

An Empirical Analysis of The Impact Of The Climate Crisis on The Misery Index in The Countries of the Mena Region

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Abstract

This study examines the macroeconomic effects of climate-induced environmental pressures in 17 countries in the MENA region, selected due to their high sensitivity to climate change and economic vulnerability. For the period 1991–2021, the Misery Index (MI) is employed as the dependent variable, while the Water Stress Index (WS), Freshwater Use (FW), Renewable Energy Consumption (REC), Forest Area (FA), and Average Precipitation (AP) are used as independent variables. Panel analyses reveal that WS, FW, and REC have positive and statistically significant effects on MI, whereas no statistically significant relationship is found between FA, AP, and MI. The findings suggest that climate–economy interactions should be systematically integrated into policy design.

Key words: Climate Change, Misery Index, Countries of The MENA Region, Panel Data Analysis

JEL Code: C33, E24, E31

1. Introduction

Climate change is a pervasive global crisis that systematically disrupts environmental systems while simultaneously reshaping economic and social dynamics (Gasper, Blohm and Ruth, 2011; Carleton and Hsiang, 2016). The impact of climate change on macroeconomic indicators has been widely examined by many researchers, (e.g. Batten, 2018; Sahin 2022; Bilal and Kanzing, 2024; Rezai, Taylor and Mechler, 2013; Anh, Anh and Chandio, 2023). Climatic factors directly affect key economic resources including agricultural production, water availability, and human health (Kang, Khan and Ma, 2009; Hasegawa et al, 2016; Haile et al., 2017). Beyond these direct effects, climate change also exerts indirect impacts on a broader range of economic sectors, such as manufacturing, transportation, and energy

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systems (Proost and Van Regemorter, 2004; Baker et al, 2010; Linnenluecke, Griffiths and Winn,2013; Akaev and Davydova,2023). Collectively, these effects have significant implications for economic growth (Fankhauser and Tol, 2005; Roson and Van der Mensbrugge, 2012; Kompas, Pham and Che,2018; Newell, Prest and Sexton, 2021; Farajzadeh, Ghorbanian and Tarazkar, 2023; Fatima et al.,2025) as well as macroeconomic factors such as unemployment (Liu and Lin, 2023; Adekunle, 2024; Liu et al., 2023) and inflation (Almajali, 2023; Grolleau and Weber, 2024; Azhar et al., 2025).

In general, the literature indicates that climate changes and climate-related crises exert a negative impact on economic growth. Adverse weather conditions reduce production capacity which in turn is expected to lower future welfare levels (Fankhauser and Tol, 2005; Bowen, Cochrane and Fankhauser, 2012; Abidoye and Odusola, 2015; Mele et al., 2021; Alagidede, Adu and Frimpong, 2016). Studies examining the macroeconomic consequences further demonstrate that key sectors, particularly agriculture, are adversely affected. Specifically, agricultural output and productivity decline in response to extreme weather events and environmental shocks (Parry et al., 2004; Kang, Khan and Ma, 2009; Mirón, Linares and Díaz, 2023; Rezaei et al., 2023).

This paper examines the effects of climate-related environmental stressors on the Misery Index (MI), a widely used indicator of macroeconomic dissatisfaction. The concept of the misery index is commonly attributed to Okun (1970), who developed the index during the stagflation period in the United States to capture the combined socioeconomic effects of rising inflation and unemployment (Cohen, Ferretti and McIntosh, 2014). The MI is calculated as the sum of inflation and unemployment rates (Welsch, 2007; Grabia, 2011; Cohen, Ferretti and McIntosh, 2014; Blanchflower et al., 2014; Clemens, Palacios and Li, 2022) and captures the degree of discomfort experienced by individuals under conditions of economic instability. Within this framework, the study aims to assess the socioeconomic impacts of climate change in a multidimensional manner by employing MI as the dependent variable (Giorgi and Meleux, 2007; Warren et al. 2006; Arnell et al. 2019). The Middle East and North Africa (MENA) region faces elevated risks arising from both climatic vulnerability and economic inequality, making it a particularly suitable setting for empirical analysis (Waha et al. 2017; Borghesi and Ticci, 2019). Countries in the region exhibit heightened sensitivity to the climate crisis due to both natural resource scarcity and socioeconomic structural vulnerabilities (Giovanis and Ozdamar, 2022; Sofuoglu and Ay, 2020).

Environmental challenges such as water stress, desertification, heat waves and low forest coverage, widely observed across the region, render the physical impacts of climate change more pronounced. At the same time, persistently high unemployment rates (Jalali and Roudi, 2002; O'Sullivan, Rey, and Mendez, 2011) and structural economic vulnerabilities in many MENA countries amplify the social consequences of these environmental pressures. Within this framework, MENA countries rank among the regions most exposed to the climate crisis due to their geographical characteristics and intertwined economic and social structures. This combination positions the region as a priority area for analysing the effects of

environmental variables on economic discontent. Accordingly, the study employs five key environmental indicators: Water Stress Index (WS), Fresh Water Use (FW), Renewable Energy Consumption (REC), Forest Area (FA) and Average Precipitation (PRC). These variables are selected to capture distinct dimensions of the climate crisis. Water stress reflects the economic pressures associated with water scarcity, renewable energy consumption represents structural adjustments linked to the energy transition, forest area serves as a proxy for ecosystem resilience and environmental sustainability, and average precipitation allows for the assessment of the macroeconomic impacts of climate variability and extreme weather events. The existing literature contains a limited number of studies examining the relationship between the climate crisis and macroeconomic welfare, particularly in the context of MENA countries, using panel data methods and long-run analytical frameworks. The present study contributes to the literature by offering an innovative, region-specific perspective through its use of an extended dataset and a robust methodological approach.

2. Literature Review

In this study, the literature review is organized under two main subheadings. The first focuses on studies examining the relationship between the climate crisis and inflation, while the second reviews research investigating the effects of the climate crisis on unemployment. The Misery Index is employed as the dependent variable and is constructed by combining the inflation rate and unemployment rate through an established weighting approach.

To capture the multidimensional nature of the climate crisis, a composite climate crisis index is developed using numerical indicators related to water stress, freshwater withdrawals, renewable energy consumption, forest area, and average precipitation. These variables are widely associated with climate-related pressures and environmental stress. Accordingly, the literature is reviewed by linking the independent climate crisis indicators to broader discussions of climate change and its macroeconomic implications.

2.1. The Relationship between Climate Crisis and Inflation

In assessing the relationship between climate change and the inflation, climate-related risks are commonly conceptualized as negative supply shocks. Such shocks are expected to reduce productivity and, in turn, exert upward pressure on inflation. Qi et al. (2025) examined the relationship between inflation and climate change over the period 2006-2019 using Generalised Method of Moments (GMM). Their findings indicate that while climate change has a significant positive effect on inflation in the short run, while no significant long-run relationship is observed between the variables. Yusifzada (2024) analysed the relationship between climate change and agricultural inflation using index data from 153 countries over the period 1901-2021. The study finds that a positive association between climate change and agricultural inflation in 142 countries, while climate change is associated with a

reduction in inflation in 11 countries. Odongo et al. (2022) employed data covering the period 2001 to 2020 to examine effects of climate change on food inflation in Eastern and Southern African countries. Their findings indicate that food inflation increased markedly in 2019, a year identified as experiencing the most severe climatic disturbances. Li et al. (2023) investigated the relationship between inflation and climate change using panel regression analysis for the period 1995-2021 and identified a positive association between the two variables. analyzed the impact of the climate crisis on inflation in BRICS countries over the period January 1993 to June 2017, finding that climate-related shocks significantly affect inflation in China, Russia, and India, with the strongest effect observed in Russia. Ciccarelli et al. (2023) investigated the relationship between rising air temperature and inflation components across major European countries and found that inflation levels tend to be higher in countries experiencing elevated temperatures.

Kotz et al. (2023) examined the impact of climate change on inflation in both developed and developing countries and concluded that climate-related shocks exert a positive effect on inflation. Heinen et al. (2019) analyzed the effects of adverse weather conditions on inflation across 15 Caribbean countries, finding that extreme weather events and elevated temperatures contribute to higher inflation rates. Similarly, Acevedo et al. (2020), who investigated the effects of global warming on production efficiency in low-income countries, reported that rising temperatures reduce productivity while increasing production costs and inflation in the long run. Parker (2018) found that climate-related crises, including natural disasters and floods, have limited immediate effects on inflation in developed economies but lead to higher inflation over extended periods. Additionally, the study observed that storms generate short-term increases in food inflation. Cevik and Jalles (2024) examined the impact of climate-induced natural disasters on GDP and inflation, concluding that the adverse effects are higher in developing economies and vary across levels of development and regions. Faccia et al. (2021) analyzed the relationship between climate change and inflation in a sample of 48 developed and developing countries and found that elevated temperatures lead to short-term increases in food prices, while the medium-term effects of temperature on inflation remain economically significant. Kabundi et al. (2022) assessed the effects of climate change and flood-related disasters on inflation, concluding that such events generate substantial supply and demand shocks. Their findings further indicate that the magnitude of these effects depends on the severity of the shocks and country-specific economic conditions, with inflationary pressures intensifying particularly during periods of drought.

Haile et al. (2017) examined whether the prices of wheat, maize, rice and soya beans were affected by the climate crisis over the period 1961-2013. Their results indicate a positive relationship between the rising temperatures and commodity prices across all four crops. Iyasu et al. (2023) employed a structural vector autoregression (SVAR) framework to analyze the effects of climate change on production and inflation in South Africa, Egypt, and Nigeria for the period 2002–2022, finding that climate-related changes positively influence both production dynamics and inflation rates. Bandara and Cai (2014) assessed the impact of climate changes on the consumer price index and agricultural production efficiency in

South Asian countries, Bangladesh, Nepal, Pakistan, Sri Lanka and India, and Mukherjee and Ouattara (2021) examined the relationship between rising temperatures increases and inflation rates in both developed and developing countries over the period 1961 to 2004 and found that temperature increases exert a negative effect on inflation. In contrast, Bayraktar (2025) reported that climatic changes adversely affect agricultural production, with declines in output resulting from unfavorable weather conditions and, consequently, higher inflation rates. Similarly, Kunawotor et al. (2022) showed that climate-related crises in Africa between 1990 and 2017 had particularly strong effects on food inflation, with inflation rates rising significantly during periods of drought and flood events.

2.2. The Relationship between Climate Crisis and Unemployment

A growing body of research has examined whether climate change and adverse weather conditions influence unemployment, a key macroeconomic indicator. Liu and Lin (2023) assessed the effects of global warming on unemployment across 95 countries over the period 1992–2020 and found that climate change has a significant impact on unemployment rates, inflation dynamics, and agricultural output. Their results further indicate that the effect on male unemployment is more pronounced than on female unemployment. Babiker and Eckaus (2007) analyzed the implications of climate-related economic policy adjustments for unemployment and argued that constraints on greenhouse gas emissions can have a favorable effect on employment outcomes.

Adekunle (2024) investigated the relationship between global warming and unemployment in South Africa for the period 1986-2021 using the ARDL approach and identified a long-run relationship between the two variables. The study also concluded that unemployment rates could be reduced through the implementation of appropriate government policies. Martin Roman et al. (2023) decomposed effective unemployment into two main components across 17 autonomous communities in Spain from 1982 to 2012 and found that the natural component plays a dominant role. Their findings suggest that natural disasters and climate-related crises increase natural unemployment, thereby raising overall effective unemployment. Finally, Yunus et al. (2024) examined the relationship between global warming and cyclical unemployment in Indonesia and concluded that while global warming does not directly affect unemployment, it suppresses long-term economic growth, which ultimately leads to higher unemployment.

Ahiwe et al. (2021) examined the effects of climate change on poultry production and unemployment, concluding that climate-related shocks adversely affect animal production and contribute to rising unemployment, particularly in the context of rapid population growth. Castellanos and Heutel (2024) analysed the relationship between climate policies and unemployment in the United States finding that the potential negative employment effects of carbon tax revenues can be mitigated through reductions in labor taxes, whereas regulatory control policies tend to be less effective. Jessoe et al. (2018) investigated the relationship between

long-term temperature variations and employment in rural Mexico and found that rising temperatures have particularly adverse effects on wage employment and non-agricultural labor, especially during periods of extreme heat. Marafa (2024) assessed the impact of temperature and precipitation anomalies on unemployment rate in Nigeria from 1991 to 2023, concluding that a 1% increase in temperature anomalies leads to a 0,28 percent rise, in unemployment, while a 1% increase in precipitation anomalies results in a 0,7% increase in unemployment. Albert et al. (2021) argued that although climate change may increase agricultural production in some developing countries, rising temperatures adversely affect agricultural productivity in Brazil, ultimately contributing to higher unemployment rates. Faehn et al. (2013) emphasized that carbon mitigation policies may exert both positive and negative effects on unemployment. On the one hand, regulations targeting carbon emissions can raise production costs, increase energy prices, and weaken international competitiveness, thereby reducing productivity and increasing unemployment. On the other hand, such policies may generate positive long-term employment effects by reducing environmental degradation, enhancing agricultural productivity, and supporting sustainable growth. Consistent with this view, Kaya (2022) evaluated the impact of renewable energy adoption on climate crises and unemployment and expanding renewable energy use—when supported by appropriate policy frameworks—can contribute to reductions in unemployment. .

Kono (2020) argued that higher unemployment insurance benefits in countries implementing carbon constraints increase workers' support for such policies. The study suggests that when unemployment insurance coverage is more generous, workers are more likely to view carbon limitations favorably, thereby enhancing public support for climate-related regulatory measures.

3. Methodology

3.1. Research Purpose and Significance

The primary objective of this study is to examine the effects of climate-related environmental indicators on the Economic Misery Index using panel data methods, with a specific focus on countries in the Middle East and North Africa (MENA) region. By investigating the relationship between climate-related stressors and macroeconomic distress, the study aims to assess the socioeconomic consequences of climate change in a comprehensive manner.

This research is particularly significant given the MENA region's heightened exposure to both climatic vulnerability and economic inequality. From a sustainable development perspective, the study provides insights into the social dimensions of climate change and offers relevant implications for policymakers seeking to mitigate the macroeconomic and social risks associated with climate-related environmental pressures.

3.2. Hypotheses and econometric model

The hypotheses of the study have been formulated as follows, in line with the research objective.

H_{0a} : There is no relationship between the Misery Index and Water Stress.

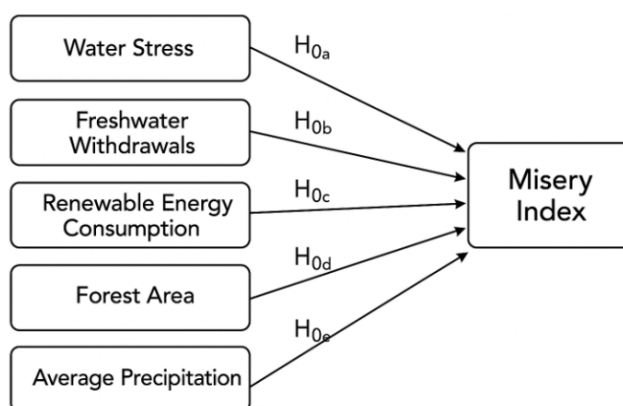
H_{0b} : There is no relationship between the Misery Index and Freshwater Withdrawals.

H_{0c} : There is no relationship between the Misery Index and Renewable Energy Consumption.

H_{0d} : There is no relationship between the Misery Index and Forest Area.

H_{0e} : There is no relationship between the Misery Index and Average Precipitation.

Figure 1: Research Model and Hypotheses



Research Model:

$$MI_{it} = \beta_0 + \beta_1 WS_{it} + \beta_2 FW_{it} + \beta_3 REC_{it} + \beta_4 FA_{it} + \beta_5 PRC_{it} + \varepsilon_{it} \quad (1)$$

MI_{it} : Misery Index observed for country i in period t , the dependent variable.

WS_{it} : Water stress (%).

FW_{it} : Freshwater withdrawals as a percentage of internal water resources (%).

REC_{it} : Share of renewable energy in total final energy consumption (%).

FA_{it} : Forest area as a percentage of total land area (%).

PRC_{it} : Average annual precipitation (mm/year).

ε_{it} : Error term representing unobserved effects.

β_0 : Intercept.

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$: Coefficients of the independent variables.

3.3. Dataset, Variables and Model Specification

The Economic Misery Index is a composite measure that simultaneously captures the societal impacts of two major macroeconomic challenges—inflation and unemployment. It serves as an effective indicator of the level of economic discomfort experienced by individuals, particularly during periods of economic volatility characterized by rising living costs and job insecurity. The Misery Index is a macroeconomic indicator commonly attributed to Okun (1970), developed to measure the level of economic discomfort experienced. Higher levels of inflation and unemployment are associated with declining economic welfare and increasing socioeconomic dissatisfaction.

In this study, the Misery Index (MI) is calculated as the sum of the inflation rate and unemployment rate:

$$MI_{it} = INF_{it} + UNEMP_{it} \quad (2)$$

where INF_{it} represents the inflation rate and $UNEMP_{it}$ denotes the unemployment rate for country i , in period t .

Employing this index as the dependent variable enables a comprehensive assessment of the extent to which climate-related environmental pressures contribute to social and economic dissatisfaction. In this respect, the study seeks to contribute to the broader objectives of sustainable development and macroeconomic stability.

The independent variables included in the study were determined based on the climate change literature and previous studies examining environmental vulnerability and climate-related risks. Previous studies emphasized that climate change affects macroeconomic outcomes through environmental stressors such as water scarcity, declining productivity, resource pressure and ecosystem vulnerability (Fankhauser and Tol, 2005; Waha et al., 2017; Arnell et al., 2019; Giovanis and Ozdamar, 2022). In this context, the selected variables are intended to capture different dimensions of climate-related environmental pressure that may

affect economic dissatisfaction through inflationary pressures, resource scarcity, agricultural productivity losses and structural economic vulnerabilities.

Moreover, five climate crisis indicators, each reflecting a distinct dimension of climate-related stress, are incorporated—using panel data from 17 MENA countries covering the period 1991–2021—to examine their potential effects on economic dissatisfaction in MENA countries.

Water Stress: Given the region's structural water scarcity, this factor constitutes a critical environmental pressure with direct implications for both agricultural production capacity and public health.

Freshwater Withdrawals: Reflecting the intensity of water resource use, this indicator is essential for assessing resource sustainability and the extent of pressure exerted on economic activities.

Renewable Energy Consumption: It serves as an indicator of the effectiveness of climate policies and sustainable development practices in promoting economic stability, given its potential to reduce the environmental costs associated with energy production.

Forest Area: It is regarded as a variable reflecting environmental resilience, given its role in ecosystem health and climate regulation functions.

Average Precipitation: Taking into account the effects of climatic shocks, such as droughts and extreme weather events, on agriculture, food security, and living costs, these factors are incorporated into the model. The selected indicators are employed as independent variables to capture environmental pressures that may intensify economic and social discontent, as measured by the Misery Index, in a multidimensional framework. This approach explicitly reflects the MENA region's heightened vulnerability to the climate crisis.

Table 1. Variables Definition and Data Sources

Variable	Code	Description	Unit	Source
Dependent Variable				
Misery Index	MI	Calculated by the authors as the sum of unemployment and inflation rates in MENA countries	Percent (%)	World Bank
Independent Variable				
Water Stress	WS	Annual freshwater withdrawal as a percentage of available water resources	Percent (%)	World Bank

Freshwater Withdrawals	FW	Annual freshwater withdrawals as a share of total internal resources	Percent (%)	World Bank
Renewable Energy Consumption	REC	Share of renewable energy in total final energy consumption	Percent (%)	World Bank
Forest Area	FA	Forest area as a percentage of total land area	Percent (%)	World Bank
Average Precipitation	PRC	Annual average precipitation	Millimeter/year (mm/year)	World Bank

The dataset covers indicators for the period 1991–2021 for a total of 17 countries in the MENA region. The countries and variables included in the analysis were determined based on the regular availability and continuity of climate-related and macroeconomic indicators reported in the World Bank (2025) database. Furthermore, 2021 represents the most recent year for which all selected variables are jointly available on a consistent basis across the sampled MENA countries.

3.4. Descriptive Statistics and Correlation Analysis

Table 2 presents the descriptive statistics of the variables employed in the study. The dataset consists of 527 observations covering 17 MENA countries over the period 1991–2021. The results indicate that all variables exhibit a wide range of dispersion. In particular, the relatively high maximum values observed for the MI, WS, and FW variables suggest the presence of substantial cross-country and temporal variation within the sample. By contrast, the REC and FA variables display comparatively lower mean values.

Although the skewness and kurtosis coefficients generally indicate a tendency to deviate from normal distribution, this pattern can be regarded as a natural outcome of the structural heterogeneity commonly observed in panel datasets. Accordingly, the use of robust estimation techniques in the empirical analysis is deemed appropriate to enhance the statistical reliability of the model.

Table 2. Descriptive Statistics of Variables

Variable	Obs.	Mean	Std. Dev.	Median	Min.	Max.
MI	527	19.572	28.656	16.189	-24.96	405.41
WS	527	278.679	400.516	107.114	13.2	1866.67
FW	527	985.251	1886.747	169.762	22.83	7750
REC	527	5.289	9.372	1.2	0	46.7
FA	527	2.936	4.103	1.04	0	14.07
PRC	527	168.359	149.135	111	18.1	661

Descriptive statistics is calculated from level (original) data

MI displays substantial variability, with a mean value of 19.572 and a relatively large standard deviation of 28.656. The wide range between the minimum

and maximum values indicates the presence of extreme macroeconomic distress episodes within the sample. Similarly, environmental indicators display large dispersion, reflecting significant cross-country differences in water resource pressures across the MENA region.

To reduce the potential influence of extreme observations in the dependent variable, robustness analyses were conducted using the inverse hyperbolic sine transformation of the Misery Index. The results remained qualitatively consistent. The Spearman rank correlation coefficient, which is robust to distributional deviations and captures monotonic relationships at the rank level, was employed in Table 3.

Table 3. Spearman Correlation Coefficients

	MI	WS	FW	REC	FA	PRC
MI	1					
WS	-0.291	1				
FW	-0.267	0.704	1			
REC	0.285	-0.612	-0.306	1		
FA	0.200	-0.404	-0.572	0.345	1	
PRC	0.244	-0.674	-0.791	0.327	0.758	1

The Spearman correlation results reported in Table 3 indicate a moderate positive association between the Misery Index (MI) and Renewable Energy Consumption (REC) ($\rho = 0.285$). In contrast, MI is negatively correlated with the Water Stress Index (WS) ($\rho = -0.291$) and Freshwater Withdrawals (FW) ($\rho = -0.267$), suggesting an inverse monotonic relationship between economic distress and certain climate-related indicators.

Moreover, a relatively strong positive correlation is observed between Forest Area (FA) and Average Precipitation (PRC) ($\rho = 0.758$), while PRC exhibits strong negative correlations with WS ($\rho = -0.674$) and FW ($\rho = -0.791$). Overall, the correlation matrix points to meaningful associations among several climate-related variables, warranting careful consideration of potential multicollinearity in the multivariate analysis.

4. Empirical Results and Findings

This study investigates the effects of selected climate crisis-related environmental indicators on economic dissatisfaction using panel data analysis.

4.1. Cross-Sectional Dependence and Panel Unit Root Tests

Prior to model estimation, cross-sectional dependence tests were conducted to determine whether the panel units were interdependent. The results reported in

Table 4 indicate the presence of significant cross-sectional dependence among the sampled MENA countries.

Table 4. Cross-Sectional Dependence Test Results

Test	Test Statistic	p-value
Pesaran CD Test	CD = 13.609	0.000
Friedman Test	$\chi^2 = 131.525$	0.000
Frees Test	Q = 1.960	0.000

The findings indicate the presence of cross-sectional dependence among the panel units. Therefore, the results of the second-generation panel unit root tests, namely the CIPS and CADF tests employed in the subsequent stage of the analysis, are presented in Table 5.

Table 5. CIPS and CADF Panel Unit Root Tests

Variable	Model Type	Lags	CIPS Stat.	Critical Values			P-Value	CADF Stat.	Critical Values			P-Value
				1%	5%	10%			1%	5%	10%	
MI	Intercept	1	-3.05	-2.4	-2.20	-2.1	-2.26	-	-	-2.1	0.016	
				2.4	2.2							
	Intercept+Trend	1	-3.39	-2.9	-2.7	-2.6	-2.63	-	-	-2.6	0.084	
				2.9	2.7							
WS	Intercept	1	-1.51	-2.4	-2.20	-2.1	-2.03	-	-	-2.1	0.124	
				2.4	2.2							
	Intercept+Trend	1	-1.32	-2.9	-2.7	-2.6	-1.91	-	-	-2.6	0.978	
				2.9	2.7							
FW	Intercept	1	-1.17	-2.4	-2.20	-2.1	-1.30	-	-	-2.1	0.980	
				2.4	2.2							
	Intercept+Trend	1	-2.15	-2.9	-2.7	-2.6	-2.13	-	-	-2.6	0.840	
				2.9	2.7							
REC	Intercept	1	-1.18	-2.4	-2.20	-2.1	-1.42	-	-	-2.1	0.936	
				2.4	2.2							
	Intercept+Trend	1	-1.68	-2.9	-2.7	-2.6	-1.73	-	-	-2.6	0.998	
				2.9	2.7							
FA	Intercept	1	0.23	-2.4	-2.20	-2.1	-0.23	-	-	-2.1	1.000	
				2.4	2.2							
	Intercept+Trend	1	-0.76	-2.9	-2.7	-2.6	-0.89	-	-	-2.6	1.000	
				2.9	2.7							
PRC	Intercept	1	2.61	-2.4	-2.20	-2.1	2.61	-	-	-2.1	1.000	
				2.4	2.2							
	Intercept+Trend	1	1.70	-2.9	-2.7	-2.6	1.70	-	-	-2.6	1.000	
				2.9	2.7							

The findings reported in Table 5 indicate that the Misery Index (MI) is stationary at level, whereas the remaining variables (WS, FW, REC, FA and PRC) contain unit roots in their level values. Therefore, first-difference transformations

were considered for the non-stationary variables in the subsequent stages of the empirical analysis.

4.2. Model Selection and Assumption Tests

Prior to model estimation, LR, F, and LM tests were conducted to assess the appropriateness of the panel data specification. The LR test was employed to examine the presence of time fixed effects, the F test was used to test for country fixed effects, and the LM test was applied to evaluate the necessity of a panel data structure. The results are presented in Table 6.

Table 6. LR Test, F Test and LM Test

Test	Test Statistic	df	p-value
LR Test (RE vs Pooled OLS)	$\chi^2 = 8.32$	1	0.002
F Test (FE vs Pooled OLS)	F = 5.60	16.506	0.000
LM Test (RE vs Pooled OLS)	$\chi^2 = 1349.03$	1	0.000

The results reported in Table 6 confirm the appropriateness of the panel data framework and indicate the presence of significant unit-specific effects across panel units.

As a subsequent step in model selection, the Hausman test (Hausman, 1978) was employed to compare the fixed effects and random effects specifications. The results reported in Table 7 indicate no statistically significant difference between the two estimators ($p > 0.05$), suggesting that the random effects specification cannot be rejected on statistical grounds.

Table 7. Hausman and Cluster-Robust Hausman Tests

Test	Test Statistic (χ^2)	df	p-value
Hausman Test	5.85	4	0.2108
Cluster-Robust Hausman Test	0.52	4	0.9714

The results of both the standard Hausman test and the cluster-robust Hausman test, reported in Table 7, further support this conclusion, indicating that the random effects model is appropriate. Accordingly, although the fixed effects model is adopted on theoretical grounds, the random effects specification may also be considered a statistically valid alternative from an econometric perspective (Cameron and Miller, 2015). However, due to the presence of cross-sectional dependence, regional heterogeneity and unobserved country-specific effects across MENA countries, the fixed effects model was preferred on theoretical and econometric grounds. Accordingly, the empirical estimations were conducted using fixed effects with Driscoll–Kraay standard errors, which provide robust inference

under heteroskedasticity, autocorrelation and cross-sectional dependence (Driscoll and Kraay, 1998; Hoechle, 2007).

4.3. Panel Regression Estimates and Interpretations

The estimates obtained from the fixed effects model, as reported in Table 8, indicate that none of the independent variables exert a statistically significant effect on the Misery Index.

Table 8. Baseline Random Effects Estimation Results

Observations (N): 527			Number of Groups: 17		
Within R ² = 0.0008			ρ (rho) = 0.1680		
Wald $\chi^2(5) = 3.44$ (p = 0.6321)					
Dependent variable: MI			Estimator: Random Effects		
Independent variable	Coefficient (β)	Std. Error	z-value	p-value	95% Confidence Interval
WS	-0.0069	0.0084	-0.82	0.412	[-0.0233 , 0.0096]
FW	-0.0005	0.0016	-0.32	0.748	[-0.0037 , 0.0027]
REC	0.0293	0.2947	0.1	0.921	[-0.5483 , 0.6070]
FA	-0.8716	1.7111	-0.51	0.61	[-4.2253 , 2.4821]
PRC	0.039	0.0507	0.77	0.441	[-0.0603 , 0.1383]
Constant	17.842	7.8386	2.28	0.023	[2.4787 , 33.2053]

Overall, the random effects model is not statistically significant (p = 0.6321), and the within R² value is low (0.0008), indicating limited explanatory power. The overall model is not statistically significant, suggesting that the selected environmental variables do not jointly explain variations in the MI.

Prior to implementing the Driscoll–Kraay estimator, which yields more reliable inference under such conditions, diagnostic tests were conducted to assess potential violations of panel data assumptions. As reported in Table 9, the results indicate the presence of such deviations in the model.

Wald Test Hypotheses (Baum, 2024):

H₀: The error variances are equal across units (no heteroskedasticity).

H₁: At least one unit exhibits a different error variance (heteroskedasticity is present).

CD Test Hypotheses (Cross-Sectional Dependence) (Pesaran, 2015):

H₀: There is no correlation between panel units.

H₁: There is correlation between panel units.

Baltagi-Wu Test Hypotheses (Autocorrelation) (Baltagi and Wu, 1999):

H₀: There is no autocorrelation in the panel.

H₁: Autocorrelation is present in the panel.

Table 9. Diagnostic Tests for Violations of Classical Assumptions

Test	Test Statistic	p-value	Decision and interpretation
Modified Wald Test	$\chi^2(17) = 45344.81$	0.000	<i>H₀ rejected → Heteroskedasticity exists.</i>
Baltagi-Wu LBI Test	1.94	-	<i>H₀ not rejected → No autocorrelation.</i>
Pesaran CD Test	CD = 13.609	0.000	<i>H₀ rejected → Cross-sectional dependence exists.</i>
Friedman Test	$\chi^2 = 131.525$	0.000	<i>H₀ rejected → Cross-sectional dependence exists.</i>
Frees Test	Q = 1.960	0.000	<i>H₀ rejected → Cross-sectional dependence exists.</i>

As indicated in Table 9, the model was estimated using Driscoll–Kraay standard errors due to violations of key classical error term assumptions, including heteroskedasticity and cross-sectional dependence. This estimator provides consistent and robust inference in the presence of such panel data issues.

According to the results reported in Table 10, the model is statistically significant overall ($F = 43.47$, $p < 0.001$), and the within R², which reflects the model’s explanatory power over within-unit variation, is 0.082.

Table 10. Driscoll-Kraay Fixed Effects Model Results

Observations (N): 527			Number of Groups: 17		
Within R ² = 0.082			F-statistic= 43.47 (p = 0.000)		
Dependent variable: MI			Estimator: FE (Driscoll–Kraay SEs)		
Independent variable	Coefficient (β)	Std. Error	t-statistic	p-value	95% Confidence Interval
WS	0.0119	0.0122	1.97	0.039	[-0.0120 , 0.0358]
FW	0.0033	0.0015	2.25	0.032	[0.0003 , 0.0063]
REC	0.0499	0.2313	1.94	0.011	[0.0226 , 0.9223]
FA	1.3484	1.792	1.12	0.271	[-1.7764 , 0.4732]
PRC	-0.1478	0.2167	-0.68	0.500	[-0.5903 , 0.2947]

Regarding the individual coefficients, Water Stress (WS) and Freshwater Withdrawals (FW) are found to have a positive and statistically significant effect on the Misery Index at the 0.05 significance level. These results suggest that

increases in environmental pressure indicators such as water stress and freshwater withdrawals are associated with higher levels of economic dissatisfaction.

Renewable Energy Consumption (REC) also exhibits a statistically significant coefficient, indicating that changes in renewable energy dynamics may influence the Misery Index. In contrast, Forest Area (FA) and Average Precipitation (PRC) are not statistically significant, suggesting that these variables do not exert a measurable effect on economic dissatisfaction within the model.

In conclusion, based on the Driscoll–Kraay estimation results reported in Table 10, the null hypotheses associated with Water Stress (H_{0a}), Freshwater Withdrawals (H_{0b}) and Renewable Energy Consumption (H_{0c}) are rejected, indicating statistically significant relationships with the Misery Index. By contrast, the null hypotheses related to Forest Area (H_{0d}) and Average Precipitation (H_{0e}) cannot be rejected.

These findings highlight the potential macroeconomic implications of environmental stress factors and support the view that climate-related pressures may indirectly contribute to socioeconomic dissatisfaction in environmentally vulnerable regions.

4. Conclusions

Rising global temperatures exert substantial pressure on ecological systems while generating significant economic challenges across regions. In recent decades, climate-related shocks have adversely affected agricultural and livestock production, leading to declines in output and income not only in primary sectors but also across manufacturing, services, and tourism. The magnitude of these impacts underscores the complex and interconnected relationship between environmental conditions and macroeconomic structures.

This study investigates the interaction between climate-related environmental pressures and the Misery Index (MI) within a macroeconomic framework. The Misery Index, defined as the sum of the unemployment and inflation rates, is employed as the dependent variable. The analysis incorporates five key environmental indicators—Water Stress Index (WS), Freshwater Withdrawals (FW), Renewable Energy Consumption (REC), Forest Area (FA), and Average Precipitation (PRC)—to capture multiple dimensions of the climate crisis. The empirical analysis focuses on 17 MENA countries using annual data for the period 1991–2021. Given the presence of both temporal and cross-sectional dimensions, panel regression techniques are employed. To address heteroskedasticity and cross-sectional dependence, the fixed effects model with Driscoll–Kraay standard errors is adopted. Violations of classical panel data assumptions can lead to biased and inconsistent standard errors when conventional estimators are employed. Therefore, to obtain more reliable statistical inference, the model was re-estimated using the fixed effects specification with Driscoll–Kraay standard errors, which are robust to heteroskedasticity, serial correlation, and cross-sectional dependence.

The empirical findings indicate that increases in water-related pressures and renewable energy consumption are associated with higher levels of economic discontent. Specifically, heightened water stress contributes to rising inflation and unemployment, thereby increasing the Misery Index. Similarly, freshwater withdrawals exert a statistically significant and positive effect on economic discontent, suggesting that excessive water use intensifies macroeconomic pressures. These results are consistent with the findings of Ciccarelli et al. (2023), Kotz et al. (2023), Heinen et al. (2019), and Onikounu et al. (2021), while diverging from those reported by Mukherjee and Ouattara (2021). By contrast, no statistically significant relationship is identified between forest area or precipitation and the Misery Index. From a policy perspective, the findings suggest that regulatory measures aimed at curbing inefficient water use can alleviate inflationary and employment pressures by mitigating water scarcity.

From a policy perspective, the results emphasize the importance of effective water resource management strategies in mitigating macroeconomic instability. Regulatory measures aimed at improving water efficiency, reducing unsustainable withdrawals, and strengthening climate-resilient infrastructure may help alleviate inflationary pressures and employment disruptions associated with environmental stress.

Moreover, while potentially reflecting short-term transition costs and structural adjustment pressures associated with the energy transformation process in the short to medium term—potentially reflecting transition costs—well-designed and long-term climate and energy policies are expected to reduce unemployment and inflation over time, thereby lowering the Misery Index.

Overall, the results indicate that effective environmental policy implementation can yield favorable macroeconomic outcomes and improve economic well-being. This study contributes to the literature by providing a region-specific, longitudinal panel data analysis that highlights the critical role of climate-related environmental pressures in shaping economic discontent in the MENA region.

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