysis.

Data Analysis Techniques

The collected data was analyzed using SPSS (Statistical Package for the Social Sciences), employing both descriptive and inferential statistical methods.

Descriptive Analysis

Frequency Distributions & Means – Used to summarize demographic data and general trends in responses.

Standard Deviation & Variance – Applied to measure the spread of opinions regarding drainage system effectiveness and climate change impacts.

Reliability Analysis

Cronbach's Alpha Test – Assessed the internal consistency of survey responses

Inferential Analysis

1. Correlation Analysis – Examined the relationships between climate change impact, drainage system effectiveness, and mitigation measures.
2. Regression Analysis – Used to predict the extent to which climate change and mitigation measures influence drainage system effectiveness.

Normality and Linearity Tests

Kolmogorov-Smirnov & Shapiro-Wilk Tests – Confirmed that data was not normally distributed, necessitating the use of non-parametric statistical techniques.

Z-Score Test of Skewness & Kurtosis – Assessed data distribution, indicating a slight right skewness, meaning responses were slightly biased toward higher ratings of climate change impact.

Linearity Tests – Determined the relationship between independent and dependent variables, ensuring valid regression analysis.

4. Result And Discussion

This chapter presents the research respondents' findings. This chapter is broken into three parts: a profile of the respondents, an analysis of the data, and an explanation. The information was obtained in the context of a summary, which was delivered to the participants. 109 individuals with diverse backgrounds, including engineers, technicians, and project managers from the Salalah region's Ministry of Housing & Urban Planning, Dhofar Municipality, Nama Dhofar Services, and the Ministry of Agriculture, Fisheries, and Water Resources, were invited to take part in this survey. The evaluation of the questionnaire results by the SPSS analytical framework is summarised in the following sections. Various techniques were employed to analyse the replies, such as graphical analysis, relation inquiry, standard testing, linearity testing, and reliability testing.

Pilot Study

The goal of a pilot test is to assess if the instruments perform as intended or if further modifications and adjustments are necessary based on the findings (Sekaran, 2003). A pilot test has been conducted to evaluate the accuracy of the data collected from thirty respondents. Every factor was subjected to the reliability test both individually and collectively.The goal of the pilot study was elucidated to the participants, who were encouraged to express their thoughts of the questionnaire's layout and design. Participants were asked to give input on whether they thought the questions were inappropriate, badly phrased, or might have been handled better.

Pilot Test for All the Variables

Table 2: Pilot test for all variables

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.909	.912	28

As seen in Table 2, Cronbach Alpha for all variables is .909, demonstrating strong internal accuracy and data reliability.

Pilot Test for Each Variable

Table 3 displays the reliability metric for both dependent and independent variables. The results show that the questionnaire is accurate, which implies an acceptable level of internal consistency (Sorra et al., 2020). The results are greater than 0.65.

Table 3: Pilot test for each variable

	IV	DV	
	Effectiveness of existing drainage system	Impact of climate change	Mitigation measures for flooding issues
Cronbach Alpha	0.806	0.817	0.851
Number	9	9	10

Demographic Information Analysis

This section covers the demographic profile of the respondents. This study looks at the key components that influence Salalah's drainage system. The investigation begins with an awareness of the respondents' backgrounds, including the sort of organisation they work for, their roles, and their years of experience in the water and wastewater department. These variables help to contextualise their thoughts on crucial topics such as how urbanisation affects the effectiveness of Oman's drainage systems. Furthermore, the analysis investigates respondents' perspectives on global warming's involvement in rising rainfall intensity, which has contributed to drainage system failure and increased the frequency of flooding. Finally, the effectiveness of Salalah's existing drainage system and the suitability of its flood mitigation measures are evaluated, with a focus on whether current systems are adequate to address the challenges posed by climate change. The results of the careful examination of the 109 participants are shown in Table 4. The mean and variance of the norms are calculated. Taking into account that the standard deviation of flooding frequency was the least motivating element for 0.164, the data are becoming increasingly accurate.

Table 4: Descriptive Analysis

	N	Mean	Std. Deviation
State the type of your organization or company	109	1.88	0.904
State your position in the organization or company	109	2.39	0.733
Years of experience working in water and wastewater department	109	2.19	1.014
Do you think the urbanization is affecting the efficiency of drainage system in Oman?	109	1.06	0.246
Global warming induced increase of rainfall intensities, which has led to the failure of the water drainage system and increased rates of floods?	109	1.06	0.246
Has the frequency of flooding increased in recent years?	109	1.03	0.164
The effectiveness of existing drainage system and the mitigation measures for flooding issues in Salalah city are poor?	109	1.06	0.229
Valid N (listwise)	109		

Type of your organization or company

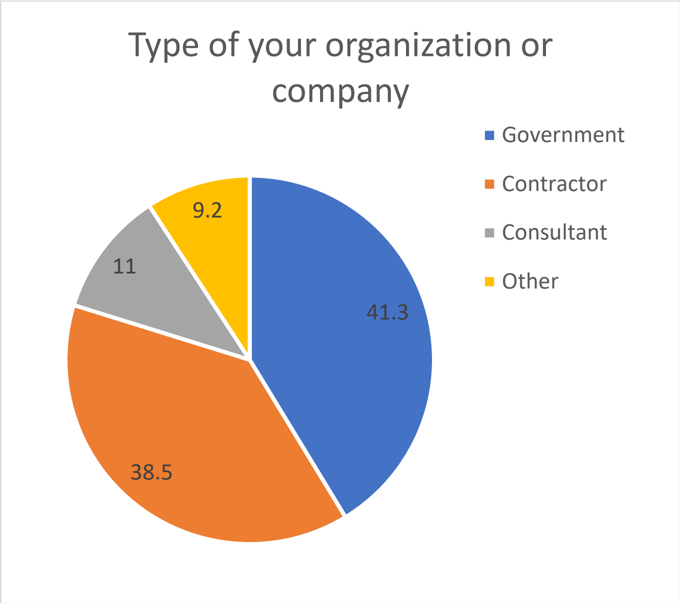


Figure 1: Type of organization Chart

Figure 1 shows the distribution of responses according to the type of organisation or firm they represent. The bulk of respondents, 41.3%, are from government organisations, demonstrating the importance of public sector companies in the study. Contractors account for the second-largest category at 38.5%, showing their vital role in the implementation and management of infrastructure projects. Consultants account for 11% of answers, highlighting the value of specialist consulting services in tackling drainage and flood management challenges. Finally, 9.2% of respondents fell into the "Other" category, which could include academics or representatives from non-governmental organisations. This broad representation offers a thorough awareness of the difficulties and opinions surrounding Salalah City's drainage system.

Position in the organization or company

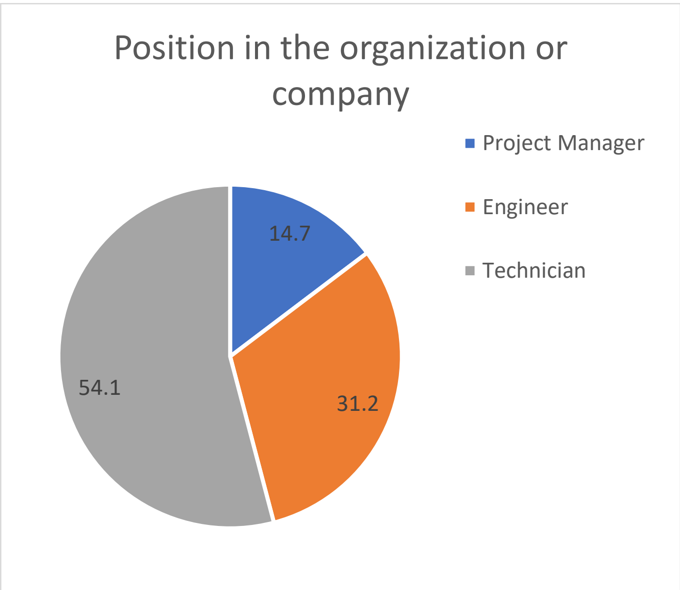


Figure 2: Position in the organization Chart

Figure 2 shows the distribution of responders according to their positions within their respective organisations or firms. Technicians make up the greatest share of responses, accounting for 54.1%, showing their critical position in the operation of Salalah City's drainage systems. Engineers account for 31.2% of the participants, indicating their major engagement in the technical design and management of flood mitigation and drainage systems. Meanwhile, Project Managers account for 14.7% of responders, demonstrating their role in project oversight and ensuring strategic objectives are integrated. This composition provides a balanced perspective from technical, managerial, and operational responsibilities, which complements the study's results on Salalah's drainage and flooding challenges.

Years of experience working in water and wastewater department

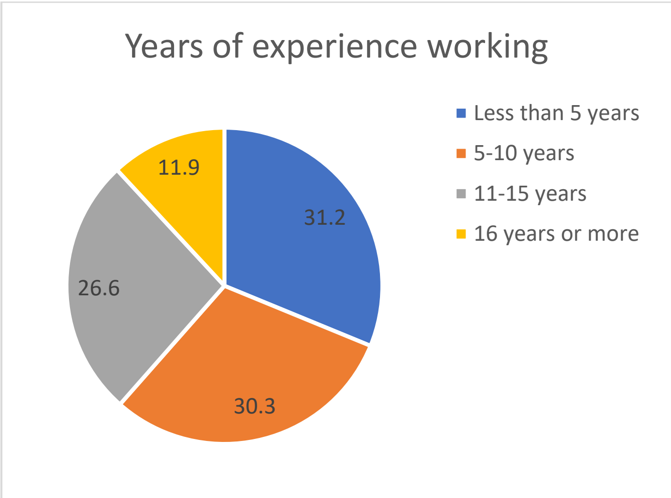


Figure 3: Years of experience Chart

Figure 3 illustrates the distribution of respondents based on years of working experience, which shows a balanced representation of expertise levels. Among the 109 participants, 31.2% have less than 5 years of experience, while 30.3% fall within the 5 to 10 years range, making these two groups the majority and accounting for 61.5% collectively. Respondents with 11 to 15 years of experience make up 26.6% of the sample, reflecting mid-level professionals with substantial field exposure. Lastly, 11.9% of the participants have 16 or more years of experience, representing the most seasoned experts. This distribution ensures diverse perspectives, blending fresh insights with seasoned expertise, which enriches the study's findings

Do you think the urbanization is affecting the efficiency of drainage system in Oman?

Figure 4 shows that 93.6% of respondents believe urbanization is affecting the efficiency of Oman's drainage system, while 6.4% do not share this view. Engineers make up the largest group of respondents (59.2%), followed by technicians (22.8%), and project managers (11.6%). Among those who disagreed, project managers were the most represented (4.4%), followed by engineers (1.2%). Most technicians had a positive view, with only two respondent (0.8%) disagreeing.

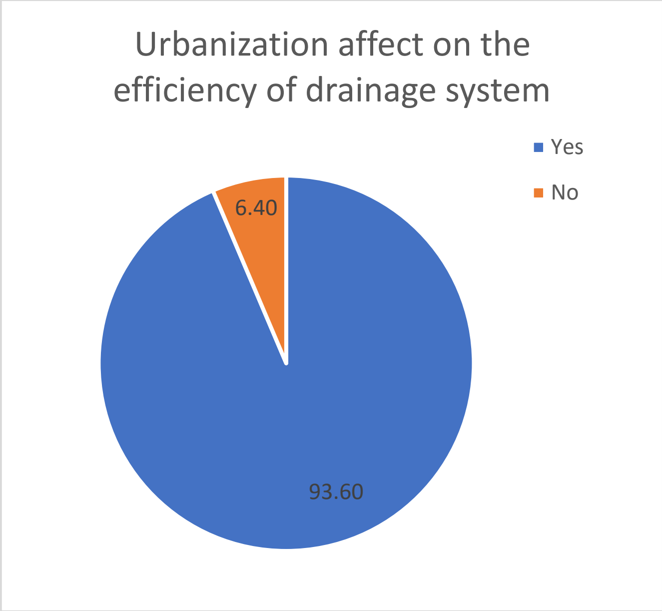


Figure 4: Urbanization effect on drainage system Chart

Global warming induced increase of rainfall intensities, which has led to the failure of the water drainage system and increased rates of floods

Figure 5 reveals that 93.6% of respondents believe that global warming has caused an increase in rainfall intensity, whereas 6.4% disagree. Engineers account for the biggest proportion of responses (59.2%), followed by technicians (22.8%) and project managers (11.6%). Project managers were the most likely to disagree (4.4%), followed by engineers (1.2%). The majority of technicians agreed, with only two respondents (0.8% disagreeing).

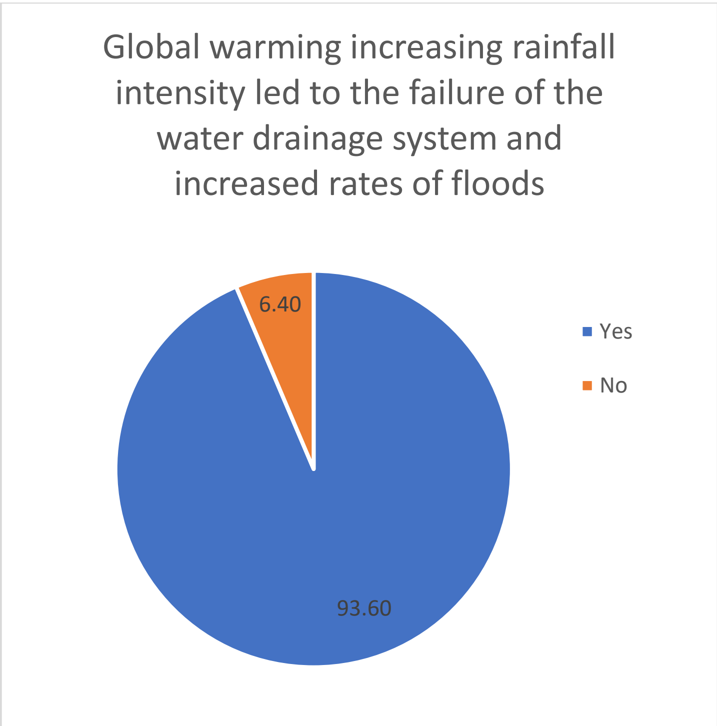


Figure 5: Global warming induced increase of rainfall intensities

Has the frequency of flooding increased in recent years?

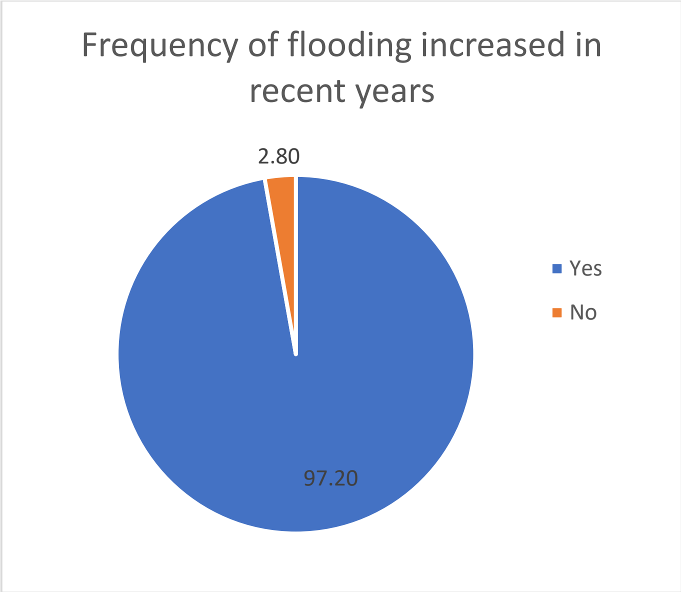


Figure 6: The frequency of flooding increased in recent years

According to figure 6, 97.2% of respondents think that the frequency of flooding has increased recently, whereas 2.8% disagree. Several reasons could contribute to the increase in flooding frequency, including the effects of climate change, which causes more intense and unpredictable rainfall, poor drainage infrastructure that cannot handle the volume of water during storms, and urbanisation, which reduces natural absorption areas. This research highlights the critical need for appropriate mitigation strategies and long-term drainage infrastructure to manage the region's growing flooding concerns.

The effectiveness of existing drainage system and the mitigation measures for flooding issues in Salalah city are poor?

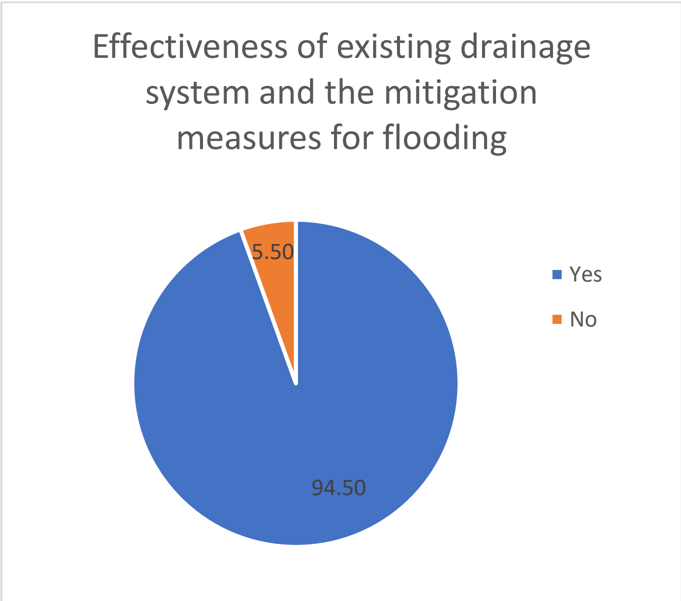


Figure 7: The effectiveness of existing drainage system

Figure 7 shows that, of the respondents, 94.5% think that Salalah city's current drainage system and flood mitigation measures are ineffective, while the remaining 5.5% disagree. This positive opinion may imply that the implemented drainage systems and techniques are effectively addressing flooding difficulties in the majority of instances. However, the low level of discontent shows that there may still be places for development, particularly in high-risk areas or during extreme weather occurrences. The findings emphasise the significance of regularly monitoring and improving drainage infrastructure in order to maintain its effectiveness and adapt to changing environmental circumstances.

Reliability Test

Reliability Test for All the Variables

Table 5: Reliability test for all the variables

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.885	.886	28

With a respondent's reliability test score of 0.885, the data's internal reliability and accuracy are highly demonstrated.

Reliability Test for Each Variable.

Table 6: Reliability test for each variable

	DV	IV	
	Effectiveness of existing drainage system	Impact of climate change	Mitigation measures for flooding issues
Cronbach Alpha	0.726	0.919	0.879
Number	9	9	10

Normality Test

Table 7: Normality test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Effectiveness of existing drainage system	.105	109	.000	.946	109	.000

significance of the Kolmogorov-Smirnov test was as a product of 0.000. This suggests that there was infrequent distribution of the questionnaires. Z is the score rating that would be applied when the results are significant enough to establish whether the violation is low-quality or if the value is within the acceptable range.

Z-score Test of Skewness and Kurtosis

Table 8: Data of Skewness and Kurtosis for Z-score test

Descriptive			Statistic	Std. Error
Effectiveness of existing drainage system	Mean		27.1009	.52055
	95% Confidence Interval for Mean	26.0691		
		28.1327		
	5% Trimmed Mean		26.8853	
	Median		26.0000	
	Variance		29.536	
	Std. Deviation		5.43470	
	Minimum		14.00	
	Maximum		45.00	
	Range		31.00	
	Interquartile Range		6.00	
	Skewness		.749	.231
	Kurtosis		.888	.459

According to Karl Pearson (1895), suggested the measure of skewness as,
Skewness = 3 (Mean - Mode) / Standard Deviation,
From Table 4.15,
Skewness = 3 (27.1009– 26.0000) / 5.43470
Skewness = ± 0.61
The Z-score values for Skewness for 109 respondents should fall between the range of -0.67 to +0.67. The following expression represents the Z-value:
Z-value = Statistic/Std. deviation
From Table 4.15,
Z-value = 0.749/0.231 = 3.24
According to the value of the Z-score, the data is 3.24, which is more the optimal range of the Z-score. The distribution is normal.

Histogram

As seen in the histogram below in figure 8, the bill histogram will be used in the analysis to show the normalcy of the data distribution.

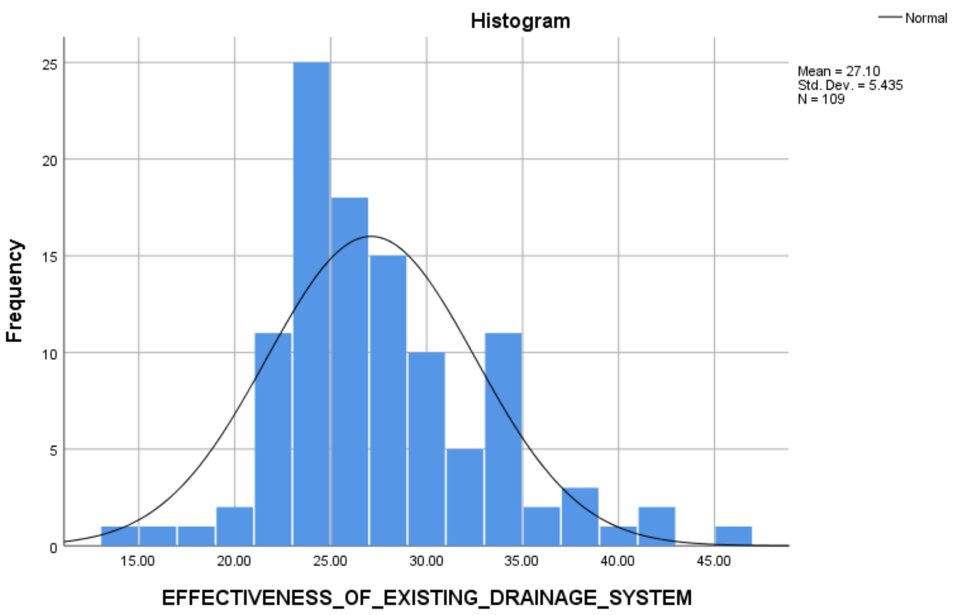


Figure 8: Histogram result

According to the figure 8 result implementation histogram. SPSS was used in this analysis to break down the standard dispersion data. The data distribution graph was nonstandard because the histogram data's precise dispersion was not ringer-shaped.

Normal Q-Q Plots

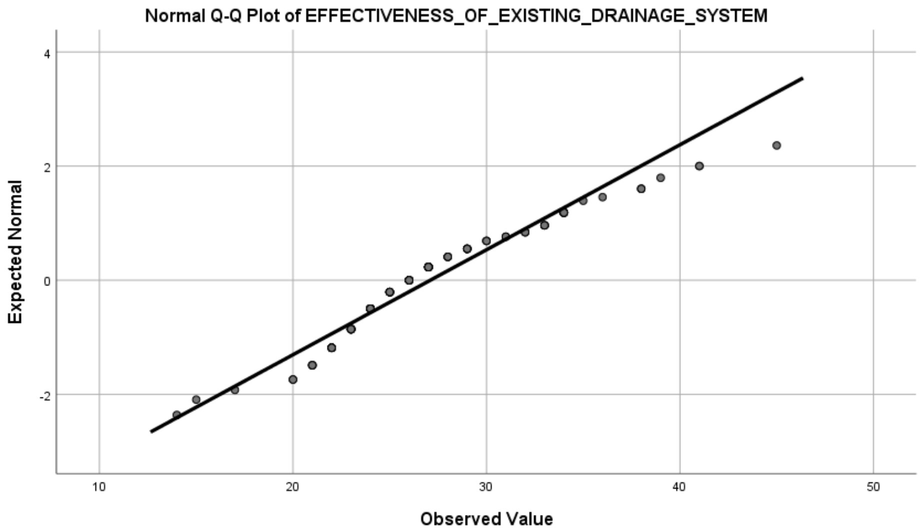


Figure 9: Normal Q-Q plots

Assembly points are usually linear, as Figure 9 illustrates. Therefore, it was decided that the hypothesis would normally be communicated.

Linearity Test

Impact of climate change Linearity Test

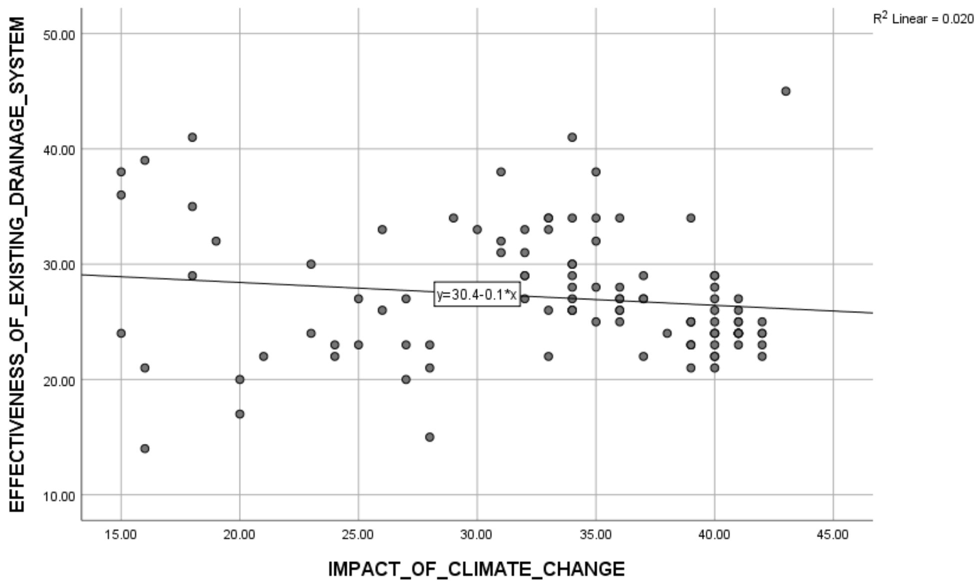


Figure 10: Impact of climate change linearity test

The IV Impact of climate change, as shown in figure 10 above, can support the efficacy of the current drainage system, and the R2 value of 0.020 suggests that there is an overall difference in DV of 02.0%. A slope of 0.1 also means that the current drainage system would become more effective by 0.1 in DV for each unit rise in IV.

Mitigation measures for flooding issues Linearity Test

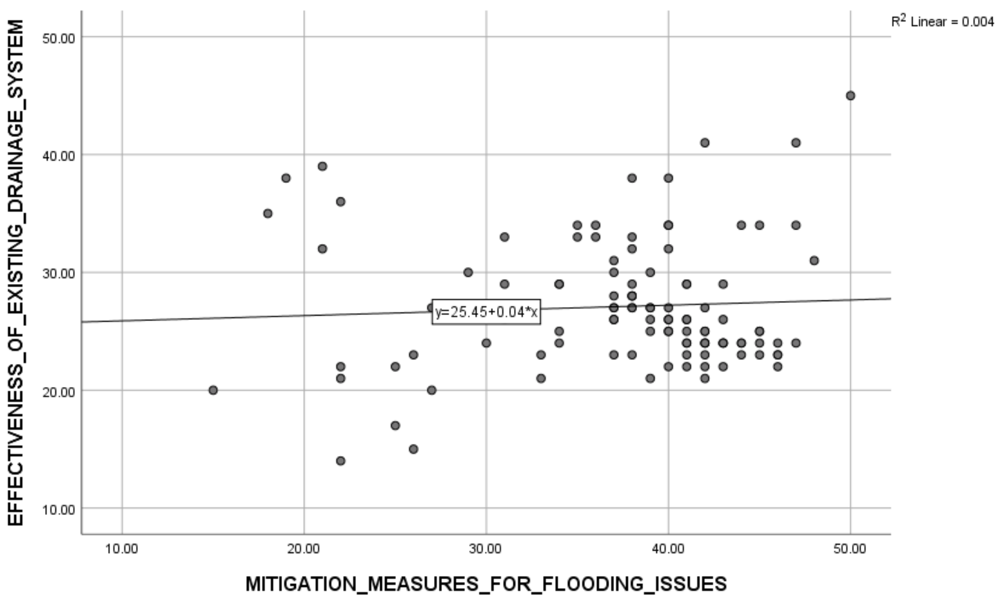


Figure 11: Mitigation measures linearity test

As seen by the R2 of 0.004 in figure 11 above, which shows an overall difference in DV of 0.04%, the efficacy of the current drainage system may be justified by the IV mitigation measures for flooding issues. In addition, the slope of 0.04 suggests that the DV would increase by 0.04 for every unit increase in IV.

Correlation Analysis

Table 9: Correlation Analysis

		Effectiveness of existing drainage system	Impact of climate change	Mitigation measures for flooding issues
Effectiveness of existing drainage system	Pearson Correlation	1.000	.763	.060
	Sig. (1-tailed)	.000	.000	.000
	N	109	109	109

Table 9 illustrates the considerable correlation between the impact of climate change and the mitigation strategies for flooding issues, with all the parameters being less than 0.005. Table 4.15 shows a significant correlation (sign value of 0.000) between the efficacy of the current drainage system and the influence of climate change. The product's correlation value (r) is 0.763, which shows that there is a positive link between the influence of climate change and the efficiency of the current drainage system. According to Table 4.15, the sign's 0.000 meaning indicates a considerable association between the influence of climate change and the efficacy of the current drainage system. Still, a high association between the two variables appears to be shown by the correlation coefficient of 0.60.

Multiple Regression Analysis

Multiple regression analysis is used in this thesis to understand the complicated links between the performance of Salalah City's drainage system and different influencing elements such as environmental conditions, infrastructure design, and operational procedures. This method integrates numerous independent variables to account for potential confounding effects, providing a better knowledge of how each variable affects the drainage system's effectiveness. Furthermore, it improves prediction accuracy, providing useful insights for developing targeted solutions to improve drainage capacity, particularly during the Khareef season. By identifying the primary drivers influencing system performance, local authorities and stakeholders may focus on the most important elements, resulting in more successful interventions and long-term management strategies for Salalah City's drainage infrastructure.

Model Summary

Table 10: Multiple Regression Analysis Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.294[a]	0.86	0.69	5.24392	1.688
a. Predictors: (Constant), Impact of climate change, mitigation measures for flooding issues					
b. Dependent Variable: Effectiveness of existing drainage					

Durbin Watson was selected for this study in order to generate an autocorrelation and find a flaw in the mathematical approach. The previous table indicates that Durbin-Watson's value of

1.668 is beyond the range of concepts, as it should be between 1 and 3. Consequently, the relationship between these separate error products has been established. The table above also specified the R square, which ascertains the interaction between the predictors and the analysis's findings. Moreover, a model is better the higher its R-square. As a result, the dependent variable's R-square value is 0.86, which represents 86% of its entire variation. The impact of climate change and flood prevention strategies are two examples of independent factors that affect how effective the current drainage system is.

ANOVA Model

Table 11: ANOVA Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	275.026	2	137.513	5.001	.008b
	Residual	2914.864	106	27.499		
	Total	3189.890	108			
a. Dependent Variable: Effectiveness of existing drainage						
b. Predictors: (Constant), Impact of climate change, mitigation measures for flooding issues						

The p-value for ANOVA is less than 0.05, as shown in the above table, suggesting that the model need to be used in further research. The analytical model is suitable as well. The model will be disregarded, though, if the ANOVA sign is greater than 0.05. Additionally, since the df value is 2, all independent factors have an impact on the dependent variable. The Significant Results in the table above, however, do not demonstrate the relevance of each variable's underlying assumptions. Determining the significance level for each independent variable also requires starting with the coefficient.

Multiple Regression Coefficient

This thesis uses multiple regression analysis to assess the effects of a variety of independent variables on the performance and efficiency of Salalah City's drainage system, including environmental factors, infrastructure quality, and operational procedures. The regression coefficients, which are shown in the appropriate analysis tables, show the strength and direction of the correlations between these factors and the drainage system's efficacy. Positive or negative coefficients illustrate how changes in each independent variable affect the dependent variable, offering light on the aspects that have the most influence on the system's ability to deal with Salalah City's specific challenges, particularly during the Khareef season. This approach gives useful information for prioritising changes and establishing effective strategies to improve the drainage system's performance.

Table 12: Multiple Regression Coefficient

Model		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.	Collinearity Statistics	
		B	Std. Error				Tolerance	VIF
1	(Constant)	26.524	2.637		1.057	.000		
	Impact of climate change	.314	.101	.444	1.096	.003	0.418	2.391
	Mitigation measures for flooding issues	.295	.106	.399	0.779	.006	0.418	2.391

In order to be considered significant at the 95% level, the variables' acceptable t values must be less than 1.96 (Uakarn et al., 2021). The multiple regression analysis provides valuable insights into the parameters that influence the effectiveness of Salalah City's drainage system. The unstandardised coefficient (B) for the *Impact of climate change* is 0.314, which means that for every unit increase in this variable, the drainage system's efficiency rises by 0.314 units, providing all other factors remain constant. The standardised coefficient (Beta) of 0.444 indicates a relatively strong positive association, which is corroborated by a significant *t*-value of 1.096 (*p =.003*). Similarly, the variable *Mitigation measures for flooding issues* has an unstandardised coefficient of 0.295 and a standardised coefficient (Beta) of 0.399, indicating a somewhat positive association with system efficiency. Its significant *t*-value of 0.779 (*p =.006*) emphasises its importance. Both variables show low collinearity, as evidenced by a tolerance value of 0.418 and a VIF of 2.391, demonstrating the predictors' independence and reliability. These findings underscore the importance of addressing climate change impacts and implementing appropriate mitigation strategies in increasing the drainage system's capacity.

Data from Table 4.18 & calculation of research equation can be derived as followed:

EFTNES ETG DNE = 26.524+ 0.314 (IPCT CME CNE) + 0.295 (MTGN MSRS FOD ISS) + 2.637

According to the computation's results, there would be increases of 0.444 and 0.399 in the efficacy of the current drainage system, the impact of climate change per unit, and the mitigation of flooding issues. The product is anticipated to have the largest influence on how well the current drainage system functions.

Study Limitations and Potential Sources of Bias

While this study provides valuable insights into the impact of climate change on drainage infrastructure in Salalah, several limitations should be acknowledged. First, the study relies on a structured questionnaire, which, despite being designed to capture expert opinions, may introduce response bias. Participants' subjective perceptions of drainage system effectiveness and climate change impacts might differ based on their professional backgrounds and personal experiences, potentially affecting the objectivity of the findings. Second, the study primarily utilizes a purposive sampling method, specifically expert sampling, which, while ensuring relevant expertise, limits the generalizability of the results to a broader population. The sample size of 109 respondents, although statistically adequate, may not fully represent all stakeholders involved in drainage infrastructure management. Future studies could benefit from a larger and more diverse sample, incorporating perspectives from local residents, policymakers, and environmental scientists. Additionally, the study focuses on quantitative data analysis using SPSS, which, while robust, does not capture qualitative insights that might provide deeper context to the findings. Incorporating qualitative methods, such as interviews or case studies, could offer a more comprehensive understanding of the challenges faced in drainage system management. Finally, external factors such as rapid urbanization, unplanned land-use changes, and socioeconomic influences, which may significantly impact drainage system performance, were not explicitly analysed in this study. Future research should consider integrating these variables to provide a more holistic assessment of drainage infrastructure resilience. By acknowledging these limitations, this study highlights areas for improvement and further research, ensuring a more nuanced and comprehensive understanding of the challenges posed by climate change on urban drainage systems

5. Conclusion

The primary goal of this study was to answer the research questions and fulfil the set objectives while also producing new knowledge of value to both academia and practical application. This chapter summarises the study's findings and discusses how the research helps to understand the effects of climate change on drainage systems, the effectiveness of current infrastructure, and long-term mitigation options. It also notes shortcomings and proposes areas for future investigation.

Objective 1: To identify the impact of climate change on the drainage system in Salalah City

This goal was successfully achieved. The investigation found that climate change has a major impact on Salalah's drainage system, notably during the Khareef season. The findings revealed that unexpected rainfall patterns and intensities aggravate the system's susceptibility, posing increasing flooding hazards. The drainage system's operational issues are positively correlated with the degree of climate change impacts, according to statistical modelling. A high standardised coefficient ($\beta = 0.444$) indicates climate change's influence. These findings underscore the essential need for drainage systems that can tolerate changing climatic conditions.

Objective 2: To assess the effectiveness of the existing drainage system in Salalah City.

This goal was also met. A thorough examination revealed various flaws in the current drainage system, including insufficient capacity, ageing infrastructure, and a scarcity of adaptable solutions. Stakeholder feedback, combined with technical study, revealed operational inefficiencies that limit the system's ability to effectively manage flooding. The report emphasised that the current infrastructure is insufficient to fulfil current and future demands, particularly during peak seasonal events in the city of Salalah.

Objective 3: To propose sustainable mitigation measures for flooding issues in Salalah City.

The study effectively offered long-term mitigating measures to solve flooding challenges. Infrastructure enhancements, smart technology integration (such as real-time monitoring systems), proactive maintenance schedules, and community participation programs are among the recommendations. If completed, these modifications are expected to dramatically reduce flooding risks and improve the overall efficiency of the drainage system. Regression analysis confirms the efficiency of these strategies, with a standardised coefficient ($\beta = 0.399$) showing a significant impact on flood mitigation. Overall, the report emphasises the critical need for comprehensive flood management techniques in Salalah City. Key findings emphasise the significance of resilient infrastructure, technological innovation, and community participation in solving the systemic issues posed by climate change and urbanisation. The findings are relevant to policymakers, engineers, and researchers working on sustainable urban drainage solutions in Oman and other arid countries.

Recommendation

The study's findings underline the importance of taking certain essential initiatives to strengthen Salalah City's drainage infrastructure. Future research should widen its scope to include additional variables such as urban growth patterns, soil permeability, and groundwater levels in order to better understand the factors impacting drainage performance. The Salalah Municipality and the Ministry of Water Resources can also help researchers by providing access to correct data and resources that will allow them to develop reliable flood management methods. Furthermore, increasing the sample size in future studies might enhance the robustness and dependability of the findings. To effectively control flood risks, authorities should prioritise the installation of long-term mitigation measures such as infrastructure upgrades, adaptive technology integration, and community awareness efforts.

Finally, climate adaptation techniques should be prioritised to guarantee that the drainage system stays robust in the face of increasing challenges provided by unexpected rainfall patterns and intensities, thereby protecting Salalah's infrastructure and resources in the future.

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