

## Article

# Examining the Interplay of Climate Change, Cultural Dynamics, and Sustainable Development: A Global Perspective

Pantelis C. Kostis \*  and Kyriaki I. Kafka

Department of Economics, National and Kapodistrian University of Athens, 105 59 Athens, Greece; kkafka@econ.uoa.gr

\* Correspondence: pkostis@econ.uoa.gr; Tel.: +30-2103689432

**Abstract:** This study undertakes a comprehensive multi-country analysis to investigate the intricate relationships among climate change, cultural dynamics, and sustainable development. Leveraging a robust, unbalanced panel dataset that encompasses one hundred and eight countries or regions over nearly four decades (1981–2019), this study employs fixed-effects estimation techniques to mitigate the impact of time-invariant heterogeneity across observational units. Structural equation modeling (SEM) is also employed as an advanced analytical tool to explore complex causal pathways and latent variables. Conducted in Stata, this multifaceted approach allows us to delve into the causal interconnections between climate change indicators, various cultural attributes, and indices of sustainable development. The findings reveal a negative influence of climate change on cultural background formation, which in turn impacts sustainable development. On the other hand, it is found that cultural background contributes positively to sustainable development. This suggests integrating cultural considerations into climate change adaptation, mitigation strategies, and sustainable development interventions. These strategies account for diverse societal values and behaviors, facilitating more effective climate change mitigation and adaptation. This study contributes to the growing research on the interplay between climate change and sustainable development by emphasizing a culturally informed policy framework. Its findings stand to inform national and international policymaking and enrich the discourse surrounding the creative economy's role in promoting sustainable development in the face of climate change.

**Keywords:** climate change; cultural background; cultural change; sustainable development



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## 1. Introduction

The relationship between climate change and its impact on societies has garnered significant attention in recent years. While much of the existing research has focused on the environmental and economic dimensions of climate change, the role of cultural background in shaping societies' response to this global challenge still needs to be explored.

Understanding the intricate interplay between climate change, cultural background, and sustainable development is crucial for formulating effective policies and strategies to foster a creative economy for sustainable development; (a) Climate change impacts the creative economy by affecting resources, infrastructure, and markets. Understanding these impacts helps identify opportunities and challenges for creative industries. (b) Cultural background influences people's attitudes, behaviors, and preferences toward sustainable practices. Policies should consider cultural diversity and engage communities to ensure local ownership and participation in sustainable development initiatives. (c) Sustainable development provides a framework for integrating economic, social, and environmental considerations. Policies should aim to create synergies between economic growth, cultural preservation, and environmental sustainability within the context of the creative economy. (d) The creative economy can contribute to sustainable development by fostering innovation, promoting cultural diversity, and generating decent employment opportunities while minimizing environmental impacts.

The existing literature acknowledges that climate can be an exogenous factor shaping cultural background formation and change. The environment in which cultures develop is significantly influenced by climate, which, in turn, profoundly impacts cultural practices, beliefs, and values. As climate change has become an increasingly pressing concern in recent decades, it is imperative to investigate whether and how this phenomenon has affected the cultural background of societies worldwide. Moreover, climate change has detrimental effects on sustainable development, including environmental disruptions, economic losses, social inequalities, and the need for robust policy responses, making it crucial to address climate change as a cross-cutting challenge to achieve sustainable development goals effectively. Additionally, examining how the evolving cultural background of societies relates to the sustainable development process can shed light on the potential implications for economies. Cultural background is crucial for sustainable development, as it shapes individuals' and societies' values, beliefs, and behaviors. It is vital in shaping how societies allocate resources, make decisions, and interact with the natural environment [1].

This research offers multiple contributions and innovations to the existing body of work. First, it employs a comprehensive unbalanced panel dataset that spans one hundred and eight countries/locations over nearly four decades (1981–2019), providing a robust and expansive basis for analysis. Second, this study's methodological rigor is elevated by using fixed-effects estimation and structural equation modeling. This allows for a nuanced understanding of the complex relationships among climate change, cultural background, and sustainable development. Third, this paper uniquely bridges disciplinary gaps by combining insights from climate science, cultural studies, and economics, creating a holistic framework for understanding and addressing the pressing issue of climate change. Finally, this study offers actionable policy implications by emphasizing the necessity of incorporating cultural considerations into climate change adaptation and mitigation strategies for sustainable development.

Investigating the above intricate relationships is undertaken to generate valuable insights and inform policymaking at national and international levels. Recognizing the significance of diverse cultural perspectives and knowledge systems, it is essential to incorporate cultural considerations into climate change adaptation and mitigation strategies. By doing so, policies and interventions can effectively account for different societies' varied values and behaviors, facilitating impactful climate change mitigation and adaptation measures, educational initiatives, and awareness campaigns, and fostering international collaboration [2]. The present study delves into the complex interplay between climate change, cultural background, and sustainable development, thereby contributing to the expanding body of knowledge on the creative economy's role in promoting sustainable development amidst a changing climate [3].

This manuscript is structured to facilitate easy comprehension and scholarly engagement. It begins with a comprehensive literature review that explores the interconnections between the core concepts of climate change, cultural background, and sustainable development. Following this, the methodology section details the data sources used, the data transformation techniques, and the statistical models employed for the analysis, which include fixed-effects estimation and structural equation modeling. After laying down the methodological foundation, this paper delves into the data analysis, providing descriptive statistics and model estimation results. The results and their implications are then discussed in depth, accounting for limitations and their impact on the findings. This manuscript includes a conclusion and recommendations section that synthesizes the key findings and suggests avenues for policy-making and future research. This sequential approach aims to provide a coherent and in-depth understanding of the intricate relationships between climate change, cultural background, and sustainable development.

## 2. Literature Review

Climate change refers to long-lasting, significant shifts in weather patterns occurring over extended periods caused by various factors, including human activities [4]. Cultural

background encompasses the life experiences shaped by one's membership in groups defined by ethnicity, race, gender, religion, socioeconomic status, and more; it is a set of evolving shared attitudes, values, and practices [5,6]. Sustainable development, popularized in the Brundtland Report by the United Nations [7], aims to fulfill the needs of the present without jeopardizing future generations' ability to do the same. It encompasses three pillars: economic, social, and environmental protection.

The importance of understanding climate change's impacts on cultural backgrounds and sustainable development is magnified in today's context. This knowledge not only underscores the urgency of comprehensive climate action but also aids in preserving cultural diversity, which enhances societal resilience and innovation. The disproportionate impact of climate change on marginalized communities raises pressing issues of equity and social justice, making this understanding crucial. Furthermore, it helps to formulate responsive policies and plans to meet the challenges of climate change. Moreover, understanding these impacts is instrumental in achieving sustainable development goals (SDGs), as climate change threatens their realization.

### *2.1. Climate Change and Cultural Background*

Climate change has historically had profound impacts on human cultures. Several studies suggest that shifts in climate have often led to shifts in agricultural practices, which in turn influences cultural traditions. An example is the transition from hunter–gatherer societies to agricultural societies during the Neolithic Revolution around 10,000 years ago, triggered by a shift towards a warmer and more stable climate [8]. Moreover, climate change has often forced human populations to migrate, leading to cultural changes. For example, the medieval Warm Period (approximately 950 to 1250 AD) facilitated Norse exploration and the establishment of settlements in Greenland, and later, the Little Ice Age (approximately 1300 to 1850 AD) led to the abandonment of these settlements [9]. Some researchers suggest that climate change played a role in the collapse of civilizations, leading to cultural shifts [10,11]. For instance, it has been proposed that prolonged drought contributed to the downfall of the Classic Maya civilization, leading to significant cultural changes [12]. Thus, cultures have adapted and evolved in response to climate change. Climate changes have also influenced spiritual and symbolic aspects of culture. Many indigenous cultures view the earth as a sacred entity, and significant climatic changes are often reflected in their mythologies, rituals, and religious practices [13].

For instance, the Sami people, indigenous to the Arctic areas of Norway, Sweden, Finland, and Russia, have witnessed drastic changes to their traditional livelihood, reindeer herding, due to climate change. Warming temperatures have altered the region's snowfall and vegetation, affecting the reindeers' food sources and migration patterns. These changes, in turn, have impacted Sami cultural practices, beliefs, and traditions linked to reindeer herding [14]. The Sami people have adapted by altering migration routes and integrating modern technologies with traditional knowledge to monitor and respond to changing environmental conditions [15]. Another example is the Maasai community in east Africa. This community is experiencing changes in rainfall patterns, leading to prolonged drought periods and affecting their pastoralist lifestyle. This threatens traditional practices, such as livestock rearing, and influences social structures and rituals [16]. However, the Maasai people are known for their resilience and have been exploring the diversification of their livelihood strategies, integrating crop farming with their pastoralist traditions [17,18].

Climate change significantly influences cultural practices, beliefs, and traditions, often necessitating adjustments, adaptations, or even complete transformations of cultures [19]. The interplay between climate change and cultural background is complex and multifaceted, often context-specific. As climate change progresses, it is crucial to recognize and respect these cultural impacts and support communities in adapting while maintaining cultural integrity [20].

Traditional practices, particularly those connected to the natural environment, are considerably impacted by climate change [21]. For instance, subsistence practices like

hunting, fishing, and agriculture can be disrupted by changing climatic conditions, such as altered rainfall patterns or temperature increases. In the Arctic regions, indigenous communities find it harder to follow traditional hunting practices due to melting ice and shifting animal migration patterns [22]. In African communities reliant on farming, changing rainfall patterns can lead to crop failures, challenging traditional agricultural practices [23].

Climate change also impacts the belief systems of many communities, particularly those closely tied to the environment [24]. For instance, in many indigenous cultures, elements of nature are sacred and hold spiritual significance. Extreme weather events or gradual environmental changes can thus affect the cultural beliefs related to these natural elements [25]. For instance, rising sea levels due to climate change are thus seen as a physical threat and a threat to cultural belief systems [26].

Moreover, traditional knowledge systems often include a deep understanding of the local environment and climate [27]. As climatic conditions change, some of this knowledge may become less applicable, altering traditional ways of life [28]. However, these traditional knowledge systems also provide a framework for understanding and adapting to climate change [29]. As climate patterns shift due to climate change, these communities modify their predictions, thus maintaining their traditions in altered forms.

In addition, various studies highlight the indirect link between weather patterns and cultural traits [30]. Notably, in colder regions with less sunlight, people tend to value privacy more due to increased isolation, while in warmer climates, this pattern is reversed [6,31]. The propensity for discipline and community compliance is also linked with colder climates [32]. Recent studies suggest that climate indirectly and directly influences cultural background by shaping individual behaviors. The study in [33] puts forward the concept of “homeostasis,” the adaptive process by which the human body adjusts (primarily regarding blood circulation) to its environment. Consequently, the extent and duration of sun exposure and the associated high temperatures result in physical and psychological responses that govern specific behaviors. This influence is guided by the “Homeo-stasis” principle, a human adaptation mechanism in response to temperature variations.

Given the complex interplay between climate change and cultural shifts, this study aims to examine the following hypothesis:

**Hypothesis 1.** *The impacts of climate change significantly influence cultural practices, belief systems, and traditional knowledge, thereby leading to adaptations or transformations within affected communities.*

## 2.2. Climate Change and Sustainable Development

Climate change deeply impacts the achievement of sustainable development goals (SDGs), as it represents a significant impediment to realizing many of these goals. The interconnection between climate change and sustainable development is evident, as the impacts of climate change can hinder progress in numerous areas outlined by SDGs.

This interconnection between climate change and sustainable development is manifest in numerous SDG areas: rising temperatures and extreme weather events (SDG 1: No Poverty and SDG 2: Zero Hunger) threaten food security and increase poverty vulnerability; health risks are amplified (SDG 3: Good Health and Wellbeing), including heat-related illnesses, vector-borne disease transmission, and mental health challenges; water scarcity issues are heightened (SDG 6: Clean Water and Sanitation); urgent actions to combat climate change and its impacts are required (SDG 13: Climate Action); biodiversity is endangered, impacting ecosystems and dependent communities (SDG 14: Life Below Water and SDG 15: Life on Land); and infrastructure damage and economic disruption can jeopardize livelihoods and economic growth (SDG 8: Decent Work and Economic Growth and SDG 9: Industry, Innovation, and Infrastructure). Therefore, strategies that mitigate and adapt to climate change are integral to sustainable development [34].

Sustainable development strategies in the face of climate change are complex and multifaceted. They typically involve mitigation and adaptation [35]. Most mitigation strategies involve transitioning to a green economy [36]. This includes increasing renewable energy sources, improving energy efficiency, and promoting sustainable transportation. A green economy reduces greenhouse gas emissions and creates new jobs and economic opportunities [37].

Moreover, strategies to make agriculture more resilient to climate change are crucial, given its vulnerability to changing weather patterns and its importance for food security. This includes agroecology, conservation, and climate-smart agriculture [38]. These strategies involve protecting, sustaining, and restoring natural or modified ecosystems, which can mitigate climate change by sequestering carbon and helping communities adapt to its impacts [39].

In addition, cities are particularly vulnerable to climate change impacts like heat waves and flooding. Strategies to increase urban resilience include green infrastructure, sustainable urban design, and inclusive urban planning [40]. Another aspect is that education and capacity building are crucial for mitigation and adaptation [41]. They empower individuals and communities to understand climate change and take effective action. This includes school climate change education, community-based capacity-building initiatives, and vocational training in green jobs. Also, climate change is a global issue that requires international cooperation. This includes climate finance, technology transfer, and effective governance at all levels, from local to global [42].

Given the observed interconnectedness between climate change and sustainable development, this study posits the following hypothesis:

**Hypothesis 2.** *The impacts of climate change have a significant, multidimensional effect on achieving sustainable development.*

### 2.3. Cultural Background and Sustainable Development

Cultural background can significantly influence sustainable development in various ways [43]. This influence primarily occurs as culture shapes people's values, perceptions, behaviors, and social organization, all of which have implications for sustainable development. Cultural activities can stimulate economic growth and environmental sustainability. Hence, the global protection of cultural identities is pivotal to promoting a sustainable future [44]. The study in [44] states that cultural considerations must be embedded in any strategy for sustainable development. Culture and creativity contribute to the three mainstays of sustainable development, economic, social, and environmental, which support the preservation of cultural heritage and the fostering of creativity [45]. The European Commission [46] recommends using culture as a powerful tool to effectively communicate scientific knowledge on various subjects highlighted in the 2030 Agenda for Sustainable Development, such as social inequality, gender disparity, biodiversity loss, food security, and climate change. Moreover, the authors of [47] have identified three functions of culture in sustainable development: (1) culture incorporated within sustainable development, (2) culture utilized for sustainable development, and (3) culture representing sustainable development itself.

Cultural background determines the values and worldviews of individuals and societies [48,49]. These values, in turn, influence how people perceive and interact with the natural environment, shaping their practices concerning resource use, conservation, and waste management [41]. Cultural background also encompasses traditional knowledge and practices, many inherently sustainable [50]. Recognizing and integrating such traditional knowledge can enhance the sustainability of development practices.

Cultural norms influence social organization, including patterns of cooperation and decision-making [51,52]. For example, in some cultures, communal land ownership and collective decision-making are prevalent, which can facilitate the implementation of community-based conservation or sustainable development projects. Cultural back-



ground also influences how societies adapt to changes and innovate [53]. This is particularly relevant in climate change, where innovative and adaptive responses are needed. Cultures with a high tolerance for uncertainty and a strong orientation toward the future may be better able to innovate and adapt to climate change.

Cultural perspectives on equity and justice can influence sustainable development practices [54]. For example, cultures that prioritize communal wellbeing over individual gain may be more inclined to pursue development practices that are equitable and inclusive. Cultures vary in their approaches to education and learning [55]. Some cultures have strong traditions of experiential learning and oral transmission of knowledge, which can be valuable for teaching about sustainability in a relatable and engaging way.

In light of the intricate relationship between cultural background and sustainable development, this study proposes the following hypothesis:

**Hypothesis 3.** *The cultural background of a community significantly shapes its approach to and effectiveness in implementing sustainable development practices, including resource use, social organization, and adaptability to environmental changes.*

### 3. Materials and Methods

The analysis in this study utilized an unbalanced panel dataset of 108 countries/locations to examine a period from 1981 to 2019. This research design was selected for its ability to control for unobserved time-invariant country-specific effects, thus reducing bias and allowing for more robust estimates. Panel data models are particularly effective when exploring the impact of variables that present small changes over time, such as cultural factors [56,57]. The analysis was performed using StataMP 13 (64 bit).

Table 1 presents the list of countries/locations used in the analysis.

**Table 1.** Countries/locations used in the analysis.

Albania	El Salvador	Kuwait	Russian Federation
Algeria	Estonia	Kyrgyzstan	Rwanda
Andorra	Ethiopia	Latvia	Saudi Arabia
Argentina	Finland	Lebanon	Serbia
Armenia	France	Libya	Singapore
Australia	Georgia	Lithuania	Slovakia
Austria	Germany	Luxembourg	Slovenia
Azerbaijan	Great Britain	North Macedonia	South Africa
Bahrain	Greece	Malaysia	Spain
Bangladesh	Ghana	Mali	Sweden
Belarus	Guatemala	Malta	Switzerland
Belgium	Haiti	Mexico	Thailand
Bosnia and Herzegovina	Hongkong-China	Republic of Moldova	Taiwan-China
Brazil	Hungary	Montenegro	Tanzania
Bulgaria	Iceland	Morocco	Trinidad and Tobago
Burkina Faso	India	Netherlands	Tunisia
Canada	Indonesia	New Zealand	Turkey
Chile	Iran	Nigeria	Uganda
China	Iraq	Northern Cyprus	Ukraine
Colombia	Ireland	Norway	United States
Croatia	Israel	Pakistan	Uruguay
Cyprus	Italy	Peru	Uzbekistan
Czech Republic	Japan	Philippines	Venezuela
Denmark	Jordan	Poland	Vietnam
Dominica Republic	Kazakhstan	Portugal	Yemen
Ecuador	Republic of Korea	Qatar	Zambia
Egypt	Kosovo	Romania	Zimbabwe

To quantify the cultural background, a comprehensive measure was employed. This measure was the first principal component of a principal component analysis (PCA) applied to various cultural values observed across societies, a method originally proposed by [58] and later expanded upon by [59]. The PCA method was chosen due to its efficiency in reducing dimensionality and its ability to identify the ‘principal’ factors that contribute the most variance to the observed cultural values. The first principal component effectively serves as a synthetic variable that captures the maximum possible variance from the original variables. The cultural values contributing to the overall cultural background measure included generalized trust, control of life, obedience, independence, honesty, competition affinity, and work ethic, as outlined in previous studies [53,60,61].

The cultural values used in the analysis were derived from the World Values Survey (WVS) and European Values Study (EVS). Generalized trust represents the percentage of those who responded that most people can be trusted to the question, “Generally speaking, would you say that most people can be trusted or that you can’t be too careful in dealing with people?”. Control of life represents the percentage of those who responded, “A great deal” to the question, “How much freedom of choice and control do you feel you have over the way your life turns out?”. Obedience and independence represent the percentage of those who responded “Obedience” and “Independence,” respectively, to the question, “Which quality do you consider to be especially important to teach your children?”. The variables described above are expressed as percentages, ranging from 0% to 100%, and represent proportions of the total population.

The factors related to honesty, competition affinity, and work ethic were obtained through separate PCAs using selected questions from the WVS and EVS to represent each variable. Honesty was derived as the first principal component of a PCA on the following two variables “Honesty I: The percentage of those who responded, “Never Justifiable” on whether it is justifiable to cheat on taxes” and “Honesty II: The percentage of those who responded, “Never Justifiable” on whether it is justifiable to avoid fare on public transport.” Competition affinity was derived as the first principal component of a PCA on the following two variables “Competition I: The percentage of those who responded, “Competition is Good” on the question how would you place your view on a scale from 1 to 10 ranging from the competition is good to competition is harmful” and “Competition II: the percentage of those that believe that people can only get rich at the expense of others.” Moreover, work ethic was derived as the first principal component of a PCA on the following two variables: “Work Ethic I: The percentage of those who responded, “Hard Work” on the question which quality do you consider to be especially important to teach your children” and “Work Ethic II: The percentage of those who responded that work is very important in their lives.” While the individual variables are expressed as proportions of the entire population, the principal components may assume values below or above zero.

Data on climate change were sourced from the HadCRUT (Hadley Centre Climatic Research Unit Temperature) analysis and pertained to the term Surface Temperature Anomaly. HadCRUT is a dataset of global historical surface temperature anomalies maintained jointly by the UK Met Office’s Hadley Centre for Climate Science and Services and the Climatic Research Unit (CRU) at the University of East Anglia. This dataset is one of the primary sources used worldwide for understanding and analyzing long-term trends in global temperatures. In this context, the term ‘Surface Temperature Anomaly’ was calculated by determining the temperature difference for each year in the analysis relative to the average temperature recorded from 1961 to 1990.

Data on sustainable development were derived from the Sustainable Development Index (SDI) developed by [62]. This index focuses on evaluating the ecological efficiency of nations in promoting human development. It builds upon the fundamental components of the Human Development Index (HDI), namely the life expectancy index, education index, and income index (adjusted with a sufficiency threshold). The SDI then incorporates an assessment of ecological overshoot, which quantifies the extent to which a country’s

consumption-based CO<sub>2</sub> emissions and material footprint surpass per-capita shares of planetary boundaries.

To ensure comparability, all data points were transformed from annual values to averages across seven waves of analysis (1981–1984, 1990–1994, 1995–1998, 1999–2004, 2005–2009, 2010–2014, 2017–2019) based on the availability of data on cultural background.

Firstly, we estimated the following two equations using fixed-effects analysis and the ordinary least squares (OLS) method:

$$\text{Culture}_{it} = \alpha_i + \beta_1 \times \text{Climate Change}_{it} + \gamma \times X_{it} + \lambda_t + u_{it} \quad (1)$$

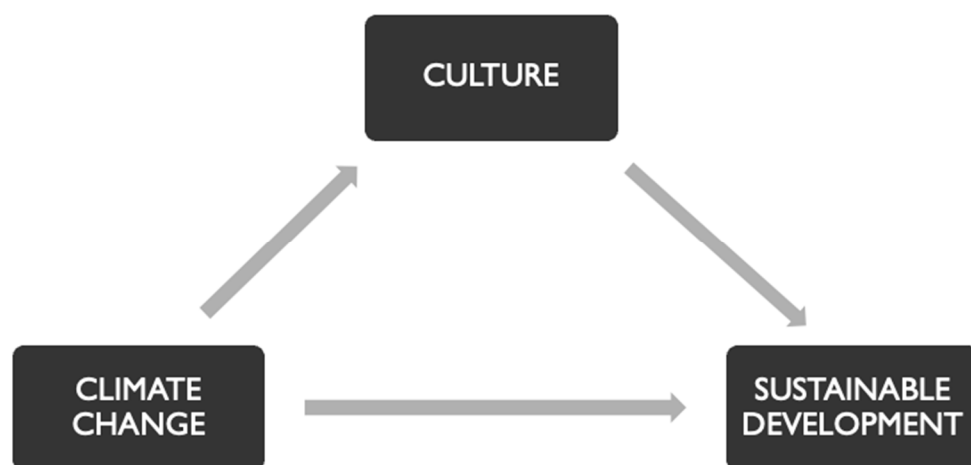
$$\text{Sustainable Development}_{it} = \alpha_i + \beta_1 \times \text{Culture}_{it} + \delta \times C_{it} + \lambda_t + u_{it} \quad (2)$$

where  $i$  denotes each economy of the sample under analysis ( $N_{\max} = 108$ ),  $t$  is the WVS wave under analysis ( $T_{\max} = 7$ ),  $X_{it}$  and  $C_{it}$  are vectors of control variables,  $\alpha_i$  is a fixed term that represents some fixed effects that take place in each economy (country-specific fixed effects) to capture the influence of unobserved and time-invariant heterogeneity across countries, and  $\lambda_t$  is a dummy variable for each wave of the sample, which controls for wave-specific effects that are common across countries.

As control variables, the GDP growth [63–65] and the economic institutions [61,66,67] were used since both significantly affect cultural background and sustainable development.

The estimates were obtained using fixed-effects (FE) analysis, which is frequently used in econometric panel data models to control for time-invariant heterogeneity across units [68,69]. The estimation used the standard ordinary least squares (OLS) method. Additionally, time dummy variables were included for each wave to account for time effects shared by all countries in the sample. Furthermore, country-specific clustered robust estimates of standard error estimates were calculated to assess correlation and heteroskedasticity within each economy.

Our second analytical approach employed structural equation modeling (SEM), as illustrated in Figure 1. While SEM is often utilized for data collected through interviews, it is increasingly recognized for its applicability and robustness in analyzing panel data and observational studies [70–72]. In this study, SEM was used as a robust multivariate technique that enabled us to comprehensively examine and assess the relationships between climate change, culture, and sustainable development [73–77].



**Figure 1.** Structural equation modelling approach between climate change, culture, and sustainable development.

Contrary to some modeling methodologies, SEM allowed us to investigate direct and indirect effects in our hypothesized causal pathways. To further corroborate the suitability of SEM for our dataset, we conducted a path analysis. This component of SEM is especially potent in examining complex relationships, as it enables the evaluation of causality, the



identification of mediating and moderating effects, and the quantification of direct and indirect influences.

Table 2 presents the descriptive statistics of the variables used in the analysis.

**Table 2.** Descriptive statistics for the variables used in the analysis.

	N	Avg.	St. Dev.	Min	Max
Sustainable development	591	0.58	0.17	0.09	0.83
Climate change	739	0.61	0.48	−0.55	2.67
Culture	162	0.00	1.71	−3.95	4.59
Trust	366	28.40	15.63	2.50	77.40
Control of life	352	15.36	8.52	0.00	43.90
Obedience	361	35.12	17.65	2.2	89.9
Independence	364	48.10	18.79	7.90	90.00
Honesty	331	0.00	1.32	−3.84	3.67
Honesty I	354	60.04	14.73	20.30	98.10
Honesty II	338	55.93	15.58	12.60	96.30
Competition	178	0.00	1.12	−1.73	6.14
Competition I	327	26.10	12.32	3.70	66.30
Competition II	183	7.66	6.95	0.30	77.30
Work ethic	335	0.00	1.03	−2.73	2.43
Work ethic I	362	52.85	25.43	2.10	94.60
Work ethic II	338	61.82	14.95	26.10	95.10
GDP growth	749	7.11	3.73	−9.99	32.2
Institutions	610	6.57	1.24	2.59	9.12

## 4. Results and Discussion

### 4.1. Principal Component Analysis of Cultural Background

To establish the cultural background, conducting a principal component analysis (PCA) was essential. Regarding honesty, the first principal component possessed an eigenvalue of 1.75, accounting for 87.6% of the overall variance. Similarly, the first principal component for competition affinity had an eigenvalue of 0.70, explaining 63.1% of the variance. The first principal component representing work ethic exhibited an eigenvalue of 1.07, explaining 53.4% of the variance.

Table 3 presents the PCA for the cultural background. The first component had an eigenvalue of 2.91, explaining 41.6% of the variance. All subsequent components, apart from the first one, presented quite low eigenvalues and variance and, for this reason, were not used in the analysis.

**Table 3.** The first principal component of the PCA for cultural background.

Trust	−0.439
Control of life	0.285
Obedience	0.431
Independence	−0.373
Honesty	0.023
Competition	0.441
Work ethic	0.453
Eigenvalue	2.914
Var	41.6%

Based on the first principal component of the PCA, the variable “cultural background” was formed positively by obedience, competition, and work ethic and negatively by trust and independence. Honesty did not play an important role in forming the first principal component. Thus, this principal component could be characterized as an “Authoritarian Competitive Drive” cultural background. This name suggests a focus on competition and achievement (competitive drive) within a structured or controlled setting that

may de-emphasize trust and independence (authoritarian). It balances the aspirational qualities of competition and work ethic with the constraints of obedience and less trust or independence.

#### 4.2. Fixed-Effects Analysis for Equations (1) and (2)

We then proceeded to conduct fixed-effects estimations for Equations (1) and (2), which aimed to understand how climate change impacts cultural background and how cultural background impacts sustainable development. These are presented in Table 4 below.

**Table 4.** Estimating Equations (1) and (2) through fixed-effects (FE) analysis.

	Dependent Variable					
	(1)	Culture (2)	(3)	(4)	Sustainable Development (5)	(6)
Climate change	−1.20 ** (−2.08)	−1.12 ** (−1.98)	−1.14 ** (−2.34)			
Culture				0.03 *** (3.27)	0.03 *** (2.75)	0.01 * (1.24)
GDP growth		0.12 ** (2.23)			0.01 ** (1.92)	
Institutions			−0.94 *** (4.89)			−0.04 ** (−2.04)
N	157	156	141	135	148	138
R <sup>2</sup>	11.92%	17.38%	44.98%	14.49%	18.51%	15.22%
F-stat	5.41 ***	5.47 ***	19.35 ***	6.44 ***	5.68 ***	4.25 ***

Note: The t-statistics values are shown in parentheses. \*, \*\*, and \*\*\* mean statistical significance at 10%, 5%, and 1% level, respectively. Each column represents a separate regression. All regressions include the effect of the time variable (to account for effects common to countries in each wave), different fixed terms (to account for economy-specific effects), and standard error corrections (clustered robust standard errors). The number of observations is reduced when culture gets into the analysis due to a lack of data for some waves for countries/locations.

The analysis revealed two key findings. First, climate change had a statistically significant, negative impact on cultural background, as shown in column 1 of Table 4. This negative association persisted even when accounting for other variables, as evidenced in columns 2 and 3.

Second, the data also indicate that cultural background had a statistically significant, positive effect on sustainable development, as shown in column 4 of Table 4. This positive relationship remained robust when we controlled for other factors, as detailed in columns 5 and 6.

#### 4.3. Structural Equation Modeling (SEM) Results

Structural equation modeling (SEM) was also utilized for a more nuanced understanding. Table 5 illustrates the SEM approach.

**Table 5.** The SEM approach for climate change, culture, and sustainable development.

	Dependent Variable	
	Culture	Sustainable Development
Climate change	−0.45 * (−1.71)	−0.04 ** (−2.26)
Culture		0.04 *** (5.55)
N	751	

**Table 5.** *Cont.*

	Dependent Variable	
	Culture	Sustainable Development
RMSEA		0.0
CFI		1.0
TLI		1.0

Notes: The z-statistics values are displayed in parentheses. \*, \*\*, and \*\*\* represent statistical significance at 10%, 5%, and 1% significance level, respectively.

The SEM analysis provided compelling evidence for several key relationships. First, it highlighted a robust and statistically significant negative correlation between climate change and cultural background. Second, the model also showed the detrimental effect of climate change on sustainable development. Finally, it uncovered culture's positive, statistically significant influence on sustainable development.

In terms of model fit, the SEM results were particularly reassuring. An RMSEA value of zero indicates an excellent fit between the model and the observed data. Further validation was provided by the comparative fit index (CFI) and Tucker–Lewis index (TLI), surpassing the generally accepted threshold of 0.95, suggesting an outstanding model fit.

#### 4.4. Path Analysis Outcomes

Lastly, Table 6 presents a path analysis to elucidate the complex relationships between climate change, culture, and sustainable development. The table provides a comprehensive overview of the statistical pathways and their corresponding coefficients, elucidating the intricate connections between these variables. The findings presented in Table 6 add another layer to understanding the complex interplay between climate change, culture, and sustainable development and support the research hypotheses proposed in this study.

**Table 6.** Path analysis for climate change, culture, and sustainable development.

Direct Effects	Dependent Variable	
	Culture	Sustainable Development
Climate change	−0.45 * (−1.71)	−0.04 ** (−2.26)
Culture		0.04 *** (5.55)
Indirect Effects	Dependent Variable	
	Culture	Sustainable Development
Climate change	No path	−0.01 * (−1.64)
Culture		No path

Notes: The z-statistics values are displayed in parentheses. \*, \*\*, and \*\*\* represent statistical significance at 10%, 5%, and 1% significance level, respectively.

Climate change exerted a pronounced, statistically significant negative impact on cultural background, underscoring its detrimental influence. Similarly, the findings indicate that climate change adversely affected sustainable development in a statistically meaningful way. On the other hand, a cultural background characterized as “Authoritarian Competitive Drive” significantly contributed to promoting sustainable development. Additionally, climate change demonstrated a measurable indirect influence on sustainable development, reinforcing its multifaceted role in shaping outcomes.

Thus, one significant research finding indicates that climate change has a detrimental effect on cultural aspects, as defined by the “Authoritarian Competitive Drive” cultural

background. This result compellingly validates Research Hypothesis 1, asserting that “The impacts of climate change significantly influence cultural practices, belief systems, and traditional knowledge, thereby leading to adaptations or transformations within affected communities.” One of the main ways that higher surface temperature anomalies can impact cultural background is through the loss of traditional knowledge and practices passed down through generations. This is in line with the authors of [78], who conclude that the impacts of climate change on cultural heritage and cultural diversity may challenge sustainable global peace. Temperature and weather patterns can affect the timing and viability of traditional farming, fishing, and hunting practices. This leads to losing traditional knowledge about these practices and the associated cultural beliefs and values. Higher temperatures can also impact cultural backgrounds by contributing to the displacement of communities. This is what the authors of [79] state: climate change leads to massive exodus on a global scale, leading to displacements. As sea levels rise and extreme weather events become more common, some communities may be forced to relocate, which can disrupt traditional social structures, relationships, and cultural practices.

Another significant research finding is that climate change poses significant challenges to achieving sustainable development [80]. This result validates Research Hypothesis 2, asserting, “The impacts of climate change have a significant, multidimensional effect on achieving sustainable development.” Its negative impacts are far-reaching and can hinder progress across various sectors, such as the economy, environment, and social wellbeing. For example, higher temperatures can lead to more frequent and severe natural disasters, such as heat waves, droughts, and wildfires, which can cause significant economic and social damage [81]. Higher temperatures can lead to several adverse environmental and social impacts, hindering sustainable development progress. Firstly, higher temperatures can lead to more frequent and severe natural disasters, such as heat waves, droughts, and wildfires, which can cause significant economic and social damage. These events can disrupt supply chains, damage infrastructure, and lead to loss of life and property, negatively impacting the SDI. Secondly, higher temperatures can exacerbate existing environmental problems, such as air and water pollution, deforestation, and desertification, which can further degrade ecosystems and threaten biodiversity [82]. This can limit the availability of natural resources, such as clean air and water, and hinder efforts to promote sustainable development. Thirdly, higher temperatures can also negatively impact human health, particularly for vulnerable populations such as the elderly and children [83]. This can increase healthcare costs, reduce productivity, and limit economic growth, negatively impacting the SDI.

In addition, one more significant research outcome is that culture plays a pivotal role in fostering and promoting sustainable development [84], exerting a positive and transformative influence on societies and the environment. This result validates Research Hypothesis 3, asserting that “The cultural background of a community significantly shapes its approach to and effectiveness in implementing sustainable development practices, including resource use, social organization, and adaptability to environmental changes.” An “Authoritarian Competitive Drive” cultural background wields significant influence over sustainable development by instilling environmental consciousness, fostering innovation, shaping consumption patterns, and strengthening social cohesion [85]. Recognizing the power of culture in promoting sustainability allows us to harness its potential to effect positive change and cultivate a harmonious relationship between human societies and the planet. Firstly, cultural background can provide valuable knowledge about the environment and natural resources. Indigenous and traditional knowledge systems have developed over generations of experience and observation of the natural world and can offer unique insights into sustainable resource management practices [86]. This knowledge can be incorporated into sustainable development plans to promote socially, economically, and environmentally sustainable practices and foster a sense of environmental consciousness and responsibility. Secondly, cultural background can provide important social and institutional frameworks that support sustainable development [87]. Cultural practices and values often emphasize

community cohesion, social responsibility, and collective decision-making, which can help build strong, resilient communities that can better adapt to environmental and economic changes. Thirdly, cultural background can provide a sense of identity and connection to the natural world that can promote the conservation of natural resources [88]. Cultural practices and beliefs often emphasize the importance of living in harmony with the environment and can promote a sense of responsibility and stewardship towards natural resources.

## 5. Conclusions

The current analysis offers invaluable insights into the intricate relationships among climate change, cultural dynamics, and sustainable development, using data from one hundred and eight countries/locations for seven waves of analysis in the period 1981–2019 (1981–1984, 1990–1994, 1995–1998, 1999–2004, 2005–2009, 2010–2014, 2017–2019). This investigation opens new avenues for understanding how these multifaceted variables interact, providing a comprehensive framework that could significantly influence future policies and intervention strategies.

One of the primary takeaways from this study is the detrimental effect of climate change on the formation of cultural backgrounds. As climate change leads to ecological shifts, it simultaneously exerts undue pressure on traditional ways of life, disrupting the communal activities and shared experiences that form the bedrock of culture. For instance, in societies dependent on agriculture or fishing, shifts in weather patterns can have disastrous consequences on livelihoods, affecting social structures, rituals, and community engagement. Consequently, this negatively impacts the formation and preservation of cultural identities, which, in turn, has a ripple effect on sustainable development.

Sustainable development is a matter of ecological balance and social and cultural harmony. A society's cultural background forms the prism through which its members perceive and interact with the environment. When climate change negatively impacts this cultural foundation, it hampers the communal mindset needed for long-term sustainable practices. A community that loses its cultural roots may find it more difficult to engage in collective actions prioritizing sustainable growth over immediate, short-term gains. Therefore, the erosion of culture due to climate change presents a social and environmental sustainability crisis.

On the flip side, this study reveals that a strong cultural background can assist in sustainable development. Cultures with embedded values that encourage communal living, respect for nature, and long-term planning are inherently aligned with sustainable development goals. Such cultures can influence their members to engage in ecologically sound, socially equitable, and economically viable practices. Therefore, maintaining and rejuvenating cultural values can catalyze sustainable practices, creating a positive feedback loop that enhances culture and sustainability.

One of the most salient implications of this study is the need for policymakers to be highly sensitive to cultural differences when designing and implementing sustainable development initiatives. Since culture plays a critical role in shaping attitudes and behaviors toward sustainable practices, policies must not adopt a one-size-fits-all approach. Instead, they must be tailored to resonate with specific cultural nuances and values. To be truly effective, educational programs should not be confined to the walls of academia; they should be expanded to reach a broader audience. Government support for these programs is pivotal; they can subsidize or sponsor educational initiatives focusing on sustainability and climate change, enabling a wider reach. These programs should teach sustainability science and include modules that foster an appreciation of different cultures and their unique relationships with their natural environments. Environmental education must become a staple in primary, secondary, and tertiary education systems to imbue future generations with the knowledge to make sustainable decisions.

Beyond traditional environmental education, the current research suggests that cultural diversity and sustainability education should be mandated in school curricula, professional training programs, and public awareness campaigns. Such an integrative approach



ensures that individuals are scientifically informed and culturally sensitive. Understanding cultural diversity is crucial for promoting empathy and social cohesion, encouraging collective action toward sustainable development goals.

In practical terms, the wisdom of indigenous and local communities often remains an underutilized resource for sustainable practices that have been fine-tuned through the ages. These should be recognized, respected, and integrated into sustainable development policies. This could mean involving indigenous leaders in policy development processes or collaborating with local communities to adapt traditional practices for modern sustainability challenges. Another practical implication revolves around the synergistic relationship between cultural diversity and innovation. Countries can stimulate their creative industries by fostering an environment that encourages the mingling of different cultures and perspectives. This has economic benefits too, as it enhances tourism and opens new markets centered on cultural products and experiences.

Furthermore, policies inclusive of local and indigenous knowledge not only serve to preserve cultural heritage but also have the potential to drastically improve social inclusion. This, in turn, contributes to a more diverse and resilient creative economy. More inclusive industries are generally more innovative, as many perspectives and experiences feed them. Finally, countries considering these policy considerations will likely be better positioned globally. Embracing cultural diversity while pushing for sustainable development can enhance global competitiveness. Countries that can showcase innovation in sustainability and culture are likely to attract international partnerships, investments, and talent, thereby creating a vibrant, dynamic economy equipped to meet the challenges of the 21st century.

However, it is important to note that this study has certain limitations. The findings are based on a specific sample and may not be generalized to other populations or contexts. Moreover, the analysis was realized in waves based on the availability of data on cultural background. Building stronger cultural background databases in the future will provide opportunities for more detailed analyses in the future. Future research should replicate these findings using diverse samples and objective measures of cultural background, climate change, and sustainable development. Furthermore, longitudinal studies could provide insights into the temporal dynamics of the relationships examined in this study.

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