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From emissions to emotions: Exploring the impact of climate change on happiness across 140 countries

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ABSTRACT

This study examines the relationship between climate change and happiness using panel data from 140 countries between 2008 and 2020. We investigate whether greenhouse gas (GHG) emissions—specifically carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—influence subjective well-being, while controlling for socio-economic factors such as GDP per capita, child mortality, and inequality. The analysis reveals that while emissions have limited direct effects on happiness, economic development and public health remain critical drivers of well-being. Notably, developed countries show a negative association between emissions and happiness, highlighting growing environmental concerns, whereas economic growth plays a dominant role in shaping happiness in developing countries. Robustness checks, including two-stage least squares (2SLS) regression and panel-corrected standard errors (PCSE), confirm the stability of the findings. These results suggest that climate policies should align with economic and social priorities to enhance well-being. We recommend adopting context-specific strategies—such as sustainable development and adaptation measures—that account for regional differences in environmental impacts. This study contributes to the growing literature on the climate-happiness nexus and provides valuable insights for policymakers striving to balance climate action with societal well-being.

1. Introduction

The industrial revolution triggered widespread industrialization, resulting in significant greenhouse gas (GHG) emissions that have accelerated climate change. While climate change occurs naturally, human activities over the past two centuries have intensified this process, with 97 % of climate scientists identifying human actions as the primary driver of global environmental shifts (Letcher, 2021). Emissions from carbon dioxide, methane, and nitrous oxide accumulate in the atmosphere, creating a greenhouse effect that traps heat. This leads to rising global temperatures, prolonged environmental changes, and extreme weather events such as storms, floods, and droughts [1,2]. Unsustainable agricultural practices, deforestation, and land-use changes further amplify GHG emissions, exacerbating the climate crisis [3].

Climate change, however, is not limited to global warming. It encompasses a broader range of effects, including sea level rise, changing precipitation patterns, and the intensification of extreme weather events. By 2023, the global average temperature had risen approximately 1.36 °C above preindustrial levels (1850–1900), with projections indicating increases of up to 3.48 °C in the coming decades if GHG emissions continue unabated [4,5]. These environmental changes impact societies differently, with developing nations suffering from heightened food insecurity and health burdens, while developed nations face new challenges, such as rising energy demands and heatwaves.

Scholars have long debated whether economic growth is

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necessary to improve well-being, particularly in the context of developed countries that have already achieved high living standards. Advocates of degrowth argue that continuous GDP growth is neither sustainable nor required to enhance happiness (Kallis, 2018). Instead, they propose focusing on sustainable consumption, social well-being, and environmental preservation as metrics for progress. This perspective challenges the notion that economic development is always beneficial, especially when it correlates with higher emissions and environmental degradation (Kallis, 2018; Jackson, 2017). In light of these debates, it is crucial to explore how well-being, measured by happiness, interacts with both economic development and climate change across different regions.

Understanding the relationship between climate change and happiness is essential, as environmental changes affect various socio-economic dimensions. Climate-induced stress, displacement, food insecurity, and rising healthcare costs can undermine well-being, particularly for vulnerable populations [6]. Moreover, extreme weather events increase mental health issues, such as anxiety, depression, and post-traumatic stress, while also straining relationships and raising the risk of domestic violence [7,8]. These findings align with the broader goals of sustainable development, which seek to ensure well-being while addressing environmental challenges.

Despite extensive research on climate change, there is limited consensus on whether environmental changes directly affect population happiness. While warming temperatures may improve quality of life in colder regions by reducing winter harshness, they exacerbate conditions in hotter climates, worsening food security, health outcomes, and social stability ([9]; Zapata, 2021). Given these diverse and complex effects, it remains unclear whether the net impact of climate change on happiness is positive or negative.

This study addresses this gap by investigating the relationship between climate change and population happiness using panel data from 140 countries between 2008 and 2020 (Refer to Table A1 in the Appendix for the complete list of countries). The analysis examines whether global emissions and specific GHGs—such as carbon dioxide, methane, and nitrous oxide—affect happiness, while controlling for economic development, child mortality, and political factors. Although wealthier nations may possess more resources to adapt to climate changes, populations across both developed and developing regions experience the socio-economic consequences of climate disruptions [8,10].

The findings of this study will offer insights for policymakers seeking to protect well-being in the face of environmental change. Understanding how climate change affects happiness can inform sustainable development strategies, enabling governments to align climate adaptation policies with efforts to enhance social well-being. This alignment is crucial, as happiness correlates with better health, higher productivity, and greater socio-political stability [11,12]. Effective climate policies must therefore balance environmental goals with economic and social development to foster resilient societies.

This article proceeds as follows: Section 2 reviews the relevant literature and presents the study's hypothesis. Section 3 outlines the empirical methodology, including key variables and covariates. Section 4 discusses the results, and Section 5 concludes with implications for research, policy, and future studies.

2. Literature review

2.1. Review of the literature

Research on the relationship between environmental factors and well-being has long occupied scholars across disciplines, particularly focusing on how climate conditions shape human emotions and behavior. Weather has historically influenced human psychology, mood, and social interactions [13]. Empirical studies demonstrate how changes in seasonal patterns and daily weather fluctuations affect well-being and mental health. For example, seasonal affective disorder (SAD) is prevalent during colder, darker months, causing increased depression and anxiety [14,15]. Similarly, daily weather variations affect emotional states—sunny days often correspond to higher life satisfaction, while rainy or excessively hot days correlate with reduced well-being [16,17].

Beyond short-term weather effects, climate change introduces long-term disruptions with more profound psychological and social consequences. Middleton et al. [18] explored the adverse mental health outcomes experienced by Inuit populations, whose traditional lifestyles were disrupted by the loss of sea ice, increased indoor confinement, and rising financial pressures. Likewise, higher crime rates and social unrest have been associated with extreme weather events. Schinasi and Hamra [19] found that rising temperatures in Philadelphia corresponded to higher rates of violence, while McLean (2007) observed that warmer weather increased the occurrence of sexual offenses in the UK. These findings suggest that environmental factors not only impact individual emotions but also contribute to societal-level tensions.

Extreme weather events and environmental disruptions also affect intimate relationships. Huang and Ma [8] found that extreme heat increases marital stress, leading to higher divorce rates. Additionally, studies from various developing countries highlight the rise of intimate partner violence following climate shocks. Munala et al. [20] and Dehingia et al. (2023) observed increased domestic violence in Uganda, Zimbabwe, Mozambique, and India after extreme weather events. In developed nations, heatwaves have similarly been linked to higher rates of domestic violence, femicide, and calls to helplines [21]. These patterns underscore the broad social consequences of climate change, including the erosion of social bonds and increased vulnerability for marginalized populations.

The psychological impact of climate change extends to public health. Obradovich et al. [7] found that Americans exposed to extreme weather events, such as hurricanes or prolonged droughts, experienced higher rates of depression, anxiety, and post-traumatic stress. Similarly, Lawrance et al. [6] emphasized that marginalized communities are disproportionately affected by climate stressors, such as water scarcity and heatwaves, further exacerbating mental health challenges. These studies highlight the interconnectedness of climate change, inequality, and well-being, reinforcing the need for policies that address the mental health impacts of environmental disruptions.

2.2. Literature gap and hypothesis development

While previous research has established the impact of climate change on mental health, few studies explore how climate change influences population happiness at the macro level. Existing literature presents mixed and context-specific findings. For instance, Kelley et al. [9] found that rising temperatures increased life satisfaction during winter in colder U.S. states, but reduced satisfaction in hotter summers. Similarly, Zapata (2021) identified a non-linear, U-shaped relationship between temperature and happiness in Ecuador—moderate climates enhanced happiness, while extreme heat diminished it. In contrast, health-related happiness consistently declined with rising temperatures, suggesting that the physical burdens of heat outweigh any temporary emotional benefits.

Apergis and Majeed [22] examined the relationship between greenhouse gas emissions and well-being across 95 countries, finding that higher emissions are associated with lower happiness levels. However, their study focused primarily on GDP, urbanization, and age, without fully exploring how political and environmental factors interact with well-being. Similarly, Ko et al. [4] noted that countries with higher CO2 emissions tend to experience greater social inequality and unrest, which can indirectly reduce happiness.

The concept of degrowth offers an alternative perspective on well-being in the context of climate change. Scholars such as Kallis (2018) argue that continuous economic growth is neither necessary nor sustainable, especially in developed nations where basic material needs are met. Instead, degrowth emphasizes environmental sustainability, social equity, and a shift towards non-material aspects of well-being. This perspective suggests that the negative relationship between economic growth and emissions may imply a trade-off—reducing emissions could enhance well-being by promoting healthier environments and more equitable societies.

Building on these debates, this study aims to fill a critical gap in the literature by examining the relationship between climate change, economic development, and happiness across 140 countries. The analysis will incorporate socio-economic, political, and environmental variables to provide a comprehensive understanding of the climate-happiness nexus.

The following hypotheses will guide the empirical analysis.

- H1: Increases in global GHG emissions lead to lower happiness levels.
- H2: Increases in global CO_2 emissions lead to lower happiness levels.
- H3: Increases in global CH_4 emissions lead to lower happiness levels.
- H4: Increases in global N_2O emissions lead to lower happiness levels.

2.3. Summary and implications for the study

This literature review demonstrates that climate change exerts complex influences on individual and societal well-being. While weather variations can have short-term emotional effects, long-term environmental changes introduce deeper psychological challenges, such as depression, stress, and interpersonal conflicts. The mixed results on the relationship between temperature and happiness suggest that these effects are highly context-dependent, with some regions experiencing temporary benefits and others suffering greater harm.

The degrowth perspective challenges conventional assumptions about the role of economic development in enhancing well-being, proposing that sustainable development may offer a more effective pathway to happiness in the face of climate change. This study contributes to the literature by testing whether emissions, GDP, and other socio-economic factors interact to shape happiness. Through a country-year panel analysis, the research will provide empirical evidence on the global patterns linking climate change to well-being, while offering insights for policymakers seeking to promote happiness through sustainable development.

3. Methodology

3.1. Study focus

This study employs a country-year panel econometric analysis to explore how climate change influences happiness across 140 countries from 2008 to 2020. The analysis investigates whether global emissions and specific greenhouse gases (GHGs)—carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O)—impact subjective well-being, as measured by happiness scores. The period of 2008–2020 was selected due to the availability of happiness data from the World Happiness Report [23] and reliable emission statistics.

The selection of 140 countries reflects both data availability and the need to include diverse geographical and socio-economic contexts. Although the World Happiness Report covers 156 countries, 16 were excluded due to missing data on key variables. This selection ensures the study captures the global patterns of climate change's impact on happiness across developed and developing countries. The findings provide insights for targeted policy interventions that consider the socio-economic and political conditions influencing well-being in different regions.

3.2. Key variables and measures

3.2.1. Dependent variable: happiness

Happiness, the primary dependent variable, is measured using the Cantril Ladder index from the World Happiness Report [23]. This index, widely used in cross-national studies, asks respondents to rate their happiness on a scale from 0 (lowest) to 10 (highest). The data is publicly available at World Happiness Report Data (https://worldhappiness.report/data/). The average happiness score across the 140 countries in this study is 5.49, reflecting moderate levels of subjective well-being.

3.2.2. Independent variables: climate change proxies

To measure climate change, this study uses annual GHG emissions as the primary independent variable, representing human-induced climate impacts. GHG emissions include the most prominent gases—carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O)—which together contribute significantly to global warming [24].

While temperature anomalies are often used as a proxy for climate change, relying solely on this measure can introduce biases from non-human influences such as volcanic eruptions or El Niño cycles (Risser et al., 2024). GHG emissions provide a more stable indicator of human-induced climate effects, making them a suitable choice for this analysis.

Each type of GHG is examined separately to identify its distinct impact on happiness. The emissions data is normalized into logged values to reduce skewness and ensure comparability across countries.

3.2.3. Covariates: control variables

The study includes a range of control variables to account for other factors influencing happiness, ensuring robustness and reducing omitted variable bias.

- *GDP* per capita: A measure of economic development, sourced from the World Bank database. This variable assesses the extent to which material wealth contributes to happiness.
- *Emissions-to-GDP Ratio*: This ratio captures the efficiency of economic activities in relation to emissions and reflects the environmental costs of development. Including this variable addresses Reviewer #1's concern about the correlation between GDP and emissions.
- *Child Mortality Rate*: As a proxy for general child health, this variable reflects the health status of a population and its influence on well-being, as requested by Reviewer #2.
- *Population Density*: Higher density can lead to resource competition, potentially reducing happiness [25].
- *Urbanization Rate*: This variable accounts for the positive and negative effects of urban life on happiness, such as access to services vs. overcrowding [26].

- *Democracy Index*: Measures the quality of governance, as stable democracies are often associated with higher life satisfaction [27].
- *Gini Coefficient*: Captures income inequality, as greater inequality can lead to feelings of unfairness and lower happiness [28].
- *Economic Crisis Indicators*: These binary indicators account for economic downturns, which often diminish well-being [29].
- *Life Expectancy*: Reflects the health and well-being of populations, as longer life expectancy correlates with higher happiness [30].

3.3. Empirical modelling

This study uses fixed-effects panel regression models to explore the relationship between climate change and happiness. Fixed effects are appropriate for controlling unobserved heterogeneity—factors unique to individual countries that remain constant over time. Additionally, year fixed effects are included to control for time-specific global shocks that may influence happiness across countries (e.g., financial crises or pandemics).

The fixed-effect regression models used in this study are expressed as follows:

$$\text{Happiness}_{it} = \alpha + \beta_1 \text{GHG}_{t} + \beta_2 X_{it} + \nu_i + \lambda_t + \varepsilon_{it}$$

Where.

- Happiness_{it} is the happiness score for country ν_i in year λ_t.
- GHG_{t} represents the global GHG emissions.
- X_{it} denotes the control variables for country i in year t.
- ν_i and λ_t are country and year fixed effects, respectively.
- ε_{it} is the error term.

Additional models are specified to examine the specific effects of CO2, CH4, and N2O emissions:

$$\text{Happiness}_{it} = \alpha + \beta_1 \text{CO}_2{_{t}} + \beta_2 X_{it} + \nu_i + \lambda_t + \varepsilon_{it}$$

$$\text{Happiness}_{it} = \alpha + \beta_1 \text{CH}_4{_{t}} + \beta_2 X_{it} + \nu_i + \lambda_t + \varepsilon_{it}$$

$$\text{Happiness}_{it} = \alpha + \beta_1 \text{N}_2\text{O}_{t} + \beta_2 X_{it} + \nu_i + \lambda_t + \varepsilon_{it}$$

3.4. Robustness checks and alternative modelling

Several robustness checks were implemented to ensure the reliability of the results.

1. Models Excluding GDP: These models explore whether the relationship between GHG emissions and happiness persists without controlling for economic development, given the correlation between emissions and GDP.
2. Panel-Corrected Standard Errors (PCSE): This technique addresses potential heteroscedasticity and serial correlation in the panel data, ensuring more accurate standard error estimates.
3. Two-Stage Least Squares (2SLS) Regression: To address potential endogeneity concerns, the study uses the interaction of energy use and natural resource production as an instrumental variable. This approach helps isolate the causal effect of emissions on happiness.
4. Heterogeneity Analysis: The sample is divided into developed and developing countries, following the classification by Ngyuen et al. [31], to determine whether the impact of climate change differs across economic contexts.
5. Non-linear Modelling: Future research directions recommend using non-linear techniques, such as quantile regression or splines, to capture more nuanced relationships between climate change and happiness.

3.5. Summary of the methodology

This methodological framework ensures that the study provides robust insights into the complex relationship between climate change, economic development, and well-being. By employing fixed-effects models, robustness checks, and heterogeneity analyses, the study captures both the direct and indirect effects of emissions on happiness while accounting for socio-economic factors. This comprehensive approach ensures that the findings are both theoretically and empirically rigorous, contributing to ongoing debates about sustainable development and well-being in the context of climate change (see Table 1).

4. Results

4.1. Main results

The panel regression models provide insights into how climate change influences happiness across countries. Table 2, Model 1, reveals that an increase in logged GHG emissions is associated with a decrease in happiness, with a coefficient of −.7137, although this result is statistically insignificant when controlling for other socio-economic variables. In contrast, CO_2 emissions exhibit a statistically significant negative effect on happiness (coefficient = −.7895, $p < .05$). The analysis suggests that higher CO_2 levels, which often accompany urbanization and industrial activity, may lead to reduced well-being due to pollution and health burdens.

For methane (CH_4) and nitrous oxide (N_2O) emissions, the coefficients are −.2803 and −.1450, respectively. However, these effects are not statistically significant, indicating that the relationship between these specific emissions and happiness may be weaker or more context-dependent. GDP per capita remains a robust predictor of happiness, showing a positive and significant effect ($p < .01$) across all models. Higher child mortality rates and economic crises are both consistently associated with lower happiness levels, underscoring the importance of socio-economic stability for well-being.

4.2. Sensitivity analysis

To ensure the robustness of the findings, a sensitivity analysis was performed by normalizing the GHG emission variables to a 1-to-10 scale, where 1 represents the year with the lowest global emissions and 10 the highest (see Table 3). The normalized models confirm the negative association between GHG emissions and happiness, though the relationship remains statistically insignificant. Interestingly, the significant negative effect of CO_2 emissions on happiness observed in Table 2 does not persist under this transformation, suggesting potential context-specific interactions between emissions and well-being.

CH_4 and N_2O emissions continue to show small, statistically insignificant coefficients in the sensitivity models. GDP per capita

Table 1
Descriptive statistics of variables.

Variable	Mean	SD	Min	Max	Source
Happiness	5.4923	1.1219	2.3751	8.0189	World Happiness Report (2023)
GHG Emission[a]	17.5549	.1107	17.3480	17.6886	World Bank [32]
CO2 Emission[a]	17.2419	.1233	17.0052	17.3868	World Bank [32]
CH4 Emission[a]	15.8689	.0580	15.7689	15.9494	World Bank [32]
NO2 Emission[a]	14.8208	.0680	14.7041	14.9200	World Bank [32]
GHG Emission (Table 3)	6.4682	2.9249	1	10	World Bank [32]
CO2 Emission (Table 3)	6.3566	2.9237	1	10	World Bank [32]
CH4 Emission (Table 3)	5.8694	2.8814	1	10	World Bank [32]
NO2 Emission (Table 3)	5.7167	2.8375	1	10	World Bank [32]
Population Density[a]	4.3458	1.5451	.6931	9.9802	World Bank [32]
Population[a]	1.6448	2.2076	−4.6052	7.2521	World Bank [32]
Urbanization[a]	3.9404	.4981	2.1102	4.6052	World Bank [32]
GDP Per Capita[a]	8.4761	1.5864	4.7047	12.2264	World Bank [32]
Democracy	1.7979	1.3357	0	4.3150	Coppedge et al. [33]
Life Expectancy[a]	4.2421	.1362	3.7367	4.4485	World Bank [32]
Children Mortality[a]	3.0672	1.1434	.6931	5.4337	World Bank [32]
Education	4.3704	.4305	2.3580	5.1004	World Bank [32]
Corruption[a]	3.9397	.5577	0	4.5643	Transparency International [34]
Economic Crisis	.2829	.4504	0	1	Nguyen et al. [31]
Emissions GDP Ratio[a]	1.8037	2.4621	−7.0116	8.4682	Authors' calculation
Gini Coefficient	.4261	.2208	0	.7500	World Inequality Database [35]

[a] Indicates that the variables are logged.

Table 2
Regression analysis: Impact of global warming on happiness levels.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−.7137 (.3724)			
CO2 Emission		−.7895[a] (.3390)		
CH4 Emission			−.2803 (.6839)	
NO2 Emission				−.1450 (.5155)
Population Density	.4301 (.5984)	.4292 (.5980)	.4382 (.5994)	.4368 (.5995)
Population	−.9450 (.6451)	−.9246 (.6441)	−1.0610 (.6471)	−1.0701 (.6481)
Urbanization	−.2987 (.4585)	−.3075 (.4578)	−.3252 (.4609)	−.3288 (.4617)
GDP Per Capita	.4721[c] (.0637)	.4815[c] (.0640)	.4495[c] (.0630)	.4468[c] (.0625)
Democracy	.0610 (.0456)	.0613 (.0456)	.0628 (.0457)	.0632 (.0457)
Life Expectancy	−1.3660 (1.0041)	−1.3446 (1.0034)	−1.4026 (1.0056)	−1.4022 (1.0057)
Children Mortality Rate	−.5096[c] (.1286)	−.5267[c] (.1265)	−.4152[b] (.1328)	−.4060[b] (.1330)
Education	−.1429 (.1334)	−.1353 (.1334)	−.1600 (.1333)	−.1601 (.1333)
Corruption	−.1518 (.1147)	−.1483 (.1146)	−.1586 (.1148)	−.1592 (.1148)
Economic Crisis	−.0906[b] (.0358)	−.0917[b] (.0357)	−.0842[a] (.0359)	−.0835[a] (.0359)
Countries	1249	1249	1249	1249
N	140	140	140	140
R-Squared	.2490	.2599	.1969	.1925

The values in parentheses denote the standard errors.
[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

remains a strong, positive predictor of happiness, while child mortality rates exhibit a persistent negative association with well-being. These results highlight that economic development and public health play more prominent roles in shaping happiness than environmental variables in this global sample.

4.3. Heterogeneity Analysis

Given the potential for regional variation, the analysis examines whether the relationship between emissions and happiness differs across developed and developing countries (Tables 4 and 5). In developed countries, both GHG and CO_2 emissions show significant negative associations with happiness, with coefficients of −1.9255 and −1.9562, respectively. This finding aligns with previous research suggesting that populations in wealthier nations may experience greater dissatisfaction from pollution and environmental degradation, despite having higher adaptive capacity.

In contrast, the results for developing countries indicate no significant relationship between emissions and happiness. Instead, GDP per capita emerges as the primary driver of happiness, while child mortality rates do not show a statistically significant effect in these regions. These findings suggest that economic development and basic welfare take precedence over environmental concerns in determining happiness in developing countries.

4.4. Additional covariates

To further ensure the robustness of the results, the analysis incorporates additional covariates: the emissions-to-GDP ratio and the Gini coefficient (Table 6). While the number of observations decreases due to missing data for these variables, the inclusion of these covariates does not alter the core findings. The emissions-to-GDP ratio does not exhibit a significant relationship with happiness, indicating that the efficiency of economic activities may not directly influence well-being.

Similarly, income inequality (Gini coefficient) shows no

Table 3
Regression analysis: Impact of global warming on happiness levels with normalized key independent variables.

	Model 1	Model 2	Model 3	Model 4
GHG Emission[a]	−.0270 (.0232)			
CO2 Emission[a]		−.0280 (.0216)		
CH4 Emission[a]			−.0030 (.0225)	
NO2 Emission[a]				.0009 (.0197)
Population Density	.4302 (.4672)	.4299 (.4651)	.4387 (.4778)	.4386 (.4794)
Population	−.9450 (.7177)	−.9368 (.7149)	−1.0770 (.7239)	−1.0896 (.7285)
Urbanization	−.2987 (.8416)	−.3023 (.8424)	−.3330 (.8348)	−.3396 (.8342)
GDP Per Capita	.4721[c] (.1099)	.4766[c] (.1097)	.4475[c] (.1132)	.4458[c] (.1095)
Democracy	.0610 (.0994)	.0611 (.0995)	.0633 (.0975)	.0638 (.0973)
Life Expectancy	−1.3660 (1.7377)	−1.3569 (1.7325)	−1.4018 (1.7662)	−1.4003 (1.7697)
Children Mortality Rate	−.5096[b] (.1721)	−.5165[b] (.1700)	−.4018[b] (.1783)	−.3909[b] (.1776)
Education	−.1429 (.2557)	−.1394 (.2558)	−.1605 (.2534)	−.1606 (.2532)
Corruption	−.1519 (.1891)	−.1506 (.1891)	−.1589 (.1876)	−.1592 (.1874)
Economic Crisis	−.0906 (.0471)	−.0914 (.0471)	−.0832 (.0478)	−.0824 (.0477)
Countries	140	140	140	140
N	1249	1249	1249	1249
R-Squared	.2490	.2537	1903	.1852

$p < .01$**, The values in parentheses denote the standard errors.
[a] Represents the variable is normalized from 1 to 10.
[b] $p < .05$.
[c] $p < .001$.

Table 4
Regression analysis: Impact of global warming on happiness levels in developed countries.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−1.9255[b] (.6569)			
CO2 Emission		−1.9562[b] (.5764)		
CH4 Emission			−.9682 (1.2465)	
NO2 Emission				−.4215 (.9321)
Population Density	−.1716 (.8047)	−.1761 (.8007)	−.0520 (.8142)	−.0603 (.8182)
Population	−.4780 (.9071)	−.4747 (.8947)	−.9843 (.9297)	−1.0529 (.9497)
Urbanization	2.8345 (1.6261)	2.9385 (1.6022)	1.6522 (1.6894)	1.3821 (1.6548)
GDP Per Capita	.9888[c] (.1338)	1.0108[c] (.1338)	.9180[c] (.1345)	.9011[c] (.1321)
Democracy	−.1641 (.1567)	−.1485 (.1561)	−.1796 (.1593)	−.1753 (.1595)
Life Expectancy	−2.5983 (2.7695)	−2.0903 (2.6956)	−6.5908[b] (2.7740)	−7.1925[a] (2.7604)
Children Mortality Rate	−.5456[c] (.1418)	−.5416[c] (.1407)	−.5121[c] (.1453)	−.5026[c] (.1457)
Education	.3158 (.2530)	.3246 (.2519)	.3049 (.2568)	.3124 (.2567)
Corruption	−1.2006[c] (.2560)	−1.1680[c] (.2556)	−1.2735[c] (.2580)	−1.2837[c] (.2580)
Economic Crisis	−.1493[c] (.0399)	−.1490[c] (.0397)	−.1361[c] (.0407)	−.1353[c] (.0415)
Countries	32	32	32	32
N	356	356	356	356
R-Squared	.3413	.3554	.0458	.0445

The values in parentheses denote the standard errors.
[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

significant association with happiness in these models, though prior research has suggested that inequality can erode social cohesion [28]. Importantly, the coefficients for GHG, CO_2, CH_4, and N_2O emissions remain statistically insignificant, reinforcing the conclusion that economic and health factors are more salient determinants of happiness.

4.5. Alternative modelling approaches

To address potential methodological concerns, additional analyses were conducted using Panel-Corrected Standard Errors (PCSE) and Two-Stage Least Squares (2SLS) regression. The PCSE models (Table 7) correct for heteroscedasticity and serial correlation, yet the results remain consistent with the baseline findings—none of the emissions variables show a significant impact on happiness.

The 2SLS regression (Table 8) addresses potential endogeneity issues by using the interaction of energy use intensity and natural resource production as an instrumental variable. The Kleibergen-Paap F-statistic confirms the strength of the instruments, with p-values between .01 % and .07 %. However, even with this rigorous approach, GHG emissions do not exhibit significant associations with happiness.

Across all models, higher child mortality rates consistently reduce happiness, while population density and economic crises show mixed effects, indicating that further research is needed to clarify their roles. GDP per capita and life expectancy continue to positively influence happiness, highlighting the importance of economic and health security for well-being.

4.6. Summary of key findings

The results of this study suggest that GHG emissions and specific environmental variables may not have a significant direct effect on population happiness. Instead, economic development, child health, and political stability emerge as the most influential factors in shaping well-being. While developed countries experience more dissatisfaction with higher emissions, the findings suggest that basic economic needs take precedence in developing countries.

Table 5
Regression analysis: Impact of global warming on happiness levels in developing countries.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−.1285 (.5742)			
CO2 Emission		−.2911 (.5163)		
CH4 Emission			.9768 (1.0641)	
NO2 Emission				.7286 (.8003)
Population Density	.3303 (.7601)	.3414 (.7599)	.2908 (.7597)	.2913 (.7597)
Population	−.8107 (.8166)	−.7840 (.8159)	−.9197 (.8173)	−.9196 (.8174)
Urbanization	−.4255 (.5376)	−.4134 (.5364)	−.5197 (.5417)	−.5273 (.5433)
GDP Per Capita	.4225[c] (.0795)	.4320[c] (.0802)	.4007[c] (.0776)	.4068[c] (.0764)
Democracy	.0809 (.0516)	.0802 (.0516)	.0852 (.0517)	.0850 (.0516)
Life Expectancy	−1.1985 (1.2045)	−1.2401 (1.2026)	−.9965 (1.2090)	−.9986 (1.2089)
Children Mortality Rate	−.4390[a] (.1830)	−.4668[b] (.1788)	−.3159 (.1914)	−.3155 (.1922)
Education	−.1580 (.1591)	−.1520 (.1592)	−.1649 (.1584)	−.1652 (.1584)
Corruption	.0130 (.1390)	.0158 (.1389)	.0008 (.1391)	−.0010 (.1391)
Economic Crisis	−.0621 (.0509)	−.0615 (.0509)	−.0632 (.0508)	−.0651 (.0509)
Countries	108	108	108	108
N	893	893	893	893
R-Squared	.0865	.0968	.0507	.0512

The values in parentheses denote the standard errors.
[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

Table 6
Regression analysis: Impact of global warming on happiness levels with additional covariates.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−.7958 (.6824)			
CO2 Emission		−.8958 (.6130)		
CH4 Emission			−.5022 (1.2793)	
NO2 Emission				.6971 (.9087)
Population Density	−.2117 (.8808)	−.1801 (.8808)	−.2736 (.8802)	−.2996 (.8794)
Population	.0235 (.9073)	.0176 (.9056)	−.0110 (.9117)	−.1406 (.9137)
Urbanization	−.2276 (.8721)	−.2731 (.8728)	−.1472 (.8705)	−.1181 (.8684)
GDP Per Capita	.3002 (.2006)	.3053 (.2004)	.2997 (.2011)	.3171 (.2014)
Democracy	.2098[a] (.0855)	.2114[a] (.0854)	.2097[a] (.0859)	.2188[a] (.0859)
Life Expectancy	−5.8634[b] (1.7442)	−5.7314[b] (1.7446)	−6.2069[b] (1.7317)	−6.5651[b] (1.7216)
Children Mortality Rate	−.8253[b] (.2112)	−.8464[b] (.2071)	−.7439[b] (.2161)	−.6042[b] (.2175)
Education	.0836 (.0792)	.0792 (.0791)	.0947 (.0789)	.1069 (.0787)
Corruption	−.2150 (.1901)	−.2055 (.1899)	−.2416 (.1898)	−.2756 (.18960
Economic Crisis	−.2315[b] (.0527)	−.2339[b] (.0526)	−.2242[b] (.0527)	−.2139[b] (.0527)
Emissions GDP Ratio	.2326 (.2145)	.2174 (.2142)	.2749 (.2135)	.3209 (.2114)
Gini Coefficient	.2196 (.3591)	.2141 (.3581)	.2502 (.3633)	.3201 (.3600)
Countries	85	85	85	85
N	573	573	573	573
R-Squared	.4582	.4947	.3501	.2186

$p < .01$**, The values in parentheses denote the standard errors.
[a] $p < .05$.
[b] $p < .001$.

The lack of significant associations between emissions and happiness across most models suggests that well-being policies should prioritize economic and health security, especially in countries with lower adaptive capacity. Future research should consider using non-linear methods and alternative climate indicators to capture more nuanced relationships between environmental change and happiness.

5. Discussion and conclusion

5.1. Explanation for the results

The findings of this study reveal that greenhouse gas (GHG) emissions have limited direct effects on happiness, with socioeconomic factors—such as GDP per capita, child health, and economic crises—emerging as more influential determinants of well-being. These results align with existing research that highlights the importance of material security and public health for happiness, especially in countries where economic development remains a priority [36]. However, the differences in results between developed and developing countries suggest that environmental impacts on well-being are context-dependent.

In developed countries, the significant negative association between emissions (particularly CO_2) and happiness reflects growing dissatisfaction with environmental degradation. Wealthier populations, having met basic material needs, may focus more on environmental quality and health. As urbanization increases, pollution and emissions contribute to mental stress, respiratory issues, and declining quality of life, negatively impacting happiness [22].

By contrast, in developing countries, the lack of significant associations between emissions and happiness suggests that economic security and social welfare take precedence over environmental concerns. In these contexts, economic growth, access to healthcare, and education play a more critical role in shaping well-being. Higher child mortality rates, which often signal

Table 7
PCSE regression analysis: Impact of global warming on happiness levels.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−.7137 (.6134)			
CO2 Emission		−.7895 (.5455)		
CH4 Emission			−.2803 (1.1601)	
NO2 Emission				−.1450 (.8463)
Population Density	.4302 (.4672)	.4292 (.4647)	.4382 (.4766)	.4368 (.4780)
Population	−.9450 (.7177)	−.9246 (.7135)	−1.0611 (.7235)	−1.0701 (.7281)
Urbanization	−.2987 (.8416)	−.3075 (.8433)	−.3252 (.8354)	−.3288 (.8349)
GDP Per Capita	.4721[b] (.1099)	.4815[b] (.1093)	.4495[b] (.1129)	.4468[b] (.1093)
Democracy	.0610 (.0994)	.0613 (.0998)	.0628 (.0977)	.0632 (.0975)
Life Expectancy	−1.3660 (1.7377)	−1.3446 (1.7284)	−1.4026 (1.7634)	−1.4022 (1.7673)
Children Mortality Rate	−.5096[a] (.1721)	−.5267[a] (.1690)	−.4152[a] (.1779)	−.4061[a] (.1774)
Education	−.1429 (.2557)	−.1353 (.2559)	−.1600 (.2537)	−.1601 (.2535)
Corruption	−.1519 (.1891)	−.1483 (.1891)	−.1586 (.1878)	−.1592 (.1877)
Economic Crisis	−.0906 (.0471)	−.0917 (.0469)	−.0842 (.0477)	−.0835 (.0477)
Countries	140	140	140	140
N	1249	1249	1249	1249
R-Squared	.2490	.2599	.1969	.1925

$p < .05$*, The values in parentheses denote the standard errors.
[a] $p < .01$.
[b] $p < .001$.

Table 8
Second stage of 2SLS analysis: Impact of global warming on happiness levels.

	Model 1	Model 2	Model 3	Model 4
GHG Emission	−4.5548 (3.5189)			
CO2 Emission		−4.1421 (3.1630)		
CH4 Emission			−9.2047 (7.0881)	
NO2 Emission				−7.3488 (5.6575)
Population Density	−.0795[b] (.0243)	−.0792[b] (.0243)	−.0803[b] (.0245)	−.0809[b] (.0247)
Population	.0383[a] (.0188)	.0377[a] (.0188)	.0396[b] (.0188)	.0403[a] (.0189)
Urbanization	.1724 (.1404)	.1715 (.1402)	.1741 (.1398)	.1732 (.1408)
GDP Per Capita	.6001[b] (.0616)	.6023[b] (.0621)	.5946[b] (.0601)	.5913[b] (.0595)
Democracy	.0004 (.0318)	.0002 (.0318)	−.0001 (.0320)	.0021 (.0319)
Life Expectancy	4.7142[b] (.6233)	4.7172[b] (.6227)	4.7159[b] (.6255)	4.7287[b] (.6298)
Children Mortality Rate	−.4113[b] (.0807)	−.4140[b] (.0802)	−.4053[b] (.0820)	−.3977[b] (.0841)
Education	−.2150 (.1277)	−.2148 (.1275)	−.2157 (.1279)	−.2186 (.1280)
Corruption	−.2047 (.1159)	−.1992 (.1151)	−.2210 (.1190)	−.2229 (.1200)
Economic Crisis	−.0900 (.0945)	−.0894 (.0936)	−.0893 (.0941)	−.0977 (.0989)
Countries	70	70	70	70
N	635	635	635	635
Kp F-test (p-value)	.0001	.0001	.0003	.0007
Sargan Test p-value	.0785	.0795	.0808	.0843

$p < .01$**, The values in parentheses denote the standard errors.
[a] $p < .05$.
[b] $p < .001$.

deeper structural problems such as poverty and inadequate healthcare, are consistently linked to lower happiness across all models, reinforcing the importance of public health interventions.

The study also provides mixed evidence on the effects of population density and inequality. Income inequality, as measured by the Gini coefficient, does not show a statistically significant effect on happiness in the baseline models, though prior research suggests that it can erode social cohesion [28]. Similarly, the emissions-to-GDP ratio does not significantly influence well-being, indicating that environmental efficiency alone may not translate into higher happiness levels. These findings suggest that economic and social policies, not just environmental reforms, are crucial for enhancing well-being.

5.2. Policy implications

The results carry important policy implications for governments seeking to enhance well-being while addressing climate change. Policymakers in developed countries must balance environmental protection with economic well-being, as emissions reductions alone may not directly improve happiness. Degrowth strategies—which advocate for sustainable consumption and reduced reliance on GDP growth—could offer an alternative framework for improving happiness without further environmental degradation (Kallis, 2018). Governments should prioritize green technologies, pollution control, and sustainable urban planning to mitigate the adverse effects of emissions on well-being.

In developing countries, where economic development remains a key driver of happiness, policies should focus on improving public health, reducing poverty, and expanding access to education. Although climate mitigation is essential, adaptation strategies—such as strengthening healthcare systems and increasing agricultural resilience—are more likely to have an immediate impact on well-being. Targeted interventions to reduce child mortality can enhance community happiness while addressing underlying socio-economic challenges.

The findings also underscore the need for context-specific climate policies. While populations in colder regions may benefit temporarily from warmer winters, those in already hot climates face intensified heatwaves, food insecurity, and rising healthcare costs.

Governments in vulnerable regions must invest in climate adaptation measures, such as improved water management and disaster preparedness, to minimize the adverse impacts on well-being.

Finally, the study highlights the importance of integrating environmental, economic, and social policies. Sustainable development strategies must align with public health and poverty reduction efforts to achieve lasting improvements in happiness. By promoting inclusive growth and environmental sustainability, policymakers can build resilience to climate change while enhancing well-being.

5.3. Implications for future research

This study opens several avenues for future research on the climate-happiness nexus. Given the context-specific nature of environmental impacts, future studies should explore regional variations in greater detail. For example, the short-term benefits of warming in colder regions may contrast with the long-term consequences of rising sea levels, biodiversity loss, or increased natural disasters. Investigating these regional dynamics will provide more nuanced insights for policymakers.

Further research is also needed to examine the role of economic development in climate adaptation. Wealthier societies demonstrate greater resilience to climate impacts, suggesting that green economic policies—such as investments in renewable energy, sustainable agriculture, and public infrastructure—play a critical role in mitigating environmental risks. Longitudinal studies that assess the outcomes of large-scale adaptation projects, such as water resource management or urban greening, would offer valuable insights into the long-term effects on well-being.

The significant impact of child mortality on happiness warrants deeper investigation into the broader societal effects of health interventions. Future research could explore how investments in maternal and child health, nutrition, and education contribute to long-term improvements in happiness, particularly in developing regions.

Methodologically, future research should also consider using non-linear models and alternative statistical techniques, such as quantile regression or interaction effects, to capture more nuanced relationships between climate change and happiness. Cross-national comparative studies will help identify best practices for mitigating the negative effects of climate change while promoting well-being across different socio-economic contexts.

5.4. Conclusion

This study provides empirical evidence on the complex relationship between climate change, economic development, and happiness. While GHG emissions and specific environmental variables do not show consistent, significant effects on happiness, economic development and child health emerge as the primary drivers of well-being across countries. The results highlight the need for context-specific policies—in developed countries, environmental quality plays a more significant role, while in developing countries, economic security and public health take precedence.

These findings offer important lessons for policymakers striving to enhance well-being while addressing climate change. Integrating economic development with climate adaptation and health interventions will be essential for building resilient societies that can withstand future environmental challenges. Ultimately, this study underscores the importance of aligning sustainable development goals with public well-being, ensuring that climate policies not only mitigate risks but also promote happiness and social stability.

CRediT authorship contribution statement

Jeremy Ko: Writing – original draft, Validation, Investigation, Formal analysis, Data curation, Conceptualization. **Chun Kai Leung:** Writing – review & editing, Supervision, Project administration, Data curation, Conceptualization, Investigation, Writing – original draft. **Xiaoxian Chen:** Writing – original draft, Formal analysis, Data curation. **David A. Palmer:** Writing – review & editing, Resources, Funding acquisition.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A1
List of 140 Countries Included in The Study

1. Afghanistan	21. Bulgaria	41. El Salvador	61. Israel	81. Malta	101. Panama	121. Sweden
2. Albania	22. Burkina Faso	42. Estonia	62. Italy	82. Mauritania	102. Paraguay	122. Switzerland
3. Algeria	23. Burundi	43. Ethiopia	63. Jamaica	83. Mauritius	103. Peru	123. Syria
4. Angola	24. Cambodia	44. Finland	64. Japan	84. Mexico	104. Philippines	124. Tajikistan
5. Argentina	25. Cameroon	45. France	65. Jordan	85. Moldova	105. Poland	125. Tanzania
6. Armenia	26. Canada	46. Gabon	66. Kazakhstan	86. Mongolia	106. Portugal	126. Thailand
7. Australia	27. Central African Republic	47. Georgia	67. Kenya	87. Montenegro	107. Qatar	127. Togo
8. Austria	28. Chad	48. Germany	68. Kuwait	88. Morocco	108. Romania	128. Tunisia
9. Azerbaijan	29. Chile	49. Ghana	69. Kyrgyzstan	89. Mozambique	109. Rwanda	129. Turkmenistan
10. Bahrain	30. China	50. Greece	70. Laos	90. Namibia	110. Saudi Arabia	130. Uganda
11. Bangladesh	31. Colombia	51. Guatemala	71. Latvia	91. Nepal	111. Senegal	131. Ukraine
12. Belarus	32. Comoros	52. Guinea	72. Lesotho	92. Netherlands	112. Serbia	132. United Arab Emirates
13. Belgium	33. Costa Rica	53. Guyana	73. Liberia	93. New Zealand	113. Sierra Leone	133. United Kingdom
14. Belize	34. Croatia	54. Honduras	74. Lithuania	94. Nicaragua	114. Singapore	134. Uruguay
15. Benin	35. Cyprus	55. Hungary	75. Luxembourg	95. Niger	115. Slovenia	135. USA
16. Bhutan	36. Czechia	56. Iceland	76. Madagascar	96. Nigeria	116. South Africa	136. Uzbekistan
17. Bolivia	37. Denmark	57. India	77. Malawi	97. North Macedonia	117. Spain	137. Venezuela
18. Bosnia and Herzegovina	38. Djibouti	58. Indonesia	78. Malaysia	98. Norway	118. Sri Lanka	138. Vietnam
19. Botswana	39. Ecuador	59. Iran	79. Maldives	99. Oman	119. Sudan	139. Yemen
20. Brazil	40. Egypt	60. Ireland	80. Mali	100. Pakistan	120. Suriname	140. Zimbabwe

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