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Asymmetric impact of temperature on subjective well-being in selected African countries

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ABSTRACT

The aim of this study is to investigate whether or not the relationship between temperature and subjective well-being (SWB) is non-linear for sub-Saharan African countries. Fixed effects estimation based on data from 1981 to 2017 from the World Value Survey, World Development Indicators, and the World Bank's Climate Change Knowledge Portal is employed. Various control variables are added to control for socioeconomic and country-specific factors. The results indicate a non-linear relationship between average temperature and SWB. Initially, SWB increases with rising average temperature but begins to decline beyond a certain threshold. Both the average temperature and its squared term are statistically significant. The findings remain robust when alternative SWB measures are applied and the sample is split by warmest years. Temperature influences SWB in a non-linear fashion, highlighting the importance of considering climatic conditions in well-being studies. The results suggest that climate change, particularly rising temperatures could have significant implications for well-being in sub-Saharan Africa. Policymakers should consider the direct and indirect effects of climate on quality of life and prioritize strategies that mitigate adverse impacts, especially in increasingly warmer climates.

Contribution/Originality: This study investigates the non-linear effect of temperature on subjective well-being in sub-Saharan Africa using long panel data from 1981 to 2017, linking climate and socioeconomic variables and applying robustness checks across different well-being measures and the warmest years on record.

1. INTRODUCTION

Global climate change has gained ample international attention and is considered one of the defining issues of the early 21st century. Today, it is widely acknowledged that the effects associated with climate change can be observable and unobservable. Such risks span far beyond physical environmental degradation, and encompass non-environmental aspects such as growth and development (Tol, 2008). Rising sea levels, warmer temperatures, wildfires, floods, heat waves, droughts etc. are some common consequences of climate change and global warming. However, more recently, studies have investigated the psychological impact that climate change has had on mental health and well-being (Berry, Waite, Dear, Capon, & Murray, 2018; Cianconi, Betrò, & Janiri, 2020; Feddersen, Metcalfe, & Wooden, 2016). Mental health[1] consequences of climate change can arise directly and indirectly (Clayton, Manning, Krygsman, & Speiser, 2017). For example, some of the mental health risks stem directly from

[1] According to the World Health Organization (WHO), mental health is a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community.

the natural disasters themselves, such as wildfires, floods and droughts. Indirect mental health risks may arise due to food insecurity, forced migration and deteriorated physical infrastructure (Clayton et al., 2017). At present, the agricultural sector is largely affected by the changing weather conditions, i.e., extreme rise in temperatures and increased frequency and intensity of precipitation causing immeasurable amounts of stress for subsistence farmers who rely on their produce as a primary source of income. Climate can also influence households because (i) it affects heating and cooling requirements. (ii) Alters an individual's caloric intake. (iii) Necessitates different clothing for the change in seasons. (iv) Constrains outdoor leisure activities (Maddison & Rehdanz, 2011). Some economists believe that "climate change is projected to accelerate human displacement in the future by increasing the frequency and severity of extreme environmental events" (Garip, 2019). In such cases, we can expect the effect of this macro-event (i.e., changing weather conditions) to be felt on an individual micro-level. Thus, we hypothesize that climate change will impact individual subjective well-being[2] and life satisfaction through both direct and indirect channels.

The consequences of global warming are disproportionately borne by those who are marginalized and who play the smallest part per capita in contributing to the rise in greenhouse gases (Hayes, Blashki, Wiseman, Burke, & Reifels, 2018). Children undeniably the least responsible for global warming will ultimately bear the greatest cost. Moreover, certain countries and regions are more vulnerable to climate change than others. Extreme weather affects people more in poorer, less-developed countries than those in relatively richer, more-developed countries because people from poorer countries lack the resources required to cope with such shocks. According to a recent UNICEF report (2020) the implications of global warming have especially serious consequences for countries in sub-Saharan Africa with many acting as hosts for several global climate change hotspots. The rise in temperature in these regions is projected to be higher than the global mean (UNICEF, 2020). As a result, the ramifications of such are expected to be profound, especially for countries in Africa and sub-Saharan Africa with every additional rise in warming exacerbating the risk of droughts, heatwaves and potential crop failures.

Given this context, we direct the focus of this study to sub-Saharan Africa which is a unique contribution to existing literature as it is the first to focus specifically on this region. In addition, we employ a rich longitudinal dataset from 1981 to 2017. The main aim of this study is to investigate the long-term impact of climate change on the subjective well-being (SWB) in sub-Saharan Africa. Our research question is as follows: Over time, has climate change affected the subjective well-being of people living in sub-Saharan Africa? To conclude this study, we provide policymakers and healthcare officials with recommendations on how to respond to climate change-induced mental stress.

Research on the impact of specific environmental conditions on SWB is limited (see cross-country studies by Maddison and Rehdanz (2011) done on 79 countries, Rehdanz and Maddison (2005) done on 67 countries) and especially studies done at a national level (see Frijters and Van Praag (1998) study done in Russia, Carroll, Frijters, and Shields (2009) study done in Australia, Welsch (2006) study done in Europe, Rehdanz and Maddison (2008) study done in Germany and Sekulova and van Den Bergh (2013) study done in Barcelona). Frijters and Van Praag (1998) are among the first to analyse this relationship. The authors used two Russian household surveys, carried out in 1993 and 1994 to investigate how climate conditions affect the cost of living and well-being in Russia. In terms of well-being, the authors find that it is influenced negatively by climate change. When looking at the so-called "stickiness factor" or the combination of high levels of humidity and temperature, the authors find a strong and negative influence on well-being.

Environmental quality has also been cited by research as a key determinant of SWB (Welsch, 2002, 2006). Welsch (2006) analyzes the effect of pollution on happiness in ten European countries. The findings reveal that air pollution is a robust determinant of cross-country and inter-temporal differences in subjective well-being. Rehdanz and Maddison (2008) use evidence from the German socio-economic panel to explain differences in reported levels

[2] Note that in line with the literature, we use the terms subjective well-being (SWB), happiness and life satisfaction interchangeably.

of well-being in relation to the environment. The results show that if other determinants are held constant, higher local air pollution and noise levels contribute significantly negatively to subjective well-being. The results confirm those of Sekulova and van Den Bergh (2013). The authors explore the determinants of life satisfaction in Barcelona from a sample of 840. One of the interesting findings in the context of our study is that the impacts of having experienced forest fires have a long-term negative effect on individuals' well-being. Grün and Grunewald's (2010) research was focused in Latin America using World Value Survey and Latino barometer survey data for 1985-2008. The authors investigated the relationship of subjective well-being as an alternative measure of welfare other than income to climate factors such as temperature, precipitation rates or cloud- covered days. Once the models were adjusted for gender, age, marital status and income, the authors ascertained that daily climate is a strong predictor of well-being that is felt subjectively. In particular, they confirmed a positive significant effect of temperature such that life satisfaction would increase with temperature during cold periods. However, the results during hot periods were confirmed to be insignificant. According to Frijters and Van Praag (1998) an increase in the number of cloud - covered days had a large negative effect on life satisfaction.

2. DATA AND METHODOLOGY

2.1. Data

We investigate the effect that temperature might have on the subjective well-being of sub-Saharan African countries by drawing on the data from all waves of the World Values Survey dataset (WVS-7, V1.0). The WVS contains information concerning various measures of SWB/happiness covering developed and developing regions like sub-Saharan countries. We examined all the waves of the WVS (starting from 1981-1984, 1989-1993, 1994-1998, 1999-2004, 2005-2009, 2010-2014 and 2017-2020) undertaken in nine sub-Saharan African countries to thoroughly unravel the effect of climate change on SWB/happiness. These countries include Ethiopia, Ghana, Mali, Nigeria, Rwanda, South Africa, Zimbabwe, Uganda, and Zambia. Apart from the WVS data, we also utilized data from other sources such as the World Development Indicators (WDI) that were merged with the WVS. Data on average annual temperature is collected from the World Bank's Climate Change Knowledge Portal.

2.1.1. Dependent Variable

The main dependent variable of interest is SWB/life satisfaction (self-report scale 1–10) which was operationalized based on the answer to the WVS question. All things considered, how satisfied are you with your life these days? Where 1 stands for *very dissatisfied* and 10 stands for *very satisfied*. For a robustness check, we used happiness (self-reported scale 1–4) as the dependent variable. This was measured by asking the respondents to answer the following question: Taking all things together would you say you are, on a scale of 1–4 if 1 = *not at all happy*; 2 = *not very happy*; 3 = *quite happy*; and 4 = *very happy*.

2.1.2. Independent Variables

We also include control variables that are considered important predictors of SWB.

Following the works of Diener, Tay, and Myers (2011) and Posel and Casale (2013) we included age (in years), *gender* (1= female or 0 otherwise), *marital status* (1)*marital* , (2) living together as married, (3) divorced, (4) separated, (5) widowed, (6) single/ never married. We added a dummy variable for marital status where 1= married, and 0= otherwise. Moreover, we included *highest education level* (1= inadequately completed elementary education, 2= completed (compulsory) elementary education, 3= incomplete secondary school, technical, 4= complete secondary school: technical/vocational, 5= incomplete secondary, university-preparation, 6= completed (compulsory) elementary education, 3= incomplete secondary school: technical, 4= complete secondary school, technical/vocational, 5= incomplete secondary, university-preparation, 6= complete secondary: university-preparation, 7= some university without degree/ higher education 8= university with degree/higher education).

Highest education variable was used as a continuous variable in the present study consistent with other research. Self-assessed health status was also one of the explanatory variables (1 = very poor, 2 =poor, 3 = fair, 4 = good and 5 = very good). A categorical variable was defined to be equal to 1 if the response is very good or good equal to 2 if the response is fair and equal to 3 if the response is very poor or poor. Religion has also emerged as a very influential determinant when it comes to research on well-being (Diener et al., 2011; Oishi & Diener, 2014). We created a dummy variable for religious status as 1= These respondents for whom religion is a significant part of their lives, and 0= otherwise. We included employment status, political party appeals, income distribution and country controls. Our employment measure is classified by the following categories (1= full time, 2= part time, 3= self-employed, 4= retired, 5= housewife, 6= student, 7 = unemployed or some other employment category). Our party political solicitations were couched in the form of the following question: in political matters, individuals refer to the left and the right. Where would you locate your views on this scale, overall? (10-point scale from 1=left to 10=right). The distribution of income was measured with a question. On this card, there is an income scale on which 1 is the lowest income group and 10 the highest income group in your country. We would like to know in which group your household is included. Please, give the appropriate number, including all wages, salaries, pensions and other revenues received. We constructed three ordinal variables: the incomes scale equal to 1 for the lowest group, 1st to 3rd scale equal to 2 for the middle group, 4th to 6th scale and equal to 3 for the highest group in the country, 7th to 10th scale. WVS also contains a set of questions on trust. We use a variable based on a trust question. Would you say that most people can be trusted or that you need to be very careful in dealing with people? (1= most people can be trusted and 2= need to be very careful). We measure country controls by using GDP at market prices "is the sum of gross value added by all resident producers in the economy plus any taxes on products not deducted at the production place plus minus any subsidies on products not subtracted at the production place? The dollar values of GDP are converted from domestic currencies with 2010 official exchange rates.

2.2. Methodology

To examine the impact of climate on SWB, one can run a pooled OLS model which is expressed as follows:

$$y_{it} = \beta_0 + \beta_1 X_{it} + \varepsilon_{it} \qquad (1)$$

Where y_{it} is the time-variant dependent variable that signifies the ordinal SWB of individual i at time t. X_{it} is a vector of determinants of SWB, including our main variable of interest being climate which is proxied by the mean temperature and the mean temperature squared (measured in degrees Celsius). By taking the mean squared temperature, it allows an analysis of the non-linear effect that temperature on SWB. β_1 is a vector of parameters to be estimated. β_0 and ε_{it} are the intercept and the error term, respectively.

A major limitation of this model is that there is no unobserved heterogeneity across countries. Consequently, the results may suffer from heterogeneity bias. We run a second pooled-OLS model which includes country controls, specifically the log of GDP per capita (expressed in terms of U.S. dollars) in addition to the same socioeconomic covariates included in the original pooled-OLS. To account for the problem of endogeneity (omitted variable bias), we additionally run a fixed effect (FE) regression which can be written as follows:

$$y_{it} = \beta_0 + \beta_1 X_{it} + z_i + \varepsilon_{it} \qquad (2)$$

Equation 2 differs from the above Equation 1 in that it includes z_i, the unobserved time-invariant individual effect. The main feature of the FE model, unlike the random effect (RE) model[3], is that it allows z_i to be correlated with the regressors, X_{it}, meaning that $E(z_i, X_{it}) \neq 0$.

[3] To test for endogeneity, we use the Durbin-Wu-Hausman test. Based on the results from the Durbin-Wu-Hausman test, we reject the null hypothesis. Therefore, we see the FE as the preferred model, however we include the RE results in Table 1A in the Appendix for comparison purposes and to act as a robustness check for our FE results.

For robustness purposes, the results of a RE ordered probit model are included in Table 1A in the Appendix. The ordered probit model is generally favoured in well-being studies given the ordinal nature of the dependent variable (i.e., it is ranked on an ordinal scale from 1 to 10, with 1 representing "very dissatisfied" and 10 representing "very satisfied"). However, based on the findings of Ferrer-i-Carbonell and Frijters (2004) which show that the results derived from OLS and ordered probit are generally very similar in sign and significance, researchers, including ourselves, chose to rely mostly on the OLS results. The primary reason for OLS coefficients is directly interpretable, unlike the ordered probit coefficient.

3. EMPIRICAL RESULTS

3.1. Results

We first employ the fixed effect to understand the SWB (coded on a scale of 1 to 10) as the main dependent variable of interest (see Table 1). We run random-effect ordered probit regressions to ensure the robustness of the fixed effect estimates (presented in the appendix). Other robustness checks undertaken through fixed- effect models are displayed in Tables 2-3. Specifically, we performed additional robustness checks by including alternative measures of the dependent variable of interest and splitting the sample into periods that are recognized as the warmest years on record (i.e., 1998). Column 1 of Table 1 presents the estimates of a baseline specification, which only regresses SWB on the independent variable of interest plus individual controls variables (such as education levels, marital status, health status, gender, religious status, employment status, views on political spectrum (right - wing or left-wing age and income scales)) without country controls as an initial analysis. On the other hand, column 2 of Table 1 displays the estimates of the specification which incorporates not only individual controls but also country controls that influence SWB. Most of the estimated coefficients in column 1 of Table 1 entered the model with expected signs and levels of significance in keeping with previous studies. Our independent variable of interest (average temperature) is entered in a non-linear fashion by including average temperature and average temperature squared. The results suggest that there is a non-linear relationship between average temperature and SWB. SWB initially rises with average temperature and begins to decrease at higher levels of temperature. Both the average temperature and average temperature squared enter the model significantly. Perhaps reassuringly, the estimates are reasonably robust when splitting the sample into periods which are recognized as the warmest years on record (2) and including alternative measures of the SWB (see Table 3).

As regards the control variables, we find that having the highest education levels, being married having a good health status, being female, being religious, being employed, being on the right side of the political spectrum — right wing and belonging to the middle- and high-income group scale are all positively associated with SWB. The estimated coefficients of age and age-squared suggests that SWB initially falls with age and rises as the individuals get older. This is consistent with many studies in this field that find the age effect on SWB to be u-shaped (Biyase, Fisher, & Pretorius, 2020; Blanchflower & Oswald, 2008). SWB is higher for individuals with the highest education levels enters positively and statistically and significantly at conventional levels consistent with Ye, Wu, and Wang (2015). Married individuals report higher SWB than their counterpart in line with Steele and Lynch (2013). Similarly, females report higher SWB than males (Steele & Lynch, 2013). Individuals on the right side of the political spectrum —right wing also report higher levels of SWB than those on the left side of the political spectrum (Owen, Videras, & Willemsen, 2008). Unsurprisingly, individuals belonging to the middle and high-income scale groups (income distribution measure) report higher levels of SWB. Posel and Casale (2013) found that in South Africa SWB is higher for those in the middle and richest thirds of the national income distribution than for their counterparts. Table A1 in the Appendix carries out some robustness checks using the random effect ordered probit. The results between the two models (OLS and ordered probit) are qualitatively similar (Ferrer-i-Carbonell & Frijters, 2004). Thus, we limit our analysis to the pooled OLS and fixed- effect estimates.

3.2. Robustness Check 1: Correcting for Country Controls

Column 2 of Table 1 is derived from the same specification as column 1 of Table 1 with the exception that it incorporates not only individual controls but also country controls that influence SWB. The estimated coefficients of the control variables are broadly in keeping with those in column 1 of Table 1 with reference to the direction, statistical significance, and magnitude. We find that the estimated coefficients which bring about the variation in SWB are having the highest education levels, being married, having a good health status, being female, being religious, being employed, being on the right side of the political spectrum —right wing and belonging to the middle- and high-income group scale. Country controls (measured by the GDP and country dummies) also appear to be important in explaining SWB. Perhaps unsurprisingly, we found that GDP is positively and significantly associated with the level of happiness with individual controls included. This finding confirms what has been found in the previous studies (please see (Woo, 2018)) that individuals living in poor countries are less happy compared to those living in rich countries.

Table 1. Fixed effect estimates of subjective well-being and climate.

Dependent variable-SWB	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**
Individual controls	**Model I**		**Model II**	
Ave-temp-Celsius	0.367**	0.144	0.948***	0.226
Ave-temp-SQ	-0.007*	0.003	-0.019***	0.005
Age	-0.083***	0.011	-0.080***	0.011
Age2	0.001***	0.000	0.001***	0.000
Highest education	0.063***	0.014	0.059***	0.015
Health status: Fair (Ref good)	-0.804***	0.071	-0.811***	0.071
HS_Poor	-1.647***	0.132	-1.644***	0.132
Gender (Female)	0.148**	0.055	0.142**	0.055
Religious_1	0.419***	0.099	0.439***	0.099
2nd (Ref: Left)	0.208	0.125	0.190	0.125
3rd	0.025	0.122	0.016	0.122
4th	0.017	0.122	0.018	0.122
5th	0.087	0.093	0.103	0.093
6th	0.176	0.109	0.175	0.109
7th	0.327**	0.117	0.331**	0.117
8th	0.366***	0.116	0.359***	0.116
9th	0.639***	0.137	0.628***	0.137
10th : Right	0.722***	0.118	0.720***	0.118
Married (Ref not married)	0.234***	0.064	0.228**	0.064
Trust (Ref trusted)	-0.126*	0.065	-0.096	0.066
4th to 6th steps (Ref 1st to 3rd)	1.060***	0.067	1.035***	0.068
7th to 10th steps	1.593***	0.077	1.562**	0.078
Part time (Ref full-time)	-0.286*	0.111	-0.296**	0.111
Self-employed	-0.145	0.088	-0.161	0.088
Retired	0.350*	0.138	0.366**	0.138
Housewife	0.284**	0.104	0.278**	0.104
Students	-0.021	0.103	-0.025	0.103
Unemployed	-0.515***	0.082	-0.504***	0.082
Cons	1.844	1.565	-6.526*	2.953
Country controls	NO		YES	YES
GDP	NO		0.184***	0.055
Country dummies	NO		YES	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

3.3. Robustness Check 2: Correcting for Severe Weather Shocks

Table 2 presents the results of the fixed effect model for sub-Saharan Africa with particular focus on the *global weather shock*. According to the Intergovernmental Panel on Climate Change (IPCC) (2001) 1998 is the warmest year in the instrumental record globally since 1861. To accurately capture this effect, we include a time dummy,

denoted as *Dummy98*, which gives a value of 0 for all observations included before 1998, and a value of 1 for all observations included after 1998. We observe the effect of climate change on SWB before and after 1998, a time period when global temperatures are known to have drastically risen.

The results show that most covariates share the same sign and level of significance as those in Table 2. Consistent with other international studies, we find a u-shaped relationship between age and happiness (Blanchflower & Oswald, 2008). Along the same lines, we find education and employment to be significant determinants of SWB. In addition, we find females to be significantly happier than males in sub-Saharan Africa. Trust, which was statistically significant at 10 percent in Table 2, is the single control variable that lost significance.

Two main findings emerge from Table 3. First, we see the non-linear relationship of temperature and subjective well-being to be u-shaped and insignificant. This suggests that prior to 1998, the impact of temperature on subjective well-being was not significant likely because prior to that period climate change was not a concept that was well-understood or widely accepted. Second, we find the time dummy to be negative and statistically significant at 1 percent, suggesting that post 1998, rising temperatures significantly reduced SWB in sub-Saharan Africa.

Table 2. Fixed effect estimates of subjective well-being and climate.

Dependent variable-SWB		
Individual controls	**Coef.**	**Std. err.**
Ave-temp-Celsius	-0.149	0.211
Ave-temp-SQ	0.005	0.005
Age	-0.080***	0.011
Age2	0.001***	0.000
Highest education	0.059***	0.015
Health status-Fair (Ref good)	-0.811***	0.071
HS_Poor	-1.644***	0.132
Gender (Female)	0.142*	0.055
Religious_1	0.439***	0.099
2nd (Ref: Left)	0.190	0.125
3rd	0.016	0.122
4th	0.018	0.122
5th	0.103	0.093
6th	0.175	0.109
7th	0.331**	0.117
8th	0.359***	0.116
9th	0.628***	0.137
10th :Right	0.720***	0.118
Married (Ref not married)	0.228***	0.064
Trust (Ref trusted)	-0.096	0.066
4th to 6th steps (Ref 1st to 3rd)	1.035***	0.068
7th to 10th steps	1.562***	0.078
Part- time (Ref full-time)	-0.296**	0.111
Self- employed	-0.161	0.088
Retired	0.366**	0.138
Housewife	0.278**	0.104
Students	-0.025	0.103
Unemployed	-0.504***	0.082
Dummy98	-0.314***	0.094
Cons	7.379***	2.278
Country dummies	YES	YES

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

3.4. Robustness Check 3: Alternative Measures of SWB

As a final robustness check, we include Table 3 which presents the results of the fixed effect model using a different dependent variable from the above two tables. We now use the dependent variable *happiness* instead of SWB. The happiness variable is similar to subjective well-being in that it is self-reported and ordinal in nature unlike subjective well-being which is ranked on a scale from 1to 10, happiness is ranked on a scale from 1to 4. Thus, we do this primarily as a robustness check to test the consistency and reliability of our previous results.

The only difference between model I and model II is that in model I, we assume homogeneity by excluding individual country controls and dummies, while in model II, we account for heterogeneity across countries by including country-specific controls and dummies. Despite this difference, both model I and model II suggest the same result and thus confirm our findings from above (referring to the findings from Tables 2 and 3). Again, we find strong evidence of the non-linear inverted u-shaped relationship between happiness and temperature for countries in sub-Saharan Africa. This suggests that as temperature raises, so too does happiness. However, rises in temperature beyond a certain threshold correspond with decreased levels of happiness.

Table 3. Fixed effect estimates of subjective well-being and climate.

Dependent variable: Happiness				
	Model I		**Model II**	
Variables	**Coef.**	**Std. err.**	**Coef.**	**Std. err.**
Ave-temp-Celsius	0.609***	0.0451	1.057***	0.071
Ave-temp-SQ	-0.015***	0.0010	-0.024***	0.002
Individual controls	YES		YES	
Country controls	NO		YES	
Country dummies	NO		YES	
Observations	8,723		8,723	
R-squared				
Within	0.147		0.154	
Between	0.642		0.707	
Overall	0.161		0.177	

Note: *** denote statistical significance at the 10%, level, respectively.

4. CONCLUSION

The purpose of this study was to investigate the effect of climate change on the SWB. The fixed effect method and the random effect ordered probit were applied. The results revealed that there is a non-linear relationship between average temperature and SWB. SWB initially rises with average temperature and begins to decrease at higher levels of temperature. Both the average temperature and average temperature squared enter the model significantly. The estimates are reasonably robust to including alternative measures of the SWB, splitting the sample into periods which are recognized as the warmest years on record. As regards to the control variables, we find that having the highest education levels, being married, having a good health status, being female, being religious, being employed, being on the right side of the political spectrum (right –wing) and belonging to the middle- and high-income group scale are all positively associated with SWB.

Research around climate change has focused mainly on its physical and environmental impacts while the mental health and well-being consequences have been secondary. This study shows that the climate factor has a significant effect on subjective well-being which puts climate on par with other traditional well-being determinants such as income, health, education, employment and so on (Mkrtchyan, Blam, Kovalev, & Tsvelodub, 2018). The effect of climate on subjective well-being can arise both directly and indirectly with certain communities and countries more vulnerable than others. A key to overcoming this is to build resilience, foster optimism and promote connectedness to family, religion and community (Clayton et al., 2017). Government and healthcare officials should expand mental health facilities, regularly assess the well-being of specific groups of concern and ensure adequate distribution of resources to affected regions.

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APPENDIX

Table 1a. Random-effects ordered probit estimates of subjective well-being and climate.

Dependent variable-SWB						
	Coef.	**Std. err.**	**z**	**Coef.**	**Std. err.**	**z**
Individual controls	**Model I A**			**Model II A**		
Ave-temp-Celsius	0.154	0.062	2.47	0.373	0.098	3.81
Ave-temp-SQ	-0.003	0.002	-2.09	-0.008	0.003	-3.55
Age	-0.035	0.005	-7.07	-0.034	0.005	-6.88
Age2	0.001	5.681	7.15	0.001	5.691	6.95
Highest education	0.024	0.006	3.71	0.021	0.006	3.4
Health status-Fair (Ref good)	-0.329	0.031	-10.69	-0.330	0.031	-10.76
HS_Poor	-0.668	0.058	-11.53	-0.666	0.058	-11.51
Gender (Female)	0.061	0.024	2.56	0.059	0.024	2.47
Religious_1	0.186	0.043	4.37	0.194	0.043	4.56
2^{nd} (Ref: Left)	0.036	0.054	0.66	0.029	0.055	0.54
3^{rd}	-0.034	0.053	-0.62	-0.037	0.053	-0.7
4^{th}	-0.046	0.053	-0.86	-0.046	0.053	-0.86
5^{th}	-0.002	0.041	-0.06	0.002	0.041	0.06
6^{th}	0.027	0.048	0.55	0.025	0.048	0.52
7^{th}	0.074	0.051	1.46	0.075	0.051	1.47
8^{th}	0.105	0.050	2.08	0.101	0.050	2
9^{th}	0.241	0.060	4.03	0.235	0.060	3.94
10^{th} :Right	0.335	0.052	6.43	0.333	0.052	6.39
Married (Ref not married)	0.097	0.028	3.51	0.095	0.028	3.45
Trust (Ref trusted)	-0.059	0.028	-2.1	-0.048	0.028	-1.7
4^{th} to 6^{th} step (Ref 1^{st} to 3^{rd})	0.428	0.029	14.62	0.418	0.029	14.19
7^{th} to 10^{th} step	0.645	0.034	19.17	0.633	0.034	18.65

Dependent variable-SWB						
	Coef.	Std. err.	z	Coef.	Std. err.	z
Individual controls	Model I A			Model II A		
Part time (Ref full-time)	-0.117	0.048	-2.45	-0.121	0.048	-2.54
Self employed	-0.061	0.038	-1.61	-0.068	0.038	-1.8
Retired	0.146	0.060	2.45	0.151	0.060	2.53
Housewife	0.135	0.045	2.99	0.132	0.045	2.93
Students	0.005	0.045	0.12	0.003	0.045	0.07
Unemployed	-0.205	0.036	-5.74	-0.201	0.036	-5.64
LOGGDP_PC_US				0.070	0.02389	0.024
Country controls		NO		YES		
GDP		NO		YES		
Country dummies		NO		YES		
Observation		8,737		8,737		
/cut1	0.292	0.686		3.297	1.269	
/cut2	0.585	0.686		3.590	1.269	
/cut3	0.883	0.686		3.888	1.269	
/cut4	1.155	0.686		4.160	1.269	
/cut5	1.591	0.686		4.597	1.269	
/cut6	1.870	0.686		4.876	1.270	
/cut7	2.240	0.686		5.246	1.270	
/cut8	2.763	0.686		5.770	1.270	
/cut9	3.188	0.686		6.195	1.270	