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DOES COUNTRY'S RESILIENCE TO CLIMATE CHANGE MATTER IN MATERNAL DEATH RISK IN EMERGING ECONOMIES?

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Abstract
One of the greatest global health threats in the 21st century is climate change, with short- and long-term consequences for the most vulnerable people, particularly in the poorest countries with the least ability to adapt. This study investigates the impact of a country's resilience to climate change on maternal health in E7 economies using data from 2000-2020. The FGLS, PCSE, and DKSE results demonstrate that as a country's resilience to climate change increases, the risk of maternal deaths reduces. Our results remain robust even after controlling for economic growth, foreign direct investment, and financial development. These control variables also reduce maternal deaths. The governments of the E7 economies must adopt policies that favour the country's resilience to climate change, as it helps in achieving Sustainable Development Goal 3 of good health.

1. Introduction
The literature has not only identified the direct negative impact of climate change and air pollution on reproductive, perinatal and mental health outcomes, but there is also a possibility that it adversely affects future generations (Roos et al. 2021). There is an urgent need to address maternal health in developing countries as it has become a serious matter (Gani and Ahmad 2024). Around `year globally in general and for poor countries in particular (WHO 2019). Furthermore, there is an approximation of 25 million incidents of pregnancy-related complications from five direct obstetric causes of maternal deaths, including obstructed labour, sepsis, abortion, haemorrhage, and hypertensive disorders (Graham et al. 2016); pregnancy-associated illness cases far exceed those of maternal deaths. Therefore, policymakers are

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giving attention to women's health in the developing economies (Gulumbe et al. 2018). Therefore, there is an essential need to critically explore the determinants of maternal health.

Climate change has both direct and indirect influence on maternal health as it modifies people's exposure levels and interrupts their social support structure and health systems (Kuehn and McCormick 2017). Extreme weather events, poor quality of water and air, and exposure to pollutants also affect maternal health. Climate change has already led to consequences including terrifying events like floods and storms, droughts, and heat waves, and the harshness and regularity of such events are increasing (Costello et al. 2009). Lower middle-income economies are mainly vulnerable to climate change due to poverty, high prevalence of malnutrition, poor quality housing, non-communicable diseases, poor sanitation and feeble and non-robust healthcare systems (Roos et al. 2021).

The existing research contributes to the knowledge on climate resilience health outcomes in several ways; initially, using the data of E7 economies for the period covering 2000-2020 for countries' resilience to climate change and its impact on maternal health. Subsequently, the study has employed the ND-GAIN index to quantify the country's resilience to climate change, which is considered a more comprehensive measure compared to the outcome-based measure including CO_2, SO_2, CH_4 and $PM_{2.5}$ (Ul-Haq et al. 2024). This index measures a country's global risk of exposure to climate change and other concerns, as well as its preparedness to enhance resilience. Lastly, lifetime risk of maternal Death (LRMD), which is more appropriate and considered a better measure for maternal health, is used.

The rest of the study is structured as: section ii about literature and theoretical framework. Section III discusses data & methodology, Section IV shows results, and Section V concludes the study.

2. Literature and Theoretical Framework

Mental health is considered to have a decisive role in empowering women and encouraging social and economic outcomes. Access to adequate and identical quality of mental health including antenatal care, postnatal care and skilled birth attendance are key prerequisite for the betterment of mental health. Access to the indispensable facilities rises the probability of harmless pregnancies and childbirth, decreases mental health hazards, recovers overall maternal health effects. The World Health Organisation (WHO) emphasises that, for reducing maternal mortality, comprehensive maternal healthcare facilities and skilled birth attendance are significantly important. Countries that have adequate access to these facilities usually experience lower maternal mortality rates.

Investment in maternal health encourages women's empowerment by improving their health, well-being, and personal development opportunities. Precisely, improved maternal health can assist education attainment of women by declining the health-related hurdles that may create barriers to continue the female education. Moreover, the intergenerational poverty cycle and inequality can be discontinued by prioritising maternal health in public policies. Women have an increased chance for better state of health and social conditions if they have access to quality maternal healthcare, which ultimately beneficial for their children and future generations. This adds to constructing a further inclusive and equitable society. Along with social benefits, both the household and national economies have substantial economic consequences of maternal health. Healthy mothers can contribute more to education, employment and other productive activities, which not only improve household welfare but also contribute to overall economic development. Thus, better maternal health should be considered an imperative investment in human capital and sustainable development. The existing evidence signifies the need for policymakers to safeguard the equitable and affordable availability

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of essential maternal healthcare facilities, women's reproductive health rights, and to address the social and economic determinants that affect maternal health. Countries can reduce poverty and inequality, promote sustainable growth, improve the overall well-being of society, and empower women by prioritising these aspects.

2.1 Country's Resilience to Climate Change and Maternal Health

Global health is most affected by climate change, particularly for the most vulnerable individuals like pregnant females and newborns. Females are affected by climate change considerably because their gender is tied to social norms. The Lancet Commission has indicated the numerous ways that human health is affected by climate change: population migration, non-availability of safe drinking water and less food, morbidity and varying disease patterns, poor sanitation, lack of shelter, and extreme weather events (Costello et al. 2009). Younger children, developing fetuses, and pregnant women are anticipated to be the more sensitive members of our species. In addition, they are already marginalised in several economies. Therefore, climate change affects them at the very basics. Moreover, taking dirct and indirect, health if affected by the climate change as shown in Figure 1. Existing literature has addressed health issues linked to climate change. However, there have been fewer studies related to maternal health. Exposure to climate change at the initial stage causes much damage at the later stages of life, which has lasting impacts over generations (Berkman et al. 2002). Studies on the link between emissions from transport and maternal health have been explored by Gani and Ahmad (2024), using the health production model for 38 developing economies from 2002 to 2016. The empirical results demonstrate a positive association, showing that the risk of maternal deaths increases with increased transport emissions. Dumbuya et al. (2024) investigated African women's pregnancy as well as maternal health issues, and found that the most alarming thing is the maternal death rates; this is not free from various risks such as maternal hypertension and preterm birth, mainly the result of the deteriorating state of climate change.

On the account of female mortality between 15-49 years, Gazeley et al. (2024) suggested a unique measurement of lifetime risk of maternal near miss (MNM); that found a cumulative risk which refers to a 15-year-old female have experienced in her reproductive lifetime. The study concludes that the lifetime risk of the MNM requires maternal morbidity indicator for the reason that the usual analysis can not find the required dangers of the reproductive life. Conway et al. (2024) provided empirical evidence on the link between air pollution and newborn and maternal health from 2010-2023. The review uncovers consistent results regarding a positive relationship between heat exposure and air pollution along with adverse birth outcomes, especially preterm birth. Upon examining the female lifetime risk, deterioration in maternal mortality is evident from using the Demographic and Health Survey of Ethiopia; for the period 2000-2016, Borde (2023) found that out of the 61,610 respondents, approximately 795 deaths were reported. The female lifetime risk of dying decreased to approximately 1.9% in 2016. In rural females, the lifetime risk was the highest during the year 2016. Khachfe et al. (2019) evaluated the mortality ratio of maternal health in the Arab world through lifetime risk, utilising analysis of variance; the study indicated that maternal mortality rates and lifetime risk of maternal death significantly decreased in Arab economies. It was also found that the highest burden of maternal mortality rates was witnessed in Somalia. The risk of infant mortality increases due to emergence of the Climate change, poorer reproductive health, and birth complications, particularly in the tropical poor economies. Therefore, the survival of the imminent population and their health is seriously compromised by this climate change (Rylander, Øyvind Odland, and Manning Sandanger 2013).

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This discussion has raised the following hypothesis:

2.2 Economic Growth and Maternal Health

In existing literature, there is a debate about the relationship between country economic performance and health outcomes. The popular idea of 'happy wealthy' was coined by the work of Pritchett and Summers (1993). They recommended that economic prosperity is an essential component of health, with the resultant economic growth improving people's living conditions and, in turn, promoting the overall health system. The literature of economic growth and maternal mortality showed the surge of economic growth declines maternal mortality efficiently (Oyedepo 2023). Moreover, the study by Borde (2023) that examined the female lifetime risk disparities for Ethiopia revealed that from 2000 to 2016, the female risk of dying was up to 1.9 per cent. Wang et al. (2013) examined the economic impact of maternal death for households in China. The research indicated that the household budget is affected by maternal death. Kirigia et al. (2006), using a cross-sectional dataset of 45 member states in the African region, found that mortality affects GDP considerably. The result confirms a negative relationship between GDP and mortality. Based on the above empirical literature, the following hypothesis is given below:

2.3 Financial Development and Maternal Health

Regarding FD, existing studies have demonstrated that FD causes several societal improvements such as EG (King and Levine 1993), increased income inequality (Demirgüç-Kunt and Levine 2009, Clarke, Xu, and Zou 2006), and a decrease in poverty (Donou-Adonsou and Sylwester 2016, Boukhatem 2016). Our research contributes to showing that FD also causes a decrease in maternal deaths. Blau, Griffith, and Whitby (2024) explored the liaison between FD and mortality rates and supported the idea that strong financial markets facilitate innovation through efficient channelling of crucial capital to the individuals accountable for health-related improvement activities, consequently improving the whole health-related outcomes. De Costa et al. (2009) showed that financial incentive matters in influencing maternal mortality and suggested that maternal deaths in the Amarpatan reduced during a project period comparative to past year. Moreover, existing literature indicates the major factors that influence the mortality rates, such as access to the credit market (Schnittker and Karandinos 2010, Baird, Friedman, and Schady 2011). Based on this literature, the third hypothesis of this paper is as follows:

2.4 Foreign Direct Investment and Maternal Health

FDI is also considered an important determinant of health outcomes. FDI may have a negative or positive influence on health. It is commonly believed to promote EG via the generation of local employment, technology spill-overs, skill transfer, and knowledge externalities, through various aspects. In addition, FDI may also have the potential to enhance wages as well as improve working conditions in poor economies (Blouin, Chopra, and Van der Hoeven 2009; Burns et al. 2017). In the literature, there is evidence that FDI is negatively associated with health (Jorgenson 2009). FDI is accountable for the harmful effects like enhances pollution, more tobacco consumption, as well as more use of unhealthy foods. FDI increase pollution and resultant health hazards leading toward more mortality (Burns et al. 2017). Further, Salahuddin et al. (2020) examine the influence of FDI and EG on children's health outcomes using the under-five child mortality rate for the period 1986-2016. The ARDL results revealed that FDI and EG are inversely related to child health outcomes. FDI produces income through employment opportunities in the host economy; the probable enhances the demand for improved health services which would ultimately promote greater public and private expenditures on better health quality

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services. Additionally, via technology and skill transfer and knowledge spillover, the country's health sector is likely to upgrade significantly. By lessening income inequality, FDI may also have an inverse influence on individuals' health. However, FDI is responsible for the rising inequality of income between developed and developing countries for skilled and unskilled workers (Feenstra and Hanson 1995). Also, studies have found that FDI have no impact on child and infant mortality (Burns et al. 2017). Multinational organisations are generally competitive enough; the skill-intensive, more productive, and get the market power, as compared to home counterparts. Moreover, these firms cause the demand for skilled labour to increase, consequently putting upward pressure on host country wages. So, FDI may also enhance wage inequality in host economies (Taylor and Driffield 2005). The study by Herzer and Nunnenkamp (2012) proposed the interaction of health and FDI, foud out life expenteancy and FDI have positive association, while Herzer, Hühne, and Nunnenkamp (2014) used infant mortality rate and found a non-linear effect of FDI on health.

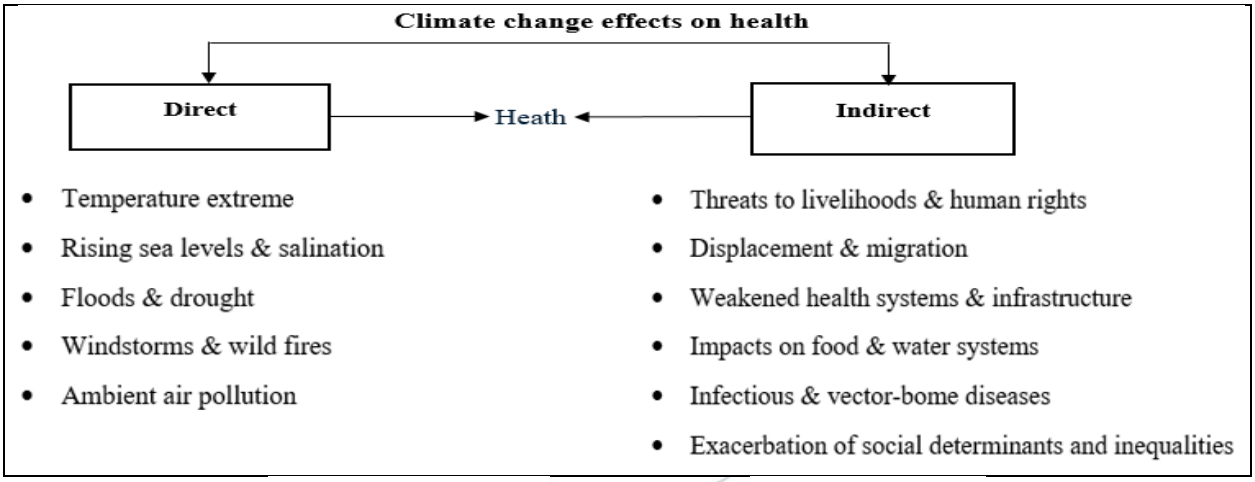


Figure 1: The effects of Climate Change on Maternal Health

2 Data and Methods

2.1 Data

The detailed explanation of the variables is given in Table 1. Following Gani and Ahmad (2024), the proxy for maternal health is used as the lifetime risk of maternal death (LRMD) as the dependent variable. Following Ul-Haq et al. (2024), ND-GAIN is used as a proxy for a country's resilience to climate change (core independent variable). According to ND-GAIN (2022), this index summarises the country's susceptibility to climate change; the other challenges, as described, are its readiness to advance resilience. The index shows higher values of this index which indicates better adaptability. Hence, the control variables are EG, FD, and FDI. The description of the variables is given in Table 2.

Table 1: Variable descriptions

Variables	Code	Definition	Sources
Dependent			
Maternal health	LRMD	Lifetime risk of maternal death	WB (2024)

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Independent			
Country's resilience to climate change	ND-GAIN	Notre Dame Global Adaptation Initiative (ND-GAIN) index.	ND-GAIN (2022)
Controls			
Economic growth	EG	Log of gross domestic product per capita	WB (2024)
Foreign direct investment	FDI	FDI, net inflows (% of GDP)	WB (2024)
Financial development	FD	FD index	IMF (2022)

Table 2: Study's descriptive statistics

	Observation	Average	S.D	Minimum	Maximum
LRMD	147	0.235	0.288	0.010	1.415
ND-GAIN	147	51.583	5.535	40.246	64.172
EG	147	8.549	0.769	6.627	9.407
FD	147	0.455	0.099	0.270	0.674
FDI	147	2.227	1.212	-2.757	5.034

2.2 Empirical Model

Following Gani and Ahmad (2024), this study explores the relationship between a country's resilience to maternal health and climate change, using the following empirical model:

$$LRMD_{it} = \beta_0 + \beta_1 ND\text{-}GAIN_{it} + \beta_2 EG_{it} + \beta_3 FD_{it} + \beta_1 FDI_{it} + e_{it} \quad (1)$$

In equation 1, the subscripts i and t indicate country (E7) and time (2000-2020), respectively. Maternal health refers to the lifetime risk of maternal death; ND-GAIN (vulnerability of the country to climate change) is a proxy for the country's resilience to climate change, EG is economic growth, FD represents financial development, and FDI denotes foreign direct investment. The coefficient β_0 indicates the average maternal health when ND-GAIN and the other regressors of the model have no impact, and the random error term is e_{it}. Maternal health is the outcome variable, while the core explanatory variable is the ND-GAIN. Our research anticipates β_1 to be negative, suggesting the inverse link between ND-GAIN and maternal death. β_2, β_3 and β_4 are also expected to be negative, indicating the negative link between these variables and maternal death.

As we have N=7 and T=21, our study employed FGLS as the main methodology technique for coefficient estimation. In comparison to fixed effects and random effects models where CSD is only defined by constant changes, FGLS performs better in handling heteroscedasticity. Furthermore, by varying cross sections, FGLS is robust to serial correlation, CSD, and heteroscedasticity.

3. Results and Discussion

The diagnostic results are presented in Table 3 below. The Wooldridge and Modified Wald test results show the existence of autocorrelation and heteroscedasticity issues. The Breusch-Pagan LM test is used for cross-sectional dependence. CD test suggests the presence of CD in the data at the 1% significance level. Particularly, the results do not recommend strong CD variables. Pesaran (2004) CD test also points to the same conclusion, suggesting the presence of CD at the 1% level of significance.

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Table 3: Diagnostic tests

Test	Stats
Wooldridge	5.696
	(0.0543)
Modified Wald	287.93
	(0.0000)
Breusch-Pagan LM	156.420
	(0.0000)
Pesaran (2004) test	
LRMD	18.68***
ND-GAIN	15.30***
EG	17.50***
FD	11.75**
FDI	1.35

Note: *** represents the 1% significance level. P-values are shown in brackets.

Further, to check the presence of multicollinearity, the VIF (variance inflation factor) test is used. Table 4 shows the VIF values for the model. As the VIF estimates fall far below the cutoff value of 10, there is no issue of multicollinearity in our study.

Table 4: VIF

Variable	VIF	1/VIF
ND-GAIN	2.02	0.4943
EG	1.84	0.5443
FD	1.29	0.7743
FDI	1.15	0.8716
Mean	1.57	

Table 5 presents the estimates of the impact of a country's resilience to climate change on maternal health. Columns (1), (2) and (3) show the results of the FGLS, PCSE, and the DKSE methods, respectively. The empirical findings in column (1) demonstrate a statistically significant negative association between country's resilience to climate change and maternal death, suggesting that as ND-GAIN increases, the risk of maternal death reduces. Further, the Wald statistics are statistically significant in the overall models. The PCSE and DKSE also reveal a negative relationship between a country's resilience to climate change and maternal death, meaning that it decreases the risk of maternal death. The study finding is consistent with Gani and Ahmad (2024), which revealed that less environmental pollution reduces the risk of maternal death. This finding highlights the significant role of investing in maternal health for sustainable development. Therefore, our study findings are helpful for policymakers to achieve the goal of SDG-3. The improvement in maternal health is crucial for nation-building. Maternal health is necessary for caring for children and is responsible for imparting ethics, morals, and values in them, and children are the future of a country. Education and nurturing provided by mothers improve children's potential to contribute more to advancing the country's development. Thus, it is important to adopt measures to improve maternal health. According to WHO, every dollar invested

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in maternal health can generate a $7 return in economic benefits, lower healthcare costs, enhance productivity and a healthier future labour force (Dowou et al. 2023).

Table 5: Impact of Country's Resilience to Climate Change on Maternal Health

	FGLS	PCSE	DKSE
ND-GAIN	-0.0335***	-0.0349***	-0.0349***
	(0.000708)	(0.00360)	(0.00677)
Constant	1.959***	2.034***	2.034***
	(0.0377)	(0.196)	(0.357)

Note: maternal health is a dependent variable in all models. '***' & '**' represent the 1% and 5% significance levels. In parentheses, standard errors are specified. N is 147 in all models.

The results in Table 6 check the robustness of our core model. The coefficient of the country's resilience to climate change demonstrates that a 1% rise in ND-GAIN decreases the risk of maternal death by 0.0104%. We employ the PCSE and DKSE methods and find the same results. After including the major control variables in all models, the sign and statistical significance of ND-GAIN are not affected, suggesting that our core findings are robust. The analysis also finds that EG is negatively related to maternal death. As EG goes up by 1% increase in EG, the risk of maternal death drops by 0.255%. As the economy grows, health packages improve, contributing to improved maternal health. The finding is in line with Kammerlander and Schulze (2023), who showed that EG reduces the risk of maternal death. GDP can influence maternal health directly or indirectly (Hojman 1996).

The analysis also finds a negative and statistically significant relationship between FD and maternal health. A 1% increase in FD leads to a 0.312% decrease in maternal death. The negative link between maternal health and credit markets suggests a broader discussion. More access to capital could ease various hurdles to accessing funds by organisations that advance health-related outcomes. So, individuals with more access to capital could get health benefits that could lead to better health-related outcomes and consequently reduce maternal death. This finding is consistent with Blau, Griffith, and Whitby (2024).

Table 6: I Impact of Country's Resilience to Climate Change on Maternal Health (robustness checks)

	FGLS			PCSE			DKSE
ND-GAIN	-0.0104***	-	-	-	-	-	-
	(0.000390)	0.00829***	0.00846***	0.0107***	0.00833***	0.00752***	0.00752***
		(0.000579)	(0.00104)	(0.00286)	(0.00289)	(0.00279)	(0.00203)
LGDPPC	-0.255***	-0.253***	-0.236***	-0.260***	-0.258***	-0.250***	-0.250***
	(0.00484)	(0.00608)	(0.00794)	(0.0286)	(0.0286)	(0.0280)	(0.0302)
FD		-0.312***	-0.253***		-0.325***	-0.237*	-0.237
		(0.0154)	(0.0313)		(0.121)	(0.121)	(0.158)
FDI			-0.0173***			-0.0350***	-0.0350***
			(0.00312)			(0.00946)	(0.0104)
Constant	2.948***	2.963***	2.835***	3.011***	3.018***	2.949***	2.949***
	(0.0433)	(0.0418)	(0.0543)	(0.215)	(0.210)	(0.203)	(0.300)

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Note: maternal health is a dependent variable in all models. '***' & '**' represent the 1% and 5% significance levels. In parentheses, standard errors are specified. N is 147 in all models.

The relationship between FDI and maternal health is negative and statistically significant. As FDI goes up by 1%, maternal death decreases by 0.0173%. Thus, there is evidence that an increase in FDI reduces the maternal death risk. This finding is in line with Dinga, Mah, and Mosikari (2024). Thus, FDI in the right sectors can upgrade infrastructure, provide essential health services, enhance amenities and promote overall human development. These investments positively influence health (Ouedraogo and Marlet, 2018).

4. Conclusion and Policy Implications

Maternal health is a central pillar of societal well-being with profound implications for economic development. Our study investigated the impact of a country's resilience to climate change on maternal health for E7 countries using data from 2000-2020. The FGLS, PCSE, and DKSE results showed a negative relationship between country's resilience to climate change and maternal death, suggesting improving the resilience to climate change of a country helps it to achieve the objective of reducing maternal death. For robustness checks, our study added EG, FDI, and FD. The robustness checks reveal that our core findings are robust. The paper also found that EG, FDI, and FD reduce maternal death.

Our findings have important policy implications that help in achieving the third goal of SDG regarding improving maternal health. These countries should take a step further towards transitioning to a cleaner environment, as it is essential for maternal health. Our study results recommend that there is a need to adopt policies for a cleaner environment. Thus, in order to reduce the risk of maternal death, policymakers should advance the country's resilience to climate change.

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