RESEARCH PAPER

Evaluation of Libyan Local Authorities in Environmental Pollution Management: A Step Towards Sustainability

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ABSTRACT

Controlling environmental pollution is extremely difficult, particularly in areas with high pollution levels. Air, land, rivers, and the sea can all contribute to pollution. In general, different nations will employ various technologies or approaches to control pollution. Since the United Nation emphasize on sustainability toward the environment, many countries now focus on the sustainability of pollution management and use the green technology. This research evaluates the Libyan local authorities on managing the environmental pollution. The evaluation is based on five independent variables, which are institutional capacity, regulatory enforcement, inter-agency coordination, training programs, and community engagement. The dependent variable under the influences of five independent variables is pollution management effectiveness. A questionnaire will be designed based on the five independent variables to assess the pollution management effectiveness. A total of 350 sample sizes of data will be collected and analyzed using statistical methods. Descriptive analysis, correlation, and multiple regressions, are used to analyze the data. The end of the research found that training program or frequency training is a main factor that influences the pollution management effectiveness.

Keywords: Environmental pollution, local authorities, Libya, regulatory enforcement, institutional capacity.

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1. Introduction

One of the worldwide problems endangering human health, the ecological system, and the economy is air pollution, which is particularly problematic in the Global South due to rapid population increase, inadequate infrastructure, and political upheaval [1]. These challenges are much more apparent in Libya due to the ongoing violence, the broken government, and the lack of resources that prevent effective environmental management [2]. The nation experiences stark pollution problems, not only pollution of air by vehicles and industry but also water pollution by raw sewage, garbage and soil pollution caused by hazardous industries all constitute major risks to health of the population and the natural ecosystems [3,4].

Local authorities (especially the Ministry of Environment) play a vital role in resolving these issues due to policy implementation, waste management, and community mobilization however such work can only go so far because of the systemic obstacles that can be found [5]. Governance frameworks have been destabilized by political anarchy since the 2011 war which has created uneven application of different policies and lack of coordination between the agencies [6].

The Ministry of Environment, which has to take care of the pollution control, fights against the lack of financial possibilities, obsolete infrastructure,

and a shortage of the trained staff, and that is why it might not be easy to adopt sustainable practices [7]. Nevertheless, the local authorities in Libya are particularly in trouble with a centralized government and the disruptive effects of the war, resulting in the inability to match United Nations Sustainable Development Goals (SDGs), including clean water, and sanitation (SDG 6) and sustainable cities (SDG 11) [8].

The study focuses on the significance of assessing the effectiveness of the Ministry of Environment in managing pollution and investigates the impact of institutional capacity, regulatory enforcement, inter-agency collaboration, training efficiency, and public involvement on sustainable environmental governance in Libya's intricate socio-political landscape [9].

1.1 Libya Environmental Pollution

The issues of environmental pollution in Libya are multidimensional as they include contamination of the air, water, and soil. Industrial emissions and vehicular exhausts are the main causes of air pollution leading to an elevated amount of particulate matter (e.g., PM2.5). The latter is an aspect contributing to respiratory diseases [10]. Groundwater and the coast are polluted by water and most of it is caused by untreated domestic and industrial effluents that endanger the people, and the ecosystem [4]. The harmful waste and oil spills cause soil contamination that worsen biodiversity and farmland [11]. Such problems are aggravated by the fast process of urbanisation in Libya where urban agglomerations such as Tripoli and Benghazi are experiencing excessive waste production and insufficient waste management [2].

Implementation of policies to help reduce these challenges is the mandate of the Ministry of Environment as the central point of the local government in matters of environmental governance.

1.2 Problem Statement

Pollution in Libya poses a serious issue because of its negative impacts on public health, ecosystems, and sustainable progress. Pollution of air, water, and soil is mainly caused by industrial processes, urban development, and the release of untreated waste [1,2]. Even though the Ministry of Environment plays a crucial role in tackling these challenges, systemic shortcomings—such as insufficient institutional capabilities, inadequate regulation enforcement, poor coordination among agencies, lack of training, and low community participation—hinder effective management [3,4].

Chronic pollution issues are the result of various deficiencies, and the related health issue of pollution is one of the top contributors to morbidity and mortality rates in Libya. The amount of revenue generated per capita to address diseases related to pollution is still inadequate and continues to increase [12]. In addition, limited funding and obsolete infrastructure limits the Ministry's ability to regulate the emission of pollutants such as PM2.5 (fine particulate matter) and COD (chemical oxygen demand). There are also issues with inadequate training and quality of training for staff who need to deal with the complex problems associated with pollution. Finally, public compliance with pollution reduction efforts has been hampered due to the low level of public awareness to engage citizens with pollution reduction activities [13,14].

Research on environmental governance in Libya currently lacks a quantitative analysis of the employee level at the Ministry of Environment [3,15]. Current research is primarily qualitative and region-based. This study is designed to assess the effect of employee's perception regarding institutional capacity, regulatory enforcement, inter-agency coordination, training, and community engagement on the efficacy of pollution management in order to provide empirical evidence regarding environmental governance in Libya.

1.3 Research Objectives

The study aims to achieve the following objectives:

1. To determine whether higher institutional capacity significantly strengthens the pollution management effectiveness of the Ministry of Environment in Libya.
2. To determine whether stronger regulatory enforcement significantly strengthens a pollution management effectiveness of the Ministry of Environment in Libya.
3. To determine whether improved inter-agency coordination significantly strengthens the pollution management effectiveness of the Ministry of Environment in Libya.
4. To determine whether comprehensive training programs significantly strengthen the pollution management effectiveness of the Ministry of Environment in Libya
5. To determine whether greater community engagement significantly strengthens the pollution management effectiveness of the Ministry of Environment in Libya.

2. Literature Review

[4] Worked on Weak institutional capacity and poor enforcement exacerbate groundwater pollution; limited coordination and training; low community engagement reduces effectiveness based on GIS, remote sensing, stakeholder consultations. It is recommended to invest in monitoring infrastructure, strengthen enforcement, improve inter-agency coordination, expand training, and enhance community engagement.

[16] Analysed using desk review and report analysis and find out the weak institutional capacity and enforcement hinder pollution control; poor coordination; limited training; community engagement essential. It is recommended to build specialized units, strengthen enforcement, improve coordination, provide training, and promote community awareness.

[3] Studied institutional capacity gaps, ineffective enforcement, poor coordination, limited training, low community awareness through semi-structured interviews. It is recommended to strengthen institutions, enforce regulations, improve coordination, provide training, and increase community engagement.

[17] Surveyed through structured interviews and find out the Weak capacity; regulatory challenges; medium coordination; limited training; community engagement improves effectiveness. It is recommended to build capacity; strengthen enforcement; enhance coordination; expand training; increase community engagement.

[18] Suggested mixed-methods to find the Good governance strengthens capacity; enforcement and coordination key; training and engagement improve effectiveness. The limitations of this paper can be overcome by build capacity, strengthen enforcement, enhance coordination, expand training, and promote engagement.

3. Methodology

The study adopts a quantitative research design with a cross-sectional survey to collect data from Ministry of Environment employees in Libya. A structured questionnaire, utilizing a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), measures employee perceptions of the independent variables ("Institutional Capacity, Regulatory Enforcement, Inter-Agency Coordination, Training Programs, Community Engagement") and their impact on the dependent variable (Pollution Management Effectiveness). This design is suitable for testing hypotheses (H1–H5) and addressing the research objectives, as it enables statistical analysis of relationships between variables [19].

According to the Libyan Ministry of Environment's 2024 annual report, the Ministry employs approximately 1,200 staff across its headquarters in Tripoli and regional offices in Benghazi, Misrata, and Sabha [20]. This population is selected due to their direct roles in developing and implementing environmental policies, monitoring pollution (e.g., air, water, soil), and coordinating with stakeholders, making their perceptions critical for assessing the study's variables.

The sample size is determined using the [21] table (See Table 1), a standardized method for calculating sample sizes based on population size, confidence level, and margin of error. For a population of 1,200 employees, the table recommends a sample size of 291 respondents at a 95% confidence level and 5% margin of error [21].

Table 1: Sample Size Calculation of Krejcie and Morgan

Population Size	Confidence Level	Margin of Error	Required Sample Size	Planned Distribution
1,200	95%	5%	291	350

The questionnaire will be distributed electronically (via email or survey platforms like Google Forms) and in-person to 350 Ministry employees across departments (e.g., policy development, monitoring, enforcement, outreach) and regional offices (e.g., Tripoli, Benghazi, Misrata). Table 2 summarizes the questionnaire items.

Table 2: Summary of Questionnaire Items

Variable	Sub-Variable	Number of Items	Source
Institutional Capacity	Financial Resources	9	[22]
Regulatory Enforcement	Inspection Frequency	9	[23]
Inter-Agency Coordination	Communication Channels	9	[24]

Training Programs	Training Frequency	9	[14]
Community Engagement	Awareness Campaigns	9	[25]
Pollution Management Effectiveness	-	9	[26] [27]

Instrument Validity and Reliability

Validity: Content validity is ensured by adapting questions from established studies (e.g., [22,23]) and aligning them with Libya's environmental context and the study's variables. A pilot test with 30 Ministry employees will assess question clarity, cultural appropriateness, and relevance, with feedback used to refine items. Face validity will be verified by providing Arabic and English versions to accommodate Libya's multilingual workforce, ensuring comprehension.

Reliability: Internal consistency will be assessed using Cronbach's alpha in SPSS, targeting a value of 0.7 or higher for each variable's scale [19]. The pilot test data will be analyzed to confirm reliability before full-scale distribution. Split-half reliability will be tested to ensure consistency across items. If Cronbach's alpha falls below 0.7 for any scale, low-performing items will be revised or removed. Test-retest reliability will be conducted with 15 pilot participants over a two-week interval to assess response stability [28].

Data analysis will be conducted using IBM SPSS Statistics (Version 27) to address the research objectives and test hypotheses (H1–H5). The following statistical methods will be applied: Descriptive Statistics, Pearson's Correlation Analysis, Multiple Regression Analysis, Cronbach's Alpha, T-tests/ANOVA, Normality and Assumption Testing. This methodology provides a robust framework to quantify employee perceptions, addressing the research gap and supporting sustainable policy recommendations.

4. Results

The study's purpose is to address the research gap in Libya-specific, employee-focused quantitative research by examining how these independent variables influence the Ministry's ability to manage environmental pollution, such as air (PM2.5), water (COD), and solid waste, within Libya's conflict-affected context. A quantitative, cross-sectional survey design was employed, utilizing a 5-point Likert-scale questionnaire distributed to 350 Ministry employees across departments (e.g., policy, monitoring, enforcement, outreach) and regional offices (Tripoli, Benghazi, Misrata, Sabha) from April to June 2025. Data were analyzed using IBM SPSS Statistics (Version 27) through descriptive statistics, correlation, regression, and reliability tests to test hypotheses (H1–H5) and address the research objectives.

The sample size for reliability and validity test is 35, which is 10% of total sample size, 350. This small sample sizes taken is known as pilot test. Table 3 shows the reliability test results.

Table 3: Reliability test results

Reliability

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	35	100.0
	Excluded[a]	0	.0
	Total	35	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.945	54

The Cronbach's alpha is more than 0.7, as you can see. This demonstrates the validity of survey findings. For the validity test, the total score of all the variables must be calculated, and the significance of the 2-tail must then be calculated using the correlation function.

Descriptive Analysis of The Variables

The findings of the statistical analysis are shown in this section. The nine questions in each section of the variables are totaled and calculated using SPSS's descriptive statistics function in order to assess the independent and dependent variables. Following the execution of the descriptive statistic operations, Table 4 displays the outcomes generated by SPSS. Keep in mind that the analysis focuses on variance, mean, and standard deviation.

Table 4: Descriptive statistical results for all the variables

Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Sum	Mean	Std. Deviation	Variance
ICF	350	28.00	39.00	11894.00	33.9829	2.67317	7.146
REI	350	21.00	36.00	11532.00	32.9486	4.48016	20.072
IAC	350	21.00	39.00	11804.00	33.7257	4.88424	23.856
TPT	350	14.00	43.00	13887.00	39.6771	5.06194	25.623
CEA	350	16.00	45.00	14685.00	41.9571	7.98070	63.692
PME	350	17.00	42.00	13579.00	38.7971	4.37124	19.108
Valid N (listwise)	350						

Correlation Analysis

The correlation analysis was computed by adding up all of the survey data for both independent and dependent variables. After adding together, calculate the correlation using the correlation calculator built into SPSS. The correlation findings produced by the SPSS correlation function are displayed in Table 5. Take note of the correlation's top and lowest scores.

Table 5: Correlation results computed by SPSS

Correlations

Correlations

		ICF	REI	IAC	TPT	CEA	PME
ICF	Pearson Correlation	1	.442**	.525**	.475**	.456**	.578**
	Sig. (2-tailed)		<.001	<.001	<.001	<.001	<.001
	N	350	350	350	350	350	350
REI	Pearson Correlation	.442**	1	.911**	.363**	.652**	.572**
	Sig. (2-tailed)	<.001		<.001	<.001	<.001	<.001
	N	350	350	350	350	350	350
IAC	Pearson Correlation	.525**	.911**	1	.206**	.469**	.469**
	Sig. (2-tailed)	<.001	<.001		<.001	<.001	<.001
	N	350	350	350	350	350	350
TPT	Pearson Correlation	.475**	.363**	.206**	1	.623**	.945**
	Sig. (2-tailed)	<.001	<.001	<.001		<.001	<.001
	N	350	350	350	350	350	350
CEA	Pearson Correlation	.456**	.652**	.469**	.623**	1	.644**
	Sig. (2-tailed)	<.001	<.001	<.001	<.001		<.001
	N	350	350	350	350	350	350
PME	Pearson Correlation	.578**	.572**	.469**	.945**	.644**	1
	Sig. (2-tailed)	<.001	<.001	<.001	<.001	<.001	
	N	350	350	350	350	350	350

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

Lowest correlation

Highest correlation

Table 5 shows that the Training Program (TPT) has the highest correlation score. The value is 0.945, which is quite near to 1. Inter-Agency Coordination has the lowest correlation score (0.469). This indicates that TPT has a big impact on PME. PME has a score of 1, which is near 0.945. Figure 1 shows the matching plot for this outcome.

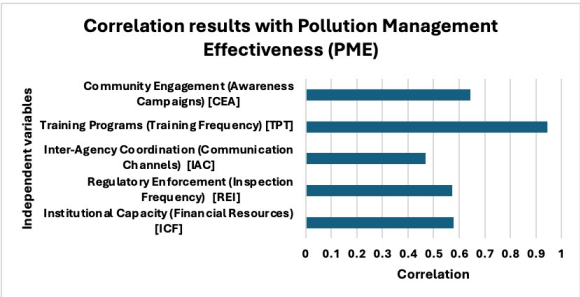

Figure 1: The Plot for Correlation Results

Multiple Regression Analysis

The regression analysis is very similar to the correlation analysis except that this regression analysis can show the linearity between the two variables. This section presents multiple regression analysis for ICF regression with PME, REI regression with PME, IAC regression with PME, TPT regression with PME, and CEA regression with PME.

Table 6 shows the R2 results for ICF variable. Figure 2 shows the regression plot for ICF variable.

Table 6: R2 result for ICF

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.578[a]	.334	.332	3.57172

a. Predictors: (Constant), ICF

b. Dependent Variable: PME

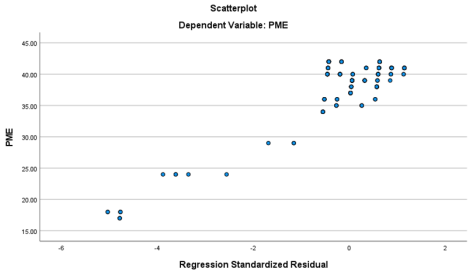

Figure 2: Regression plot for ICF

Table 7 shows the R2 results for REI variable. Figure 3 shows the regression plot for REI variable.

Table 7: R2 for REI variable

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.572[a]	.327	.325	3.59029

a. Predictors: (Constant), REI

b. Dependent Variable: PME

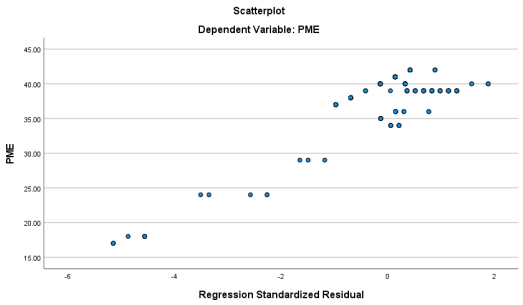

Figure 3: Regression plot for REI

Table 8 shows the R2 results for IAC variable. Figure 4 shows the regression plot for IAC variable.

Table 8: R2 of IAC variable

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469[a]	.220	.218	3.86655

a. Predictors: (Constant), IAC

b. Dependent Variable: PME

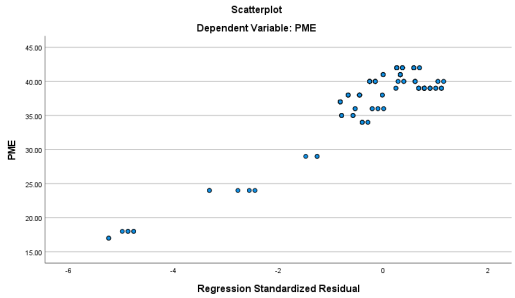

Figure 4: Regression plot for IAC

Table 9 shows the R2 results for TPT variable. Figure 5 shows the regression plot for TPT variable.

Table 9: R2 results for TPT

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.945[a]	.894	.894	1.42602

a. Predictors: (Constant), TPT

b. Dependent Variable: PME

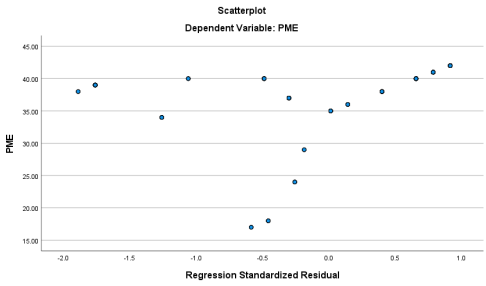

Figure 5: The regression plot for TPT

Table 10 shows the R2 results for CEA variable. Figure 6 shows the regression plot for CEA variable.

Table 10: R2 results for CEA

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.644[a]	.414	.412	3.35066

a. Predictors: (Constant), CEA

b. Dependent Variable: PME

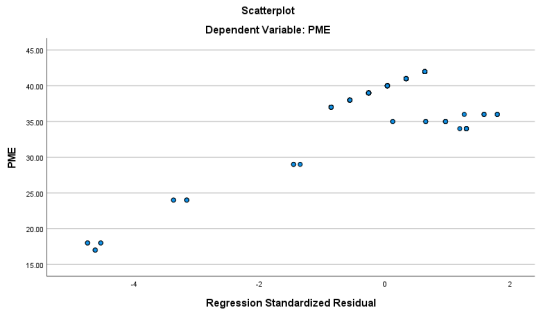

Figure 06: The regression plot for CEA

The statistical analysis reveals varying degrees of influence of the independent variables on pollution management effectiveness (PME), as measured by employee perceptions. The descriptive statistics (Table 4.8) show that community engagement (CEA) has the highest mean (41), indicating strong employee recognition of its role, while regulatory enforcement (REI) has the lowest mean (32), suggesting perceived weaknesses in inspection frequency. The correlation analysis (Table 4.10) demonstrates that training programs (TPT) exhibit the strongest relationship with PME ($r = 0.945$, $p \leq 0.001$), followed by community engagement (CEA, $r = 0.644$), institutional capacity (ICF, $r = 0.578$), regulatory enforcement (REI, $r = 0.572$), and inter-agency coordination (IAC, $r = 0.469$). The regression analysis (Tables 4.11–4.20) further confirms TPT's dominant influence ($R^2 = 0.894$, $F = 2931.33$), explaining 89.4% of the variance in PME, while IAC has the weakest impact ($R^2 = 0.22$, $F = 98.053$).

6. Conclusion

In this study, the effectiveness of the local authorities in Libya, specifically the Ministry of the Environment, will be evaluated, focusing on the effectiveness of managing pollution in spite of the socio-political challenges. The study found that the effectiveness of pollution management is affected by the institutional capacity for pollution management, enforcement of regulations, coordination among agencies, training of staff and involvement of local communities. The study indicates that there are a number of challenges to pollution management; including limited financial resources, weak enforcement, fragmented coordination, inadequate training, and low levels of public awareness. However, the study identifies the training of staff as the primary factor that will improve management practices. The study highlights the importance of strengthening institutional structures,

improving regulatory enforcement, improving coordination among agencies, and actively engaging local communities in order to achieve sustainable environmental outcomes and to contribute to the overall sustainable development and pollution control efforts in Libya.

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