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The Impact of Climate Change on Macroeconomic Situation of the MENA Region and its Implications on Monetary and Macroprudential Policies

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Abstract

This paper investigated the impact of climate change on key macroeconomic variables in the MENA countries. A vector autoregressive (VAR) approach was employed to assess the effect of climate disasters on growth and inflation in the MENA countries using panel data from 1990 to 2022. The econometric analysis was separately conducted on the entire sample of countries and sub-samples of data split into high and low-income countries. The key findings of the study show that climate shocks have a significant effect on inflation particularly in low-income countries while their impact on growth is insignificant. Based on the findings of the paper, it is crucial for central banks to incorporate the climate aspect into their monetary policy and macroprudential frameworks to better address inflationary pressures.

JEL classification E23, E31, E52, Q54, E58
Keywords: Output, Inflation, Monetary policy, climate, natural disasters and Central Banks

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I. Introduction

Climate change has evolved from a potential threat to an immediate and tangible challenge with far-reaching implications for global economies. The literature highlights that climate shocks manifest through multiple channels, including heat waves, sea level rise, droughts, floods, and lower precipitation, with profound effects on agriculture, labor productivity, energy supply, and ultimately on growth and inflation dynamics (Dell, et al., 2012). These "physical risks" often translate into financial losses, supply chain disruptions, and population displacement. In parallel, "transition risks" emerge from policy changes, technological innovations, and market adjustments required to reduce carbon emissions, creating additional macroeconomic uncertainties (NGFS, 2019; IMF, 2020).

Middle East and North Africa (MENA) region has a unique geographical location characterized by a hot and dry climate where extreme high temperatures of up to 56°C may become the norm in the region making it highly vulnerable to climate shocks. This is amplified by its economic concentration on sectors that are highly vulnerable to climate-related risks both physical and transition, including agriculture, oil and gas and tourism. A prominent example is the impact that climate related risks have on agriculture and by proxy food production posing a threat to food security in the region and accordingly on price levels resulting in supply driven inflationary environment.

Climate change risks are posing new threats to price and financial stability, requiring central banks to develop policies to mitigate these risks, including both physical and transition risks, given that these risks can impede the effectiveness of the monetary policy and threaten the stability of the financial system. On the price stability front, climate disruptions generate higher inflation volatility, as extreme weather shocks destabilize agricultural production, supply chains, and energy supply (Batini et al., 2022; Boneva et al., 2021). Transition risks, such as carbon taxes and energy policy reforms, can also raise prices of carbon-intensive goods, complicating monetary policy efforts (Krogstrup & Oman, 2019). On the other hand, banks financing carbon-intensive sectors with high exposure to transition risks may face declining profitability due to asset price drops and increasing probability of defaults among clients. The overlap between physical and transition risks can create systemic risks in the banking sector and the broader financial system by amplifying the impact of each type of risk and increasing the likelihood of widespread financial instability. Previous work on the Euro Area, show that physical risks result in asset damage, production disruptions, and a rise in non-performing loans (NPLs) in the affected sectors and areas, which results in substantial financial losses for individuals and businesses as well as banks (ECB, 2023).

Although an expanding body of research has examined the macroeconomic and financial implications of climate change globally, few studies have analyzed these dynamics within the MENA region. This paper seeks to fill this gap by assessing the impact of climate-related disasters on inflation and growth in MENA countries, while differentiating outcomes by income levels (low, middle, and high). This study thus provides policymakers with an evidence-based understanding of how climate risks shape macroeconomic variables in the region, thereby supporting the design of effective strategies to mitigate and adapt to such risks.

The rest of the paper is structured as follows: Section II provides a description of the macroeconomic structure as well as a brief description of climate-risk mitigation efforts and regulatory responses in the MENA Region. Section III presents an overview of the relevant literature while section IV describes the data and methodology used in the study. Section V discusses the results of the empirical model while section VI concludes with some policy recommendations.

II. Overview on the Macroeconomic Structure in the MENA Region Economic Structure of the Region

Before delving into the effect of climate change on Macroeconomics of the MENA region, it is important to have a clear view on the current Macroeconomic situation in the region. The MENA region is characterized by considerable heterogeneity encompassing oil-exporting economies, the Gulf Cooperation Council (GCC countries) on one side and oil-importing economies (Egypt, Jordan, Morocco, Tunisia) on the other. This heterogeneity implies different macroeconomic structures, where oil exporters benefit from hydrocarbon revenues yielding fiscal and external balances while in contrast, oil importers deal with chronic fiscal and current account deficits, elevated debt burdens, and dependence on external financing.

Despite the heterogeneity, MENA countries have some common economic features such as persistent unemployment, high population growth with low productivity and vulnerability to external shocks leading to economic performance that is below the potential. Hence, creating meaningful employment for such a rapidly rising labor force, reducing poverty and improving living conditions will help those countries achieve higher rates of sustainable growth and integrate more fully into the global economy. The region is one of the most food-import-dependent in the world, making local inflation highly sensitive to global agricultural commodity prices besides the associated imported inflation due to exchange rate path, which together make inflation dynamics in the region highly volatile.

2.1 Monetary Policy Framework in the Region

Monetary policy frameworks in the region are also heterogenous. Some countries in the MENA region such as the GCC have pegged exchange rates which on one hand provide nominal stability but on the other hand limit the scope for independent monetary policy. Interest rates closely follow U.S. Federal Reserve decisions, constraining central banks' ability to respond to domestic shocks. Other non-peg economies have gradually moved toward more flexible exchange rate arrangements with greater reliance on interest rate instruments. However, shallow domestic financial markets, limited monetary policy credibility, and fiscal dominance weaken the transmission mechanism in these economies.

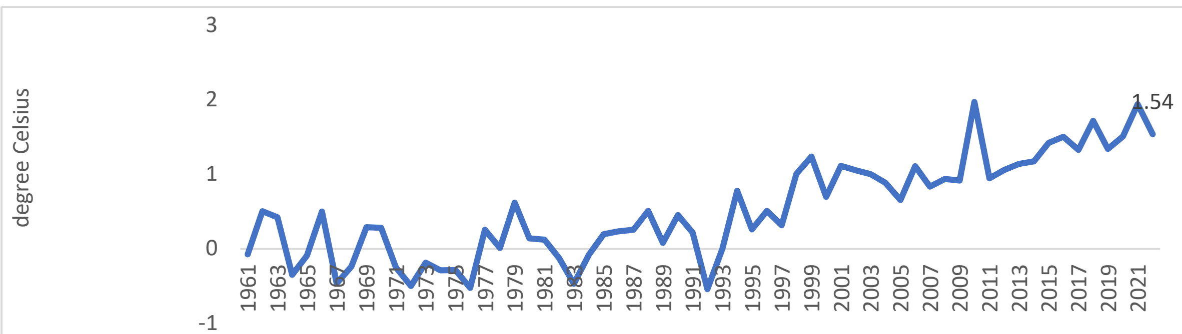
Monetary policy in the MENA region is also highly vulnerable to Global Financial conditions as global risk sentiment affect capital flows, sovereign spreads, and exchange rate stability. Overall, monetary policy in MENA faces a dual challenge: balancing price stability amid repeated supply shocks, while supporting growth in economies constrained by structural rigidities and external vulnerabilities.

2.2 Climate Change as an Additional Challenge for Monetary Policy in the MENA region

Given the aforementioned fragile macroeconomic structure, climate change is considered an additional risk as rising temperatures, declining water availability, and increasing frequency of extreme weather events directly affect agricultural productivity, food prices, and energy demand. MENA region is considered one of the most climate vulnerable regions. This is explained by the geographical position characterized by arid and semi-arid climates leading to more intense heat waves and limited water resources.

Over the last fifty years, the average surface air temperature across the countries in the region has increased significantly. The Food and Agriculture Organization of the United Nations (FAO) data, from 1961 to 2022, indicate that the Surface Temperature Change with respect to a baseline climatology has increased from an average of -0.07°C to 1.54°C as shown in Figure 1.

Figure 1: MENA Surface Temperature Change



Source: Climate Change Indicators Dashboard, International Monetary Fund

This has led to severe heat waves posing a significant risk to the region's water availability. According to the World Bank, the region is considered the world's most water scarce where 60% of people live in high or extremely high water stressed areas. The situation is further accentuated by the high dependence of the region on agriculture sector which is 70% rainfed hence highly exposed to climate risk. Shorter growing seasons are then expected which are threatening not only the production and the income of the region but also food security. Furthermore, rapid population growth and urbanization are exacerbating the situation by increasing demand for water and energy.

These climate shocks have implications for both oil importer and exporter countries; for oil importers, climate shocks exacerbate food and energy import bills, worsening current account deficits and inflation volatility. While oil exporter countries are exposed to transition risks caused by the climate policies and global decarbonization trends which may undermine fiscal sustainability and asset valuations in the long run. These risks have major implications on monetary policy as they complicate inflation management, weaken the credibility of inflation-targeting frameworks and put pressure on the exchange rate.

2.3 Climate-Risk Mitigation Efforts and Regulatory Responses in the MENA Region

Addressing the impacts of climate change requires a holistic approach, one that involves both private and public sector. MENA economies have begun to institutionalize climate-risk mitigation through national strategies, supervisory guidance, and market instruments in order to dampen macroeconomic volatility transmitted via food, energy, and investment channels.

As an example for a national strategy employed, the United Arab Emirates launched a Net Zero 2050 initiative and hosted COP28 (2023), where the "UAE Consensus" committed parties to a transition away from fossil fuels and to tripling global renewables and doubling energy efficiency by 2030. Moreover, Morocco submitted long-term strategies toward about 80% renewable electricity by 2050, positioning the power sector to lower cost-push pressures from imported fuels. While on the financial market side, Egypt issued the region's first sovereign green bond worth, US$750m in 2020 to finance clean transport, water, pollution control and renewables signaling a pipeline for green public spending. The UAE also moved to develop market infrastructure for carbon credits, Abu Dhabi Global Market licensed ACX in 2022 as the world's first regulated carbon exchange and clearing house for environmental instruments, to channel private finance toward mitigation.

In addition, financial authorities are integrating climate risk into supervision to contain credit and liquidity spillovers from climate shocks. In Egypt, the Central Bank of Egypt (CBE) issued the Sustainable Finance Guiding Principles (July 2021) and the Binding Regulations on Sustainable Finance (November 2022) that require banks to integrate sustainability into policies, establish dedicated departments, report periodically, and consult environmental experts. The Financial Regulatory Authority (FRA) has also demonstrated a proactive approach by requiring listed companies and significant non-banking financial firms to include climate change financial impacts in their ESG disclosure reports, aligning with TCFD guidelines.

Collectively, these measures aim to internalize climate risk by shifting climate impacts from being an "external shock" to a measurable, managed, and priced factor inside the economic and financial system. Although, the implementation risks remain present, the direction of policy is broadly consistent with lowering medium-term climate-macro vulnerabilities in MENA.

III. Literature Review

3.1 Theoretical Literature Review

The theoretical literature identifies three main channels that relate climate change to monetary policy, namely, the asset prices channel, the natural rate of interest channel, macroeconomic objectives channel, and the expectations channel. The first channel highlights the transmission of climate change effects to the banking sector. In this case, the effect is expected to occur during the shift toward a low-carbon economy, which may result in significant swings in asset prices and the creation of large volumes of stranded assets. This may cause severe stress on financial institutions' balance sheets leading to a reduction of the flow of credit to the real economy. Extreme weather events further aggravate this risk by potentially causing direct credit losses. Central banks are not immune from this risk as they are facing potential losses from securities acquired through asset purchase programs and from the collateral provided by counterparties in monetary operations. This vulnerability creates tighter financial conditions in the economy which impair the transmission channel of monetary policy to firms and households.

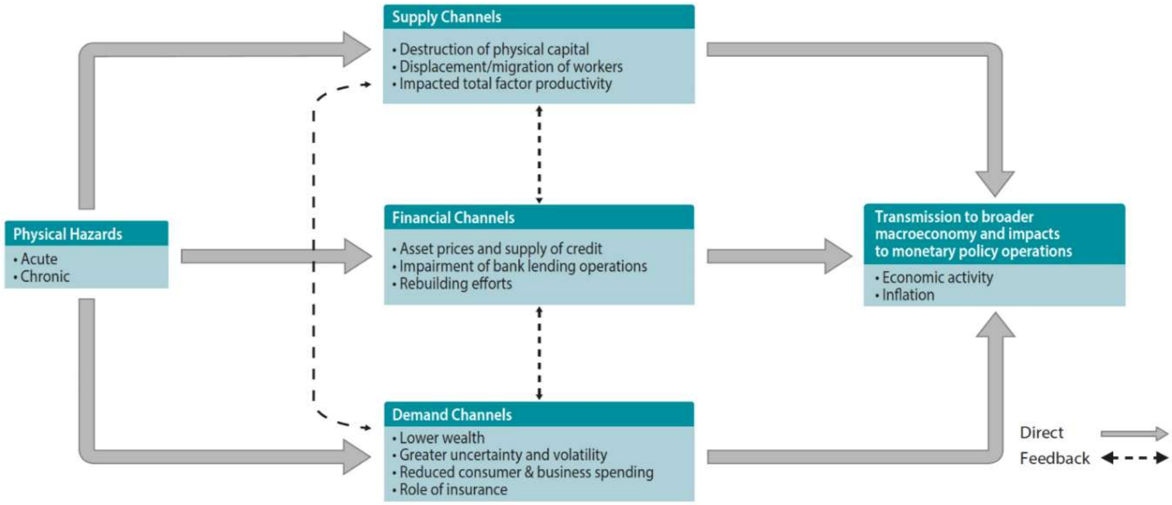
The second channel of transmission of climate risk to monetary policy is by diminishing the space for conventional monetary policy tools. Climate shocks pose downward pressure on the equilibrium real interest rate (r*) which is the rate at which the aggregate economic activity is at its potential level and inflation is at the monetary authority's target level. The downward pressure is due to the fact that extreme weather events affect productivity, raise risk aversion, increase precautionary savings and reduce incentives to invest. These factors combined tend to reduce r* which limit the ability of central banks to employ its conventional monetary policy tools in case of downturn before hitting the zero lower bound.

A third channel is the macroeconomic objective channel, extreme weather events can be primarily thought of as supply shocks, which tend to increase prices and lower output. This arises from physical climate risks that cause shortage of commodities or the damage of infrastructure and accordingly lead to price volatility. This has ramifications on trade as higher temperature leads to reduced productivity and food supply and consequently the quantity of goods exported, particularly, by poor countries.
In addition, there might be disruptive effects on labor supply and productivity by reducing physical and cognitive performance of human capital as extreme heat can lead to a rise in mortality rate in the population.

Supply shocks are difficult to counter from a central bank perspective as policymakers are faced with a dilemma between stabilizing inflation and maintaining economic activity. Climate shocks amplify the frequency and severity of supply shocks making them more persistent, hence there could be risk of de-anchoring of inflation expectations making the task more difficult for central banks to set suitable monetary policy. Extreme climate events such as floods and storm can also cause a demand side shock as these events reduce household wealth and hence private consumption. In addition, uncertainty, financial losses and tighter climate policy which cause dislocation in high carbon sectors can negatively affect investment.

Another indirect way through which climate change affects monetary policy is the expectations channel. Anticipations of future environmental regulations, carbon pricing, and the green transition significantly influence economic behavior; consumer and investor expectations about future policy impacts may lead to precautionary savings or speculative behavior, intensifying macroeconomic fluctuations. These behaviors influence long-term interest rates and credit conditions. For example, if households expect future carbon taxes to reduce real income, they may cut spending today, potentially lowering aggregate demand and inflation. This also applies to firms as they adjust their own expectations around input costs, wages, and pricing strategies in response to anticipated regulatory changes. These expectation-driven effects further complicate the task for central banks as they could deviate the monetary policy from achieving its desired targets.

The below diagram summarizes the different channels of transmission:



Source: NGFS (2024)

3.2 Empirical Literature Review

The reviewed empirical literature focuses on three key questions: how asset returns are being affected by climate change, how asset prices could be affected by climate-related costs, and whether financial markets are efficiently pricing these risks. Campiglio, et al. (2022) surveyed the academic literature on the influence of climate-related risks on financial assets. The authors found strong evidence that natural disasters like hurricanes and droughts already have a detrimental impact on debt and equity instruments, resulting in increased non-performing loans and lower payoffs. The authors also pointed out that certain financial assets are more impacted by transition costs which are associated with the move to a low-carbon economy than others. Their findings show that these risks are monetarily significant in terms of future climate-related costs. Nevertheless, the degree to which investors have factored these risks into asset prices will determine how significant they are.

Levine & Pontines (2024) also examined the effect of climate shocks on the natural rate of interest rate by incorporating an environmental aspect into a Keynesian growth model. They build on the baseline Keynesian growth model of Fornaro & Wolf (2023), which found that temporary supply shock in the form of increase in energy prices or the emergence of a pandemic cause a reduction in the natural real interest rate. By extending the model to include an environmental aspect, the simulation results proved that a decline in natural rate of interest rate following a supply shock is aggravated when the environmental component is part of the model.

Dell et al. (2012) studied the relationship between changes in a country's temperature, precipitation and changes in its economic performance using panel data for 125 countries. Their model results prove that higher temperatures result in a significant negative effect on growth in poor countries as 1◦C rise in temperature reduces economic growth by 1.3%, but this effect is not significant in rich countries. Higher temperature also leads to wide-ranging effects such as reducing agricultural output and industrial output in the countries. Changes in precipitation, however, have relatively mild effects on economic growth both in rich and poor countries. Abdelfattah et al. (2021) investigated the effect of temperature and precipitation deviation from historical average on growth in the MENA countries.

The analysis was conducted on 20 countries over the period 1980 to 2017 using a stochastic growth model. The results show that climate change has long-term negative impacts on economic growth.

Byrne and Vitenu-Sackey (2024) studied the impact of climate variability on real GDP growth by differentiating between the impact of global climate risk and country specific climate risk using a factor model. The study employed a Bayesian Panel VAR on 30 countries over the period 1901 to 2020. The findings showed that global climate risk has a significant negative and relatively more important impact on GDP than country specific climate shocks. Both advanced and emerging economies are impacted to a greater extent by common, rather than the idiosyncratic climate risk, which emphasizes the global dimension of climate change. In addition, results indicate the presence of spillover effects from one country to another.

Using a stochastic growth model where productivity is affected by deviations in temperature and precipitation from their long-term moving average historical norms, Kahn et al. (2021) assessed the impact of climate change on growth using panel data for 174 countries from 1960 to 2014. A panel ARDL model was estimated where the results show that per-capita real output growth is negatively affected by persistent changes in the temperature above or below its historical norm but no statistically significant effects were identified for changes in precipitation. They estimated that a rise (or fall) in temperature above (or below) its historical norm by 0.01 ◦C annually for a long period of time will decrease income growth by 0.0543 % per year. The authors have estimated the differential impact of weather shocks across climates and income groups where they concluded that the marginal effects of weather shocks are larger in low-income countries as they have lower capacity to deal with the consequences of climate change.

Other studies have also investigated the effect of climate shocks on inflation in addition to the effect on growth where some of them have counterintuitive results. Cevik and Jalles (2024) studied the effect of climate-induced natural disasters on inflation and economic growth in a large panel of 173 countries over the period 1970–2020. Using local projection methodology, the results show that inflation and real GDP growth react significantly but differently in terms of direction and magnitude to different types of climate disasters as extreme temperatures yield lower inflation while storms lead to higher inflation. By splitting the sample into income groups (advanced and developing countries), the study showed that the impact of climate shocks on headline inflation differ in economies with varying levels of economic development showing that developing countries are more vulnerable. While for growth, it was found that the initial effect of climate shock on growth is negative but the magnitude and pattern of response show variation over the long run. A similar study by Mukherjee et al. (2021) used a panel VAR model to estimate the impact of temperature shocks on inflation for a sample of developed and developing countries from 1961 to 2014. Their findings suggest that in fact temperature shocks lead to inflationary pressure in all the countries under study while the effect is persistent and prolonged for developing countries only. These findings support the analysis by Barrios, et al. (2008), which concluded that Africa has been disproportionately affected by climate change and this has been a major contributor to its weaker agricultural performance compared with other developing regions.

Faccia et al. (2021) investigated how extreme temperatures affect various measures of inflation in 48 advanced and emerging economies (EMEs) during the period 1951–1980. The analysis was done on a range of prices such as consumer prices, producer prices and the GDP deflator where they found that higher temperatures increase food price inflation in the near term, especially in EMEs while over the medium term, the impact on the various price indices tends to be either insignificant or negative. Abidi et al. (2024) empirically investigated the impact of climate shocks on inflation and monetary policy transmission in the Middle East and Central Asia (ME&CA) region. Local projection methodology was used to estimate the impact of climate shocks on headline and food inflation for 18 countries over the period 2013 to 2022. The results proved that changes in water availability, other climate-related disturbances and negative climate shocks can significantly impact food prices and inflation. On the other hand, positive climate shocks such as increase in rainfall have reduce inflation. The findings also showed that ME&CA countries that are more severely impacted by negative climate shocks exhibit diminished sensitivity to monetary policy tools. This study sheds some light on the importance of considering climate-related supply shocks when designing monetary policy, particularly in countries where food makes up a significant part of the CPI-basket.

IV. Data & Methodology

This section provides an econometric model representing the effect of climate shocks on the macroeconomic situation of the MENA region. In line with previous studies, the analysis used a panel estimation due to the limited availability of large and consistent dataset for single countries. The utilized a vector autocorrelation (VAR) methodology, as the VAR treats all variables as endogenous and hence facilitates analysis of the dynamics between the different variables over the short run through running impulse response functions and variance decomposition approach.

$$y_{it} = \alpha + \sum_{l=1}^{p} A_l y_{i,t-1} + Bc_{it} + \varepsilon_{it}$$

The above equation is estimated where A_ℓ are autoregressive coefficient matrices; B captures contemporaneous impacts of climate on macroeconomic variables. This study is based on annual data from 1990 to 2022 on MENA countries. Some countries were excluded from the analysis due to data unavailability hence the study considered 15 countries (shown in Annex 1), including Egypt.
The following are the variables used in this study:

Variables of Interest:

- **Inflation** (π): Annual percentage change in consumer price index (CPI), obtained from the World Economic Outlook, (IMF, 2024).

- **GDP Growth (**g**)**: Annual percentage change in real GDP, sourced from World Development Indicators, (World Bank, 2024).

- **Climate disaster frequency**: Annual number of climate-related disasters (floods, droughts, storms, extreme temperatures, wildfires) per country, sourced from IMF Climate Change Dashboard (EM-DAT / CRED). A disaster is recorded when at least 10 deaths, 100 affected people, a state of emergency, or an international aid request is reported.

- **Average mean temperature** (used in the robustness check of the model): Sourced from the World Bank Climate Change Knowledge Portal (CCKP) and measures the annual average near-surface air temperature (°C) for each country, based on gridded climate data from the Climatic Research Unit (CRU) and other observational datasets.

Other Variables

- **Gross capital formation (**GCF): Gross capital formation as a share of GDP (%), measuring investment in productive assets.

- **Broad money growth (**ΔM2**)**: Annual percentage change in broad money (M2), representing monetary liquidity conditions.

- **Lagged variables are i**ncluded to capture the dynamic interdependence of a panel VAR framework.

The choice of the variables is guided by previous studies, notably, Mukherjee & Ouattara (2021) who employed a panel-VAR to demonstrate pronounced inflationary pressures from temperature shocks in a sample of developed and developing countries.

The following is the equation form of the model.

$$\pi_{it} = \beta_0 + \sum_{p=1}^{P} \beta 1 \, \text{Disaster}_{\text{i,t-p}} + \sum_{p=1}^{P} \beta 2 \, \pi_{i,t-p} + \sum_{p=1}^{P} \beta 3 \, g_{i,t-p} + \sum_{p=1}^{P} \beta 4 \, \text{GCF}_{i,t-p} + \sum_{p=1}^{P} \beta 5 \, \Delta \text{M2}_{i,t-p} + \varepsilon \text{it}$$

$$g_{it} = \propto_0 + \sum_{p=1}^{P} \propto 1 \, \text{Disaster}_{\text{i,t-p}} + \sum_{p=1}^{P} \propto 2 \, \pi_{i,t-p} + \sum_{p=1}^{P} \propto 3 \, g_{i,t-p} + \sum_{p=1}^{P} \propto 4 \, \text{GCF}_{i,t-p} + \sum_{p=1}^{P} \propto 5 \, \Delta \text{M2}_{i,t-p} + \varepsilon \text{it}$$

Expected Signs (Guided by Theory and Regional Context):

- Climate disasters coefficient (β1>0) is expected to be positively correlated with inflation. In the MENA region, climate shocks affect agricultural output and food supply which increase food prices and import dependence. This results in cost-push inflation.

- Climate disasters coefficient (α1<0) is expected to be negatively correlated with GDP growth. Disasters damage infrastructure, reduce labor productivity due to heat stress, and disrupt production, leading to lower output growth.

- Money supply growth (β5>0 and α5>0) is expected to be positively correlated with both inflation and growth. Monetary expansion increases liquidity and demand, potentially fueling inflation in financially shallow economies. A similar relationship is expected on GDP growth as expansion in M2 can stimulate economic activity by lowering borrowing costs, increasing liquidity, and supporting credit to the private sector.

- Gross capital formation (β4>0 and α4>0) is expected to be positively correlated with both inflation and growth. Higher investment boosts productive capacity, enhances infrastructure, and stimulates economic activity.

The study tests the null hypothesis which postulates that 'climate shocks have no effect neither on inflation nor growth' versus the alternative hypotheses below:

- *H1 (Climate–Inflation link): Climate shocks have a positive effect on inflation through supply-side disruptions, especially food and energy prices.*

- *H2 (Climate–Growth link): Climate shocks have a negative impact on GDP growth, reflecting lower productivity, damages to capital, and disruptions to economic activity.*

As a preliminary analysis of the data, Table 1 presents a summary statistic of the main variables of interest. In addition, a correlation matrix between climate disasters, growth and inflation is presented in Annex 2. The analysis in Annex 2 show that inflation is positively correlated to the frequency of climate disasters while growth shows a small negative correlation.

Table 1:Descriptive Statistics

	Average Mean air temperature (°C)	Number of Climate disasters	GDP growth	Inflation YoY
Mean	23.04	0.71	0.04	0.08
Median	23.17	0.00	0.04	0.04
Maximum	29.42	7.00	0.86	1.71
Minimum	13.48	0.00	-0.50	-0.1
Std. Dev.	4.11	1.16	0.08	0.15
Observations	495	495	495	495

V. Empirical Findings

5.1 Unit Root and Lag Structure results

In order to conduct a Vector Autoregressive analysis, the first step is to test for the stationarity of the data, many of the widely adopted panel unit root tests were used such as Levin et al. (2002) test (LLC), Im et al. (2003) (IPS) and the Fisher-type test (ADF-Fisher) proposed by Maddala and Wu (1999). The different models showed almost same conclusions, as shown in Annex 3, suggesting that the null hypothesis of the presence of a unit root is rejected for all the variables, except for broad money, implying that all the variables are stationary in level. For the broad money, the results indicate that the variable is integrated of order (1), hence the variable will be differentiated to be used in the model. The second step is the choice of the lag structure of the VAR. Using the lag length criteria it appears that the different criteria show different optimal lags lengths so we decided to stick to the Akaike information criteria (AIC). The AIC suggests using 3 lags as shown in Annex 4.

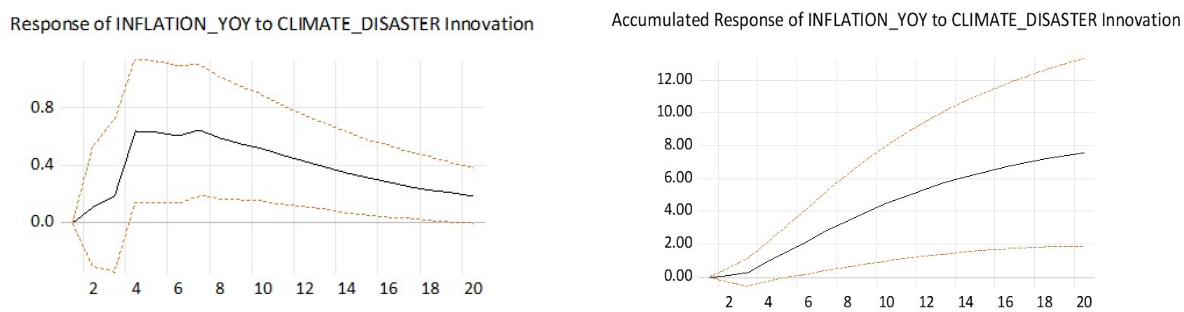
5.2 VAR Results

- **Results of the Estimation on the Full Sample of Countries**

The VAR model was then estimated using a Cholesky ordering of the variables such that the climate disaster variable is set first as it is not contemporaneously affected by all the other variables but could respond to the shock in the other variables with a lagged effect. To analyze the results of the VAR model, Impulse Response Function (IRF) are utilized to observe how shocks or changes in one variable affect the others over time. Given that the research question of the paper focuses on growth and inflation, the impulse response graphs will present the effect of a climate disaster shock on inflation and growth over time. Shocks are defined as one standard deviation innovations.

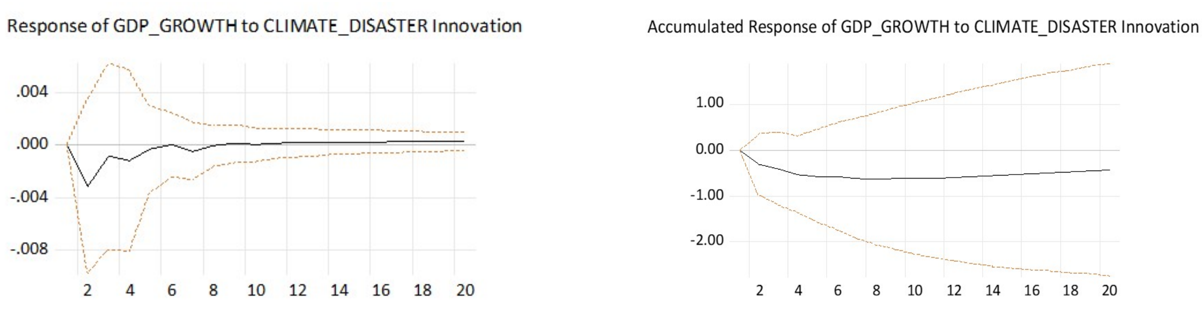
As shown in Figure 3, a climate disaster shock has an effect on inflation in the MENA region but the effect starts to be significant (where the two confidence bands lie in the same positive territory) after 3 years of the shock. Inflation reaches the peak in year 4 of the shock recording a change of 0.6% before the effect starts to decrease over time. The accumulated response figure indicates that after 20 years, inflation could increase by 6% on the back of climate disaster shock.

Figure 3: IRF of Inflation to Climate Disaster



Unlike the significant effect of climate disaster shock on inflation, the impulse response function indicates that a one standard deviation climate shock yields negative effect on growth however this effect is insignificant and fades completely over time as shown in Figure 4. This is confirmed by the accumulated response which shows that after 20 years, the effect of the shock on growth is very close to zero.

Figure 4: IRF of Growth to Climate Disaster



The study used the variance decomposition analysis to quantify the degree to which the volatility of one variable can be explained by a shock in another variable. This analysis is used to assess the relative importance of different variables in explaining the variability of the system. In this study, the variance decomposition helps in gaining insights on the relative contribution of the climate shock in explaining volatilities in inflation and growth. The results shown in Annex 5 indicate that inflation volatility is mainly driven by its own shocks. However, climate shocks appear to be the second contributor to inflation volatility and their effect becomes more explicit in longer horizon, contributing by 6% to inflation volatility after 20 years. Despite the modest contribution of climate shock, these results confirm that over the long run climate disaster will have a clear impact on inflation. In line with the results of the impulse response function, the variance decomposition of growth shows that climate shock almost has no effect on the GDP growth volatility.

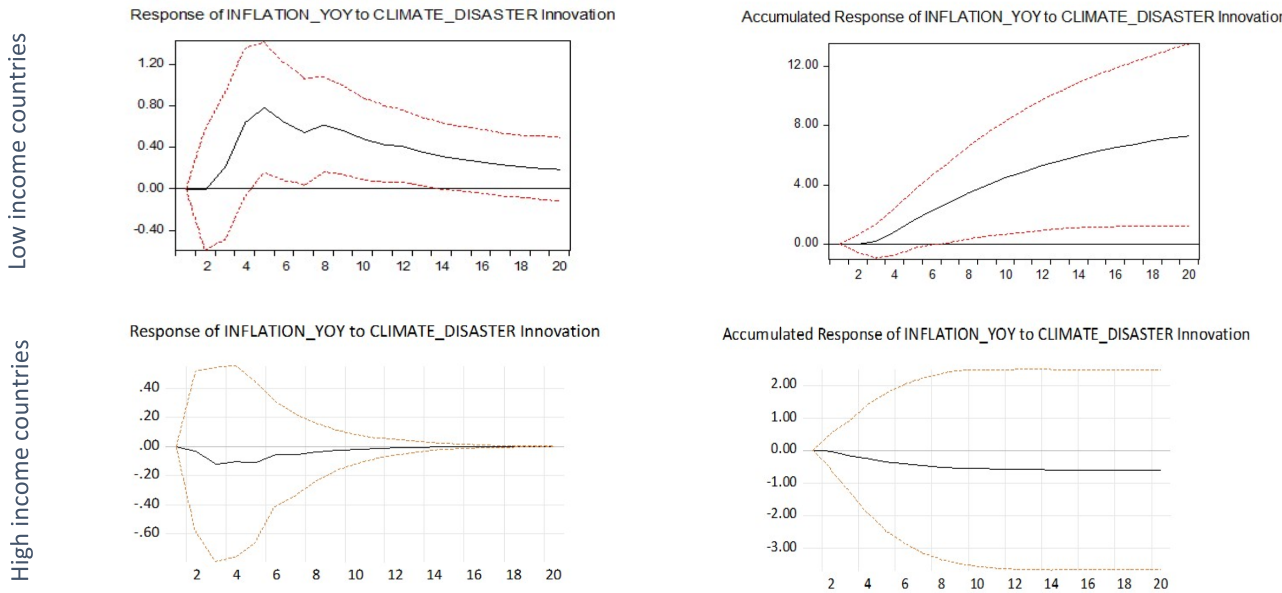
As a robustness check, the same model exercise was estimated using another climate variable, which is the average mean air temperature instead of the climate disaster variable (Annex 6). The findings in Annex 6 indicate the same trend as in Figure 3 but with different magnitude. It appears that a shock in the average mean air temperature has smaller effect on inflation compared to a climate disaster shock. It can thus be concluded that changing the definition of climate conditions does not change the results confirming the robustness of the model.

5.3 Results of the Estimation with a Split Sample (Low Vs High Income Countries)

Despite their geographical proximity, MENA countries are heterogenous in terms of economic development and income level. To gauge the impact of climate shock on inflation and growth taking into account this heterogeneity, this study focused on a more granular level by splitting the sample into 2 groups according to their income level as per the World Bank classification. The two groups are high income group encompassing high and higher middle-income countries and low-income group including low and lower middle-income countries. The same analysis was conducted on both groups where the results show a contrast in the impact of climate shock on inflation. Low-income countries are more vulnerable to climate disaster shocks.

The effect becomes significant at year 4 and until year 14 and the accumulated response indicates that inflation increases by 7% in year 20 as shown in Figure 5. This is higher than the accumulated response estimated on the whole sample analysis. This could be explained by the high reliance of these economies on climate-sensitive sectors such as agriculture and tourism and the high share of food in household consumption baskets. Consequently, extreme weather events disrupt agricultural production and supply chains which translate directly into a sharp rise in food prices and higher inflation in those economies. This is amplified by the limited fiscal space which hinders the capacity of governments to stabilize prices through subsidies or buffer stocks. Moreover, exchange rate pressures and import dependence exacerbate the pass-through effects of climate shocks into domestic prices. In contrast, results for high income countries show that climate disaster has insignificant effect as shown in Figure 5. However, splitting the sample didn't change the results as they remain insignificant for both income groups with regard to the effect of the climate change shock on growth, (Annex 7).

Figure 5: IRF of Inflation to Climate Disaster Segregated by Income Level



The heterogeneity in the effect of climate shock on inflation is consistent with many previous studies such as Mukherjee et.al (2021) and Cevik & Jalles (2024), where the results show a striking contrast in the impact of climate shocks on inflation according to income level, state of the economy, and fiscal space. They also indicated that shocks in developing countries have more prolonged effect on inflation. This conclusion reflects the high vulnerability of low-income countries in terms of structure of the economy, fiscal and institutional capacity that limit the ability to adapt and mitigate the consequences of climate shocks compared to high income countries.

VI. Conclusion and Policy Recommendations

Climate change risk is global in its nature but the effects may be heterogenous on the different countries according to their geographical location, income, development level and capacity to adopt mitigation and adaptation policies. This study assessed the impact of climate change using different climate indicators on the main macroeconomic variables of the MENA countries. The study estimated the effect of climate disasters on growth and inflation over the period 1990 to 2022.

Using a VAR model, the findings show that a climate disaster has a significant and prolonged effect on inflation in the MENA region countries while the effect on growth is insignificant. The findings also show that low-income countries are more vulnerable to inflationary pressure caused by climate risk than high income countries.

The significant and prolonged effect of climate change on inflation is a signal for Central banks to be vigilant and to consider this effect when setting their monetary policy. This is even more critical for central banks with inflation targeting regime as climate shocks could delay the progress to accomplish this mandate requiring an increase in interest rates to manage inflation. The problem is further amplified by the fact that climate shocks are classified as supply shocks presenting a dilemma for central banks between stimulating economic output and controlling inflation. Central banks are thus forced to increase interest rates to curb inflation while impeding economic growth.

Accordingly, central banks must prioritize proactive measures to address climate change risks by integrating climate shocks into their monetary policy frameworks to ensure more accurate inflation and output forecasting. This requires the development of new analytical tools and models to assess climate impacts and project their long-run effects on the economy. In addition, central banks should implement green policies such as promoting green lending and greening their own portfolios, while actively communicating with the public and financial community about climate risks through disclosure of their own carbon footprint, speeches, research, and conferences that raise awareness.

Policy-specific instruments also provide an effective way to address climate challenges. On the monetary policy side, this could include adopting dual interest rate systems that offer lower borrowing costs for environmentally friendly projects, adjusting reserve requirements in favor of green portfolios, incorporating climate risks into collateral frameworks and pursuing green quantitative easing through the purchase of sustainable assets. Macroprudential tools can further strengthen resilience by embedding climate stress tests into supervisory frameworks, adjusting capital requirements in line with climate exposures, monitoring sectoral leverage ratios and imposing large exposure restrictions in sectors highly vulnerable to climate risks. At the micro-prudential level, regulators should require banks to incorporate climate risks into their risk management systems, disclose their exposures to climate-related risks, and maintain a minimum share of green assets in their portfolios. Beyond their direct role, central banks can also act as advocates for broader government policies that incentivize sustainable investment and carbon reduction. Taken together, these measures are crucial to preserving economic and financial stability in the face of climate change and to mitigating the threat of climate-related disasters.

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Annexes

Annex 1: List of countries Included in the Sample Classified According to their Income Level as per the World Bank Classification.

- **Low and Lower Middle-Income Countries**

Algeria	Lower middle income
Egypt	Lower middle income
Djibouti	Lower middle income
Iran	Lower middle income
Jordan	Lower middle income
Lebanon	Lower middle income
Morocco	Lower middle income
Yemen	Low income
Tunisia	Lower middle income

Israel	High income
Libya	upper middle income
Oman	High income
Qatar	High income
Saudi Arabia	High income
United Arab Emirates	High income

- **High and Upper Middle -Income Countries**

Annex 2: Correlation Matrix

Correlation matrix	Climate disaster	GDP growth	Inflation YoY
Climate disaster	1	-0.07	0.14
GDP growth	-0.07	1	-0.02
Inflation YoY	0.14	-0.02	1

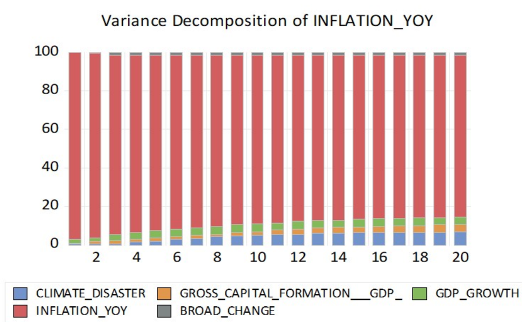
Annex 3: Panel Unit Root Test Results

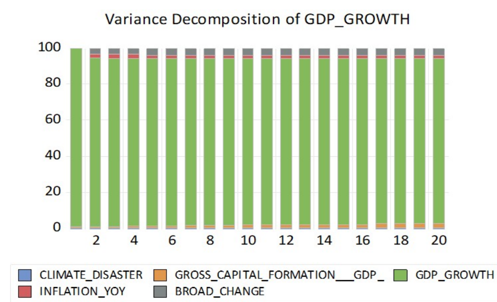
Panel Unit root tests	**LLC**	**ADF- Fisher Chi-square**	**IPS**
Average Mean air temperature change	0.000***	0.0313**	0.0039***
Broad Money (%GDP)	0.6774	0.9311	0.9622
Climate disaster	0.000***	0.000***	0.000***
GDP Growth	0.000***	0.000***	0.000***
Gross capital formation (%GDP)	0.3399	0.0443**	0.0665*
Inflation YoY	0.0001***	0.000***	0.000***
Note: *, ** and * denote 10%, 5% and 1% significant level respectively.**			

Annex 4: Lag Length Criteria

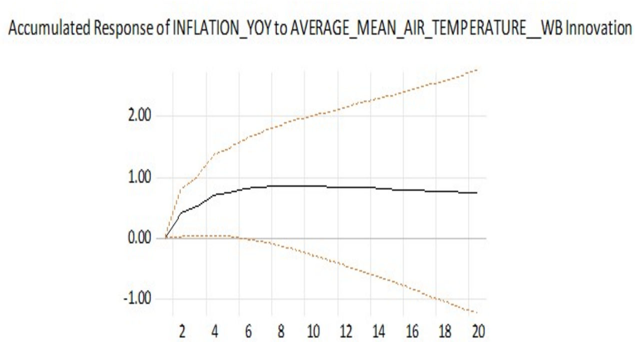
Lag	AIC	SC
0	-5.424575	-5.367013
1	-7.644851	-7.299479*
2	-7.738133	-7.104951
3	**-7.841790***	-6.920798
4	-7.826957	-6.618155
5	-7.829996	-6.333383
6	-7.784543	-6.000121
7	-7.767741	-5.695509
8	-7.817824	-5.457781

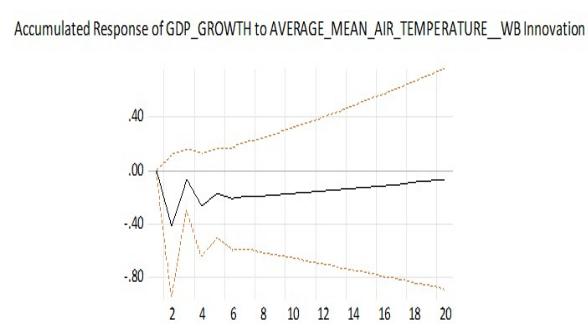
Annex 5: Variance Decomposition Analysis of Climate Disaster Shock on Inflation and Growth on the Whole Sample of Countries.





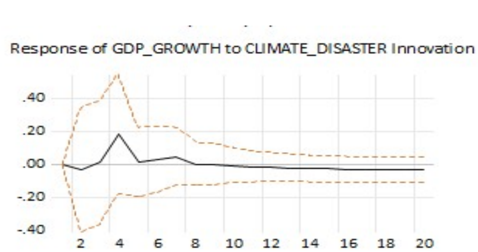
Annex 6: Impulse Response Function Results of Average Mean Air Temperature Shock on Inflation and Growth Over the Full Sample of Countries





Annex 7: Impulse Response Function Results of the Climate Disaster Shock on Growth with a Split Sample into Low and High-Income Countries.

IRF for low-income countries



IRF for high income countries