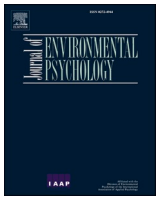
Journal of Environmental Psychology 87 (2023) 101991

Contents lists available at ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep



Climate change anxiety in China, India, Japan, and the United States

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ARTICLE INFO

Handling Editor: Mark Ferguson

Keywords:
Climate change
Climate change anxiety
Climate anxiety
Cross-cultural
Measurement invariance
Pro-environmental behavior

ABSTRACT

Climate change anxiety is becoming recognized as a way in which climate change affects mental health. It is not only observed in populations that suffer the most from the direct impacts of climate change but also can be trigged by the mere thought and perception about such impacts. Although climate change is a global problem that is a cause for concern around the world, research on climate anxiety has only recently utilized validated measures, and it has mostly been conducted in Western and developed societies. In response to this research gap, we conducted a cross-national study of climate change anxiety using the Climate Change Anxiety Scale, with participants (N = 4000) from four of the top emitters in the world (China, India, Japan, and the U.S.) which vary in their climate change vulnerabilities and resilience. We demonstrated that the widely adopted measure of climate change anxiety exhibited configural and metric invariance in the four countries. Climate change anxiety was apparently higher in the Chinese and Indian populations than in the Japanese and American populations. There were some demographic correlates of climate change anxiety, but the pattern was not always consistent across the countries. Climate change anxiety was positively associated with engagement in climate action in all four countries, but apparently more so for sustainable diet and climate activism than resource conservation and support for climate policy. The effect was driven more robustly by the cognitive-emotional impairment dimension than the functional impairment dimension of climate change anxiety. Taken together, these observations suggest that the Climate Change Anxiety Scale can be used to assess climate change anxiety across countries, and that there are both similarities and variations across different societal contexts with respect to the experience of climate change anxiety. Future research must take these complexities into consideration.

1. Introduction

The recent contribution by Working Group II to the Sixth Assessment Report of Intergovernmental Panel on Climate Change (IPCC, 2022) highlights an alarming reality: The impacts of climate change are already felt in every corner of the world, and humanity is locked to even more severe and intense impacts in the near term. Urgent action in terms of both mitigation and adaptation is needed. For the world to preserve a chance of limiting temperature rise to 1.5 degrees C, a target designated in the Paris Agreement, greenhouse gas emissions should be halved by 2030 (IPCC, 2022). Put it simply, the window for action to avoid irreversible outcomes is closing more quickly than previously thought.

Against this backdrop of a changing climate, stories regarding people's anxiety and worries about the existential and symbolic threats of climate change, as well as their despair and anger towards the lacklustre performance of governments and world leaders in mitigation and adaption efforts, are increasingly gaining traction in the media. These negative emotional responses are not only observable among people who are directly affected by the ill impacts of climate change; they can also be trigged by mere thought and perception about climate change among individuals who do not personally suffer from direct impacts (Clayton, 2020; IPCC, 2022). The latter observation suggests that these negative responses can be observed even in populations who are not critically vulnerable to climate risks, such as those living in highly developed and resilient regions.

The emerging phenomenon of fear, worry, and apprehension associated with concerns about climate change has also become a focus of scientific investigations in recent years. Researchers refer to this phenomenon as *climate change anxiety* (Clayton, 2020) and *climate anxiety* (Crandon et al., 2022), or, when referring to the ecological crisis in the broadest sense, *eco-anxiety* (Coffey et al., 2021; Hogg et al., 2021). Empirical efforts have been made to understand who experiences more

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https://doi.org/10.1016/j.jenvp.2023.101991
Received 3 September 2022; Received in revised form 13 February 2023; Accepted 23 February 2023
Available online 28 February 2023

climate change anxiety, whether it is associated with human physical and mental health, how people cope with it, and whether it can motivate climate action (Clayton, 2020; Crandon et al., 2022; Stanley et al., 2021).

Although we have learned much from previous studies, our knowledge is limited by the fact that most of these studies have relied on samples drawn from a narrow subset of human populations, namely Western, Educated, Industrialized, Rich, and Democratic (WEIRD) societies (Henrich et al., 2010). A recent systematic review on climate anxiety and eco-anxiety by Coffey et al. (2021) located only four studies that empirically assessed eco-anxiety or climate anxiety (Clayton & Karazsia, 2020; Helm, Li, Curran, & Barnett, 2022; Searle & Gow, 2010; Stanley et al., 2021) within the period from 2010 to 2021. Notably, both Clayton and Karazsia (2020) and Helm et al. (2022) used participants from the U.S., and both Searle and Gow (2010) and Stanley et al. (2021) used participants from Australia. Coffey et al. (2021) concluded that more research evidence on climate or eco-anxiety is needed from populations that have been underrepresented. Our own reading of the literature revealed a few more studies in the past two years (e.g., Hogg et al., 2021; Innocenti et al., 2021; Mouguiama-Daouda et al., 2022; Wullenkord et al., 2021). With only a few exceptions, these studies were also based on samples from WEIRD societies. Such samples are not only limited, but they are also likely to be less affected by climate change than samples from other countries. Although they are not immune, the financial resources as well as the geographic location of North America and Europe provide some protection from the extreme consequences that are already being experienced by Africa, Southeast Asia, and low-lying island nations.

To advance our understanding of climate change anxiety, we need to expand our geographical representation and obtain research findings from a wider range of societies. The present research is primarily aimed to present a cross-national study of climate change anxiety with participants from four of the top emitters in the world: China, India, Japan, and the U.S. These four countries were carefully selected with reference to not only their emissions levels but also their geographical location, economic development, population size, and vulnerability to climate change impacts and readiness to adapt. Although they are similar at a country level as major contributors to greenhouse gas emissions, they are very different in culture and in individual lifestyle.

1.1. Climate change anxiety

More people than not are conscious of the impending threat of climate change. A recent survey study, *Peoples' Climate Vote*, which was said to be the largest survey of public opinion on climate change ever conducted (United Nations Development Programme, 2021), revealed that close to two-thirds (64%) of the 1.2 million respondents from 50 countries believed that climate change is a global emergency. Another recent poll based on over 76,000 active Facebook users from 31 countries by the Yale Program on Climate Change Communication (2021) showed that in most countries, a majority of respondents believed that climate change would harm them personally by a "a great deal" or "a moderate amount." People's perception of the impacts of climate change is not limited to its existential threat. Recent studies have shown that people may also be aware of the social and cultural impacts of climate change. For example, a recent study (Tam et al., 2022) showed that respondents from Singapore and the U.S. reported strong awareness of the impacts of climate change on both tangible (e.g., monuments, historical sites) and intangible entities (e.g., values, know-hows, traditions) of human cultures.

It is well understood that direct experience of acute climate events is detrimental to human physical and mental health (e.g., Manning & Clayton, 2018; Obradovich et al., 2018), but emerging research has reported that the ill impact of climate change on mental health also extends to people who do not have a direct experience of climate-related extreme events or disasters via the role of climate change anxiety (Clayton & Karazsia, 2020). Despite its clinical relevance, climate change anxiety is not necessarily pathological. It can be seen as a reasonable response to anticipated and uncertain threats, although it may lead to both adaptive (e.g., adaptation and mitigation) and maladaptive consequences (e.g., climate change denial, psychological ill-being).

To date, little research has empirically examined the antecedents and consequences of climate anxiety. A recent systematic review on climate anxiety and eco-anxiety by Coffey et al. (2021) found only four studies that empirically examined climate or eco-anxiety and its correlates (Clayton & Karazsia, 2020; Helm et al., 2022; Searle & Gow, 2010; Stanley et al., 2021) since 2010. We are aware of a few more studies after Coffey et al.'s (2021) review (e.g., Hickman et al., 2021; Innocenti et al., 2021; Reyes et al., 2021). Together, these studies showed that higher climate or eco-anxiety is associated with poorer mental health, including more clinically significant anxiety and depressive symptoms, lower levels of psychological well-being, and higher levels of psychological distress and ill-being. People who are more connected to nature tend to report higher levels of climate or eco-anxiety, probably because they are more disturbed by the happening of environmental degradation (Clayton & Karazsia, 2020; Helm et al., 2022). Clayton and Karazsia (2020) found that younger adults reported higher levels of climate anxiety than older adults did; they attributed this age difference to the possibility that young people are more likely to experience the catastrophic impacts of climate change in the future. Hickman et al. (2021) also found that this heightened level of climate-related distress among young people was related to the perceived failure of the government in tackling climate change. Lastly, while some studies found that climate anxiety was unrelated to mitigation behaviors (Clayton & Karazsia, 2020; Helm et al., 2022), other studies revealed a positive association (Mouguiama--Daouda et al., 2022; Wullenkord et al., 2021).

1.2. Climate change anxiety in China, India, Japan, and the U.S

With only a few exceptions (Hickman et al., 2021; Reyes et al., 2021), studies on climate change anxiety were predominantly based on samples from WEIRD societies. It is important to recognize the potential relevance of socio-cultural contexts to climate change-related phenomena. Recent studies have already demonstrated that there are substantial variations across societies and cultures in terms of how people perceive and respond to climate change (e.g., Chan & Tam, 2021; Tam & Chan, 2017). Unfortunately, the existing knowledge base is still dominated by evidence from the Western world (Tam et al., 2021; Tam & Milfont, 2020). Many have already made a call for expanding the geographical representation of behavioral research in general (Henrich et al., 2010) and the study of climate change and human behavior specifically (Eom et al., 2019; Tam et al., 2021; Tam & Milfont, 2020). Echoing these calls, in the present research, we aim to examine climate change anxiety with a cross-national study.

The present study included China, India, and Japan, in addition to the U.S. Table 1 provides a detailed comparison of the four countries. This sample of countries allowed us to examine climate change anxiety in both WEIRD and non-WEIRD contexts. Specifically, this sample included Western as well as Asian countries. Also, educational level (in terms of adult literacy rate), economic development (in terms of GDP per capita), and level of democracy varied across these four countries.

There are climate change-related similarities and differences among these four countries (Table 1). All of them are the biggest emitters in the world, both historically and currently. They are among the top of the world in terms of population size. Also, all four countries are currently insufficient or highly insufficient in terms of government targets and actions to reduce greenhouse gas emissions with respect to the Paris Agreement. Significantly, these four countries also varied in vulnerability. Compared to China and India, Japan and the U.S. are less vulnerable to the impacts of climate risks and have a higher level of readiness to adapt to such impacts. In particular, India was among the

Table 1
Comparing the four countries sampled in the present study.

	Country			
	China	India	Japan	US
Continent	Asia	Asia	Asia	North America
Population size in 2021 (in thousands)[a]	1,412,360.00 (1st)	1,393,409.03 (2nd)	125,681.59 (11th)	331,893.74 (3rd)
GDP per capita (current $US)[b]	10,217 (65th)	2100 (135th)	40,247 (24th)	65,298 (6th)
Adult literacy rate[c]	96%	72%	99%	99%
Democracy Index 2021 [d]	2.21 (148th)	6.91 (46th)	8.15 (17th)	7.85 (26th)
Cumulative GHG emissions 1999–2019 (in $MtCO_2e$)[e]	212,226.95 (1st)	61,248.92 (3rd)	35,546.11 (7th)	177,781.15 (2nd)
GHG emissions in 2019 (in $MtCO_2e$)[e]	12,055.41 (1st)	3363.59 (3rd)	1134.45 (7th)	5771.00 (2nd)
ND-GAIN vulnerability score (lower scores, less vulnerability)[e]	0.39 (66th)	0.50 (134th)	0.36 (38th)	0.35 (29th)
ND-GAIN readiness score (higher scores, more readiness)[e]	0.47 (66th)	0.34 (123rd)	0.73 (9th)	0.69 (18th)
Climate action tracker overall rating[f]	Highly insufficient	Highly insufficient	Insufficient	Insufficient

Note. The numbers in brackets refer to country ranking. Ranking was identified based on individual countries; member states in European Union were counted separately.

[a] The World Bank. https://data.worldbank.org/indicator/SP.POP.TOTL.
[b] International Monetary Fund. https://www.imf.org/external/datamapper/NGDPDPC@WEO/OEMDC/ADVEC/WEOWORLD
[c] The World Bank. https://ourworldindata.org/grapher/cross-country-literacy-rates.
[d] Democracy Index. https://www.eiu.com/n/campaigns/democracy-index-2021.
[e] Climatewatch. https://www.climatewatchdata.org/ghg-emissions.
[f] Climate Action Tracker. https://climateactiontracker.org/countries.

top in the world in terms of both vulnerability to climate change impacts and lack of readiness to adapt.

In sum, the sampling of these four countries allowed us to examine climate change anxiety not only in both Western and non-Western contexts but also in societies with different climate change-related landscapes. As these countries are the biggest emitters in the world and currently exhibit insufficient efforts in emissions reduction, urgent and deep transformations are needed there. Our findings could potentially contribute valuable insights into how these transformations can be motivated.

1.3. Research questions

With a cross-national study including the four countries named, we attempted to answer the following four research questions.

1.3.1. Measurement invariance of climate change anxiety

Empirical research on climate change anxiety necessitates a validated measure of climate anxiety. One of the few available measures in the psychological literature is the *Climate Change Anxiety Scale* (Clayton & Karazsia, 2020). It was developed in the U.S. using participants recruited via Amazon Mechanical Turk. Its 13 items were developed based on extensive reading of the psychological literature, existing measures, and a variety of blogs discussing people's emotional responses to climate change. According to Clayton and Karazsia (2020), these items fall into two factors: cognitive-emotional impairment (i.e., cognitive and emotional impairment in response to climate change, as reflected in sleep difficulties, nightmares, difficulty in concentrating, and rumination), and functional impairment (i.e., interference with the person's work or school and social life). Recent studies using this scale suggested that climate change anxiety indeed carries mental health and even psychiatric implications. For example, with a sample of young adults (undergraduate and graduate students) in the U.S., Schwartz et al. (2022) found that both factors of climate change anxiety were significantly associated with generalized anxiety disorder symptoms, and the functional impairment factor was associated with higher major depressive disorder symptoms.

Developed just two years ago, the Climate Change Anxiety Scale has attracted increasing attention. To understand how the scale was used in previous studies, we performed a systematic review of the literature. We performed a search on August 29, 2022 using the following two databases: Web of Science, and Scopus. We retrieved all articles that had cited the article by Clayton and Karazsia (2020). We were able to retrieve 79 articles in Web of Science and 87 articles in Scopus, respectively. We read the abstract and full text of these articles in order to identify studies that adopted the Climate Change Anxiety Scale. In the end, we located eight articles reporting nine studies in total. We additionally located two articles that were just published and did not show up in the two databases yet. In the end, we had 10 articles reporting 11 studies.

Table 2 details the information of these 11 studies. A noticeable issue of these previous studies using the Climate Change Anxiety Scale is the predominance of samples from WEIRD societies. The original studies by Clayton and Karazsia (2020) were conducted in the U.S. Among the 11 studies identified in our search, eight studies used only participants from either the U.S. or a European country that can be classified as high-income, developed, and democratic. Two of the exceptions were Reyes et al. (2021) and Simon et al. (2022), both of which were conducted in the Philippines. Another exception was Heeren, Mouguiama-Daouda, and Contreras (2022), wherein French-speaking participants were recruited from multiple European and African countries; it should be noted that for this study, a huge majority of the participants were from France and Belgium, and only 2.21% were African.

For meaningful conclusions to be drawn from future research to be conducted in different societies, the measurement of climate change anxiety must be evidenced to be cross-culturally valid in the first place. That is, it must be empirically established that the measure indeed assesses the same psychological construct in all groups, a condition referred to as measurement invariance (Milfont & Fischer, 2010). To date, in research on climate change anxiety, evidence of measurement invariance of existing measures is lacking. As Table 2 shows, most of the previous studies using the Climate Change Anxiety Scale demonstrated the psychometric properties of the measure used (mostly in terms of factor structure and internal consistency) were adequate among the participants from a single country. However, it is inconclusive to date that the two-factor structure reported in the original study (Clayton & Karazsia, 2020) is replicable in other countries (Wullenkord et al., 2021). The factor structure of the scale was found to be acceptable in several studies (Larionow et al., 2022; Mouguiama-Daouda et al., 2022; Simon et al., 2022), but it was either not tested at all (Bratu et al., 2022; Heeren, Mouguiama-Daouda, & Contreras, 2022; Reyes et al., 2021; Schwartz et al., 2022; Whitmarsh et al., 2022) or found to be not acceptable (Innocenti et al., 2021; Wullenkord et al., 2021) in the remaining studies.

It should be noted that among studies on negative emotions in response to climate change in general, those studies involving participants from multiple countries also did not include any cross-cultural validation. Typically, only internal consistency (in the form of

Table 2
Previous studies that used the climate change anxiety scale (Clayton & Karazsia, 2020).

Study	Participants	Country	Factor structure accepted	Sample means	Correlations with demographic factors	Correlations with climate action
Original study						
Clayton & Karazsia (2020)	(Study 1) 197 participants recruited via Amazon MTurk (Study 2) 199 participants recruited via Amazon MTurk (Study 3) 217 participants recruited via Amazon MTurk	The United States	(Study 1) Four-factor model (including behavioral engagement and climate change experience as well) accepted in EFA (Study 2) Four-factor model (including behavioral engagement and climate change experience as well) accepted in CFA (Study 3) Not examined	(Study 1) Cognitive-emotional impairment: 1.75; functional impairment: 2.09 (Study 2) Cognitive-emotional impairment: 1.75; functional impairment: 2.01 (Study 3) Not reported	(Study 1) No sig. gender differences; higher among younger participants (Study 2) No sig. gender differences; higher among younger participants; higher among more educated participants	(Study 1) No sig. correlation with behavioral engagement (Study 2) Same as Study 1 (Study 3) Not examined
Later studies						
Bratu et al. (2022)	439 participants (pre-heat dome) and 420 participants (post-heat dome) recruited via paid social media ads	Canada	Not reported	(Pre-heat dome) Cognitive-emotional impairment: 1.65; functional impairment: 1.68 (Study 2) Cognitive-emotional impairment: 1.84; functional impairment: 1.92	Not reported	Not reported
Heeren, Mouguiama-Daouda, & Contreras (2022)	2080 French-speaking participants recruited via online social media and listserv ads	Mainly France and Belgium, plus Switzerland, Gabon, Rwanda, Morocco, Algeria	Not reported	Cognitive-emotional impairment: 2.00; functional impairment: 2.16	Higher among women (cognitive-emotional impairment only); higher among younger participants; no sig. relationship with education	Positively correlated with behavioral engagement
Innocenti et al. (2021)	130 adults recruited via convenience and snowball sampling methods	Italy	One-factor model accepted in EFA; no model accepted in CFA	Full scale: 1.39 (derived from reported item means)	Not reported	Positively correlated with self-reported pro-environmental behavior
Larionow et al. (2022)	603 adults recruited via social networking sites	Poland	Three-factor model accepted in EFA; two-factor and three-factor models accepted in CFA (also, 2-factor and the 3-factor models showed measurement configural, metric, and scalar invariance across different gender, age, and educational level categories)	Cognitive-emotional impairment: 1.59; functional impairment: 1.52 (derived from reported item means)	Higher among women; higher among younger participants; higher among less educated participants	Positively correlated with behavioral engagement
Mouguiama-Daouda et al. (2022)	(Study 1) 305 adults recruited via online social media and listserv advertisements (Study 2) 905 adults recruited via similar procedures	France	(Study 1) Two-factor model accepted in CFA (Study 2) Two-factor model accepted in CFA	(Study 1) Cognitive-emotional impairment: 1.80; functional impairment: 1.68 (derived from reported item means) (Study 2) Cognitive-emotional impairment: 2.02; functional impairment: 2.26 (derived from reported item means)	Not reported	Not examined
Reyes et al. (2021)	433 young adults recruited via social media posts	The Philippines	Not reported	Full scale: 2.38	Not reported	Not examined

(continued on next page)

Table 2 (*continued*)

Study	Participants	Country	Factor structure accepted	Sample means	Correlations with demographic factors	Correlations with climate action
Schwartz et al. (2022)	284 young adults recruited via university participant pool and email and social media outreach	The United States	Not reported	Cognitive-emotional impairment: 1.41; functional impairment: 1.69	No sig. gender differences; no sig. correlations with age, ethnicity, or financial aim recipient status	Cognitive-emotional impairment positively correlated with climate activism; functional impairment positively correlated with individual action and climate activism
Simon et al. (2022)	452 undergraduate students in a private university recruited via class announcements	The Philippines	Two-factor model with correlated errors accepted in CFA	Cognitive-emotional impairment: 2.33; functional impairment: 1.97 (derived from reported mean subscale total sores)	Not reported	Positively correlated with behavioral engagement
Whitmarsh et al. (2022)	1338 adults (Time 1) and 891 adults (Time 2) recruited via an online participant panel, demographically representative	The United Kingdom	Not reported	(Time 1) Full scale: 1.25 (Time 2) Full scale: 1.28	No sig. gender differences; higher among younger participants; no sig. correlation with income	Positively correlated with some of the self-reported pro-environmental behaviors examined
Wullenkord et al. (2021)	1011 adults recruited via an online panel provider, stratified by age and gender	Germany	No acceptable model in CFA; no acceptable model in EFA (single scale score adopted in the end)	Full scale: 1.81 (on 7-point scale)	Higher among women; no sig. correlations with age, income, and education	Positively correlated with pro-environmental intentions and policy support

Note. CFA = confirmatory factor analysis. EFA = exploratory factor analysis.

Cronbach's α) was considered in each country separately. For instance, in Hickman et al. (2021), a 10-country study, a list of negative words was used to measure respondents' negative emotional responses to climate change. The factor structure of these words was not examined, and the cross-national measurement invariance of the measure was not established. Similarly, in both Ogunbode et al. (2021), a 25-country study, and Ogunbode et al. (2022), a 32-country study, negative climate-related emotions were measured with a 7-item index; again, the factor structure of this scale was not reported, and measurement invariance was not tested.

In all, notwithstanding the advances previous studies on climate change anxiety have made, it is still uncertain whether the existing measures (e.g., the Climate Change Anxiety Scale) have the same psychometric properties and carry the same meanings for people from different populations. As a result, arguably, it can be said that to date, findings on the topic based on different populations are not directly comparable. This presents a hindrance for the development of future research. To address this issue, in the present study, we first examined the measurement invariance of the Climate Change Anxiety Scale in the four countries (*Research Question 1*).

1.3.2. Prevalence of climate change anxiety

Clayton and Karazsia (2020) reported that the prevalence of climate change anxiety was fairly low in their American samples, with a minority of participants reporting high scores. Our summary (Table 2) also shows the low prevalence among the samples in the later studies using the Climate Change Anxiety Scale. Among these studies, most of the time the sample means were substantially below the scale mid-point and even below 2 on a five-point scale. Interestingly, the sample means were apparently higher among the two Philippines samples (Reyes et al., 2021; Simon et al., 2022). The apparent difference between studies suggests the potential cross-country variability of the experience of climate change anxiety. Two recent studies (with different measures of negative emotions or anxiety toward climate change) also hinted at this possibility (Clayton, Pihkala, Wray, & Marks, 2023; Ogunbode et al., 2022), but measurement invariance and sample representativeness were not established in these studies.

To what extent does the prevalence of climate change anxiety vary between societies? To stringently compare it across societies, we need to first establish the measurement invariance of the Climate Change Anxiety Scale in multiple countries. Also needed is the use of more representative and comparable samples from the countries. In the present research, because we included four countries with varying levels of climate change vulnerabilities and resilience (see Table 1), assuming scalar invariance of the scale, we would be able to directly explore if climate change anxiety is more prevalent in some populations that others (*Research Question 2*).

1.3.3. Demographic correlates of climate change anxiety

If higher climate change anxiety is associated with poorer mental health, as discussed, then it is important to identify individuals in a society who are more susceptible to it and provide timely intervention. This practical concern leads us to the following research question: Demographically, which groups of individuals are more prone to the experience of climate change anxiety?

As summarized in Table 2, some of the previous studies using the Climate Change Anxiety Scale did compare different demographic groups, but the results were inconsistent. For example, while Clayton and Karazsia (2020), as well as Schwartz et al. (2022), did not find any significant gender differences, both Larionow et al. (2022) and Wullenkord et al. (2021) observed that anxiety was higher among female participants. Similar inconsistencies were observed with respect to the effects of age, income, and educational levels.

These results are difficult to reconcile, primarily because the sampling methods varied across the previous studies. Except for Schwartz et al. (2022) and Whitmarsh et al. (2022), all of these studies recruited participants based on convenience, without any systematic procedures to recruit participants representing members from different demographic groups. With the assumed configural and metric invariance of the Climate Change Anxiety Scale and the use of more representative and comparable samples from the four countries in the present study, we were able to explore these demographic correlates of climate change anxiety more stringently and also expose any cross-national differences in terms of these relationships (*Research Question 3*).

1.3.4. Association with climate action

Another critical issue to consider with respect to the experience of climate change anxiety is the extent to which it motivates adaptive responses in terms of engagement in climate action. Clayton and Karazsia (2020) reported that both dimensions of climate change anxiety were not significantly correlated with their measure of behavioral engagement (which referred to not only engaging in sustainable behavior, but also endorsing the significance of a behavioral response and self-efficacy). However, among the remaining studies that examined this relationship, all of them observed a positive relationship between anxiety and at least some types of climate action, as summarized in Table 2.

In the present study, we conceptualized climate action in terms of not only private-sphere pro-environmental behavior but also climate activism and support for climate policies.

With the assumed measurement invariance of the measures of climate chance anxiety and the various types of climate action, as well as the use of more representative and comparable samples, we were able to more stringently examine the association between climate change anxiety and climate action in multiple societal contexts (*Research Question 4*). We expected a general positive association, based on studies summarized in Table 2.

It is noteworthy that recent environmental psychology research has well documented that pathways to climate action tend to vary across societies (Chan & Tam, 2021; Tam & Chan, 2017; Tam & Milfont, 2020). For example, climate change concern and social norms, both of which are often assumed to be a significant determinant of climate action, have respectively found to have a stronger effect in some societies (e.g., individualistic countries, wealthier countries) than in others (Chan et al., 2022; Chan & Tam, 2021). This pattern was also observed in a recent study regarding the relationship between climate change anxiety and climate action (Ogunbode et al., 2022). Our study was also able to expose any cross-national variability of this association.

2. Method

We conducted our study with samples from the four countries. All procedures were approved by the Committee of Research Practices of The Hong Kong University of Science and Technology. This study was preregistered before data collection. The preregistration can be viewed here: https://doi.org/10.17605/OSF.IO/64TBE.

2.1. Participants

This survey was administered in summer 2021. In total, 4000 participants (1000 from each of the four countries) were recruited. The participants were sampled with the service by a market research company named Ipsos. The samples were nationally representative in terms of distributions of gender and age. Participants from diverse income levels and education levels were included. For full details of the distributions of these demographic factors in each country, please refer to the supplementary document.

2.2. Measures

2.2.1. Climate change anxiety

Participants responded to the Climate Change Anxiety Scale (Clayton & Karazsia, 2020). Responses were recorded on a 5-point scale (1 = never to 5 = almost always). Details of the validation of the scale will be reported in the Results section. The scale items (with English and the translated Chinese and Japanese versions) are listed in Table 3.

2.2.2. Demographic variables

We included the following demographic variables: age (1 = 18–24 years to 6 = 65 years and over), gender (0 = female, 1 = male), income (because different scales were used in different countries, we standardized this variable within country for easier comparison), and education (1 = less than high school to 5 = Master's degree or higher).

Table 3
The climate change anxiety scale (original version and translated Chinese and Japanese versions).

English
Please rate how often the following statements are true of you. (1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, 5 = Almost always)
1. Thinking about climate change makes it difficult for me to concentrate.
2. Thinking about climate change makes it difficult for me to sleep.
3. I have nightmares about climate change.
4. I find myself crying because of climate change.
5. I think, "why can't I handle climate change better?"
6. I go away by myself and think about why I feel this way about climate change.
7. I write down my thoughts about climate change and analyze them.
8. I think, "why do I react to climate change this way?"
9. My concerns about climate change make it hard for me to have fun with my family or friends.
10. I have problems balancing my concerns about sustainability with the needs of my family.
11. My concerns about climate change interfere with my ability to get work or school assignments done.
12. My concerns about climate change undermine my ability to work to my potential.
13. My friends say I think about climate change too much.
Chinese
请说明以下情况发生在您身上的频率。(1 = 从未, 2 = 偶尔, 3 = 有时, 4 = 经常, 5 = 几乎总是)
1. 想到气候变化会让我难以集中注意力。
2. 想到气候变化会让我难以入眠。
3. 我会做关于气候变化的噩梦。
4. 我发现自己会因为气候变化而哭泣。
5. 我会思考「为什么我不能更好地应对气候变化？」
6. 我在独处的时候会思考为什么我对气候变化有这种感觉。
7. 我写下自己对气候变化的看法并进行分析。
8. 我会思考「为什么我要以这种方式应对气候变化？」
9. 我对气候变化的担忧使我很难与家人或朋友一起玩乐。
10. 我无法平衡我对可持续性的担忧和家人的需求。
11. 我对气候变化的担忧使我无法很好地完成工作或學校作业。
12. 我对气候变化的担忧削弱了我发挥潜力的能力。
13. 我的朋友说我对气候变化过虑了。
Japanese
以下の記述があなたにどの程度該当するかを評定してください。(1 = 全く該当しない, 2 = ほとんど該当しない, 3 = 時々該当する, 4 = 頻繁に該当する, 5 = ほとんど常に該当する)
1. 気候変動について考えると、集中することが難しくなる。
2. 気候変動について考えると、眠ることが難しくなる。
3. 気候変動について悪夢を見る。
4. 気候変動が原因で泣きたくなる。
5.「なぜ私は気候変動にもっとうまく対処できないのか？」と思う。
6. 一人で、気候変動についてこのように感じるのはなぜか考える。
7. 気候変動について自分の考えを書き留め、それを分析する。
8.「なぜ私は気候変動にこのように反応するのか？」を考える。
9. 気候変動に関する私の懸念によって、家族や友人と楽しむことが難しくなっている。
10. 持続可能性についての懸念と、家族のニーズのバランスを取ることができない。
11. 気候変動についての懸念によって、仕事や学校の宿題が手につかなくなっている。
12. 気候変動についての懸念によって、私の能力を発揮することができなくなっている。
13. 友人は、私が気候変動について考えすぎだと言う。

2.2.3. Climate action

Participants reported their intention to perform private-sphere climate action by indicating how likely they would do each of the nine behaviors in the next year. This list of behaviors was adopted from a survey study by Ipsos (2020). Participants responded on a 5-point scale (1 = not at all likely to 5 = extremely likely), with an option of "Not applicable" (which was treated as a missing value). A set of preliminary analyses revealed a two-factor structure of this measure. After removing items with double loadings, six items were retained, with four items referring to resource conservation (e.g., avoiding products which have a lot of packaging) and two items referring to sustainable diet (e.g., eating less meat, or replacing the meat in some meals with alternatives such as

beans). This measure with two sub-scales displayed configural and metric invariance (but not scalar invariance) across the four countries. For each participant, we computed the mean score for each subscale. Both sub-scales were reliable. (All items and details of the psychometric analyses for this measure and the following ones are reported in the supplementary document.)

Participants also reported their intention to participate in climate activism by indicating how likely they would do each of the six things when asked by a person they like and respect (e.g., sign a petition about climate change, either online or in person). This list of behavior was adopted from Leiserowitz et al. (2019). Participants responded on a 4-point scale (1 = definitely would not to 4 = definitely would), with an additional option of "Prefer not to answer/not applicable" (which was treated as a missing value). A set of preliminary analyses revealed a one-factor structure of this measure. This measure displayed configural and, to some degree, metric invariance (but not scalar invariance) across the four countries. For each participant, we computed the mean score for all items. The measure was reliable.

In addition, participants reported their attitudes toward each of 14 emissions reduction and pro-environmental policies using a 7-point scale (1 = completely against to 7 = completely in favor). There was an option of "Don't know" (which was treated as a missing value). A set of preliminary analyses revealed a one-factor structure of this measure. This measure displayed configural invariance (but not metric or scalar invariance) across the four countries. For each participant, we computed the mean score for all items. The measure was reliable.

2.2.4. Climate change beliefs

In addition, we included a range of climate change beliefs variables as covariates. The questions included: i) With respect to climate change, which of the following do you personally believe? (0 = Climate change is NOT happening now/Climate change is happening now, but caused mainly by natural forces, 1 = Climate change is happening now, caused mainly by human activities); ii) As far as you know, what percentage of climate scientists think human activities are causing the world's climate to change? (participants indicated a percentage); iii) In general, how worried are you about climate change? (1 = not at all worried to 5 extremely worried); iv) How much do you think climate change will harm you personally? (1 = not at all to 5 = a great deal); v) How much do you think climate change will harm people in [participant's country]? (1 = not at all to 5 = a great deal).

3. Results

3.1. Measurement invariance of the climate change anxiety scale

We first examined the factor structure of the scale with a series of confirmatory factor analyses. We tested both the original two-factor structure (Clayton & Karazsia, 2020; Mouguiama-Daouda et al., 2022) and one-factor structure (Innocenti et al., 2021) in each country. Some of the 13 items of the scale were not normally distributed in some countries, as indicated by Skewness >1 and Kurtosis >3. Also, the Doornik-Hansen test of multivariate non-normality revealed significant results in all four countries (*ps* < .001). We therefore used maximum likelihood estimation with robust standard errors in our analysis (Finney & DiStefano, 2013).

Table 4 shows the results. Many researchers have warned against reliance on a single goodness-of-fit index and the use of a universal cutoff value (e.g., Chen et al., 2008; Marcoulides & Yuan, 2017). We therefore considered multiple indices. For the one-factor model, all goodness-of-fit indices consistently indicated poor model fit in Japan (RMSEA >0.08, CFI <0.90, SRMR >0.05, Gamma-hat < 0.90). One of the indices (RMSEA) also indicated poor fit in the other three countries. As for the two-factor model, all goodness-of-fit indices indicated good or acceptable fit in China (RMSEA = 0.08, CFI >0.95, SRMR <0.05, Gamma-hat = 0.95). A similar pattern (except for RMSEA) was also observed in the U.S. (CFI >0.95, SRMR <0.05, Gamma-hat > 0.95), and India (CFI = 0.93, SRMR <0.05, Gamma-hat = 0.95). The model fit was acceptable in Japan, as indicated by CFI = 0.90, SRMR = 0.05, and Gamma-hat = 0.92 (but not RMSEA). Considering these findings, we concluded that the two-factor model was acceptable in all four countries.

Table 4
Goodness of fit in the one-factor model and the original two-factor model.

Country	China	India	Japan	US
One-factor model				
robust χ^2(df)	527.929(65) ***	552.829(65) ***	1001.012(65) ***	409.961(65) ***
robust RMSEA	.100	.100	.169	.115
robust CFI	.935	.908	.839	.936
SRMR	.038	.048	.061	.035
robust Gamma-hat	.934	.930	.874	.950
AIC	29466.917	34671.450	19288.874	24204.236
BIC	29594.519	34799.052	19416.476	24331.838
Two-factor model				
robust χ^2(df)	408.217(64) ***	433.523(64) ***	659.293(64) ***	301.035(64) ***
robust RMSEA	.084	.087	.134	.096
robust CFI	.954	.931	.900	.957
SRMR	.033	.043	.050	.030
robust Gamma-hat	.950	.946	.916	.965
AIC	29270.815	34510.434	18592.278	23921.092
BIC	29403.360	34642.943	18724.787	24053.602

Note. Maximum likelihood estimation with robust standard errors was used. Chi-squared, CFI, and Gamma-hat statistics were scaled according to Satorra and Bentler (1994); RMSEA statistics were further corrected based on the method by Brosseau-Liard et al. (2013).

We proceeded to test the measurement invariance of the scale across the four countries with a multigroup confirmatory factor analysis (Milfont & Fischer, 2010). We tested and compared the following three nested models: configural invariance model (in which the basic model structure is invariant across groups, indicating that participants from the four countries conceptualized the concept in the same way), metric invariance model (in which factor loadings were constrained to be invariant, indicating that the relations between items and the underlying construct were the same across the four countries), and scalar invariance model (in which both factor loadings and intercepts were constrained, indicating that scale scores can be directly compared across the four countries).

Table 5 shows the results of our comparisons. Following the relevant recommendations regarding measurement invariance tests (Chen, 2007; Cheung & Rensvold, 2002; Milfont & Fischer, 2010), we referred to the differences in RMSEA, CFI, SRMR, and Gamma-hat between the three models. We did not base our decision on the conventional likelihood ratio test as it tends to yield significant results when samples are large. Specifically, we referred to the cutoff values recommended by Chen (2007). If the more restrictive model shows a decrease in the value of CFI and GH greater than .005 and an increase in the value of RMSEA and SRMR greater than 0.01 and 0.025 respectively, it should be rejected. As all the changes of the metric invariance model from the configural variance model were smaller than the recommended cutoff values, we consider this model to be acceptable. On the contrary, the changes of the scalar invariance model from the metric variance model were larger than the recommended cutoff values of CFI and Gamma-hat; in addition, both RMSEA and SRMR indicated poor fit (>0.08 and > 0.05, respectively). Also, the metric invariance model exhibited acceptable fit (CFI = 0.93, SRMR = 0.05, Gamma-hat = 0.94). Accordingly, we concluded that the configural and metric invariance models were acceptable, and

Table 5
Fit indices for the measurement invariance test.

	χ^2(df)	$\Delta\chi^2$(Δdf)	robust χ^2(df)	RMSEA (ΔRMSEA)	CFI (ΔCFI)	SRMR (ΔSRMR)	Gamma-hat (ΔGamma-hat)
configural invariance	3124.224(256)***	–	1778.488(256)***	.102 (–)	.936 (–)	.037 (–)	.945 (–)
metric invariance	3303.139(289)***	158.69(33)***	1960.520(289)***	.099 (−.003)	.933 (−.003)	.054 (.017)	.940 (−.005)
scalar invariance	3945.157(322)***	792.49(33)***	2473.166(322)***	.103 (.004)	.918 (−.015)	.064 (.010)	.924 (−.016)

Note. Except for the first two columns regarding standard χ^2 tests, the other statistics in the table were based on maximum likelihood estimation with robust standard errors, as in the previous table.

we rejected the scalar invariance model.

In conclusion, our analyses revealed that the two-factor structure of the climate change anxiety scale originally proposed by Clayton and Karazsia (2020), but not the one-factor structure observed in Innocenti et al. (2021), is acceptable in our Chinese, Indian, Japanese, and American samples. In addition, there is evidence of metric invariance of the scale across the four country samples, suggesting not only that our participants from the four countries conceptualized the concept of climate change anxiety in the same way but also that the relations between the 13 items and the underlying construct of climate change anxiety were the same across the four countries. However, because scalar invariance was not achieved, we concluded that any direct comparisons of the scores between the four countries must be interpreted with caution.

3.2. Prevalence of climate change anxiety

Based on the two-factor model, we computed two scores for each participant: the first for cognitive-emotional impairment (alpha = .93, .88, 0.93, and 0.95 in China, India, Japan, and the U.S. respectively), and the second for functional impairment (alpha = .91, .87, 0.93, and 0.94 respectively).

Table 6 shows the descriptive statistics of the two scores in the four countries. As we rejected the scalar invariance model earlier, we did not directly compare the scores across the countries. However, a series of one-sample *t*-test within each country revealed that in all samples, both cognitive-emotional impairment and functional impairment scores were significantly below the scale mid-point. This observation implies a generally low level of prevalence of the experience of climate change anxiety in the samples. This observation is similar to those reported in previous studies (e.g., Clayton & Karazsia, 2020; Schwartz et al., 2022).

To more intuitively understand the distribution of climate change anxiety in each country, we classified our participants based on their experience of cognitive-emotional impairment or functional impairment into four groups: "never to less than rarely" (subscale score <2), "rarely to less than sometimes" (score≥2 and < 3), "sometimes to less than often" (score≥3 and < 4), and "often to almost always (score >4). Figs. 1 and 2 show the distribution of these categories for cognitive-emotional impairment and functional impairment respectively in each country. Among our Japanese and American participants, the predominant category was "never to less than rarely," which accounted for about 70%–75% of the participants. Also, only a small percentage of these participants were in the "sometimes to less than often" or the "often to almost always" category. Notably, a much bigger percentage of our Chinese and Indian participants were classified into these latter categories. Over 20% and 30% of our Chinese and Indian participants, respectively, reported that they sometimes or more frequently experienced cognitive-emotional impairment or functional impairment. In particular, 8.50% and 10.80% of our Indian participants "often to almost always" experienced cognitive-emotional impairment and functional impairment respectively.

3.3. Demographic correlates of climate change anxiety

We then examined the relationships between climate change anxiety and the demographic variables (see Table 6). We observed that male participants had a significantly higher level of both cognitive-emotional impairment and functional impairment in China and the U.S. (*r*s ranging from 0.151 to 0.222). Interestingly, the opposite was found in India, although the effect size seemed negligible ($r = -0.062$). Regarding age, we found the younger participants reported stronger climate change anxiety in India and the U.S. (*r*s ranging from −0.181 to −0.417). However, in China, the opposite was found (*r*s = 0.242 and 0.297), and in Japan there was no significant relationship. As for income, a positive correlation was found in China (*r*s = 0.165 and 0.164) but a negative, though small, correlation was found in Japan (*r*s = −0.068 and −0.100), with no significant relationship found in the other two countries. Education was almost uncorrelated with climate change anxiety; the strongest correlation was found in India with a magnitude of only .084.

Overall, there were some substantial relationships between age and climate change anxiety, although the pattern observed in China was opposite to that observed in India and the U.S. As for the remaining variables, there were some inconsistencies across countries and, most important, most of the correlations were of a very weak magnitude.

We also explored the relationships between climate change anxiety and climate change beliefs. Consistently, anxiety was positively associated with climate change worry, perceived harm to self, and perceived harm to country in all countries at weak to moderate levels (*r*s ranging from 0.109 to 0.409). Cognitive-emotional impairment and functional impairment were both positively correlated with belief in scientific consensus in India, Japan, and the U.S., but the relationships were generally very weak (*r*s ranging from 0.044 to 0.127). A similar pattern was observed for belief in the happening of climate change. For both belief in the happening of climate change and scientific consensus, a negative, though negligible, correlation was observed in China (*r*s = −0.033 to −0.106). In all, only climate change worry and harm perceptions were consistently associated with the two components of climate change anxiety in all four countries.

3.4. Association with climate action

We then examined the relationships between climate change anxiety and climate action (see Table 6). Consistently, in all four countries, both cognitive-emotional impairment and functional impairment were positively correlated with resource conservation with a weak to moderate magnitude (*r*s ranging from 0.102 to 0.218) (except for functional impairment in China, which was non-significant). An apparently stronger correlation was consistently observed for sustainable diet (*r*s ranging from 0.317 to 0.476) and climate activism (*r*s ranging from 0.353 to 0.551). Both cognitive-emotional impairment and functional impairment were also positively associated with support for climate policies (*r*s ranging from 0.182 to 0.325), except for functional impairment in India, which was non-significant).

We proceeded to further examine the role of climate change anxiety on climate action through a series of regression analyses. In each country, we first regressed a climate action outcome variable on the demographic variables and climate change beliefs. This served as our baseline model. In the next model, we added the two subscales of climate change anxiety. This served as our main model. With this analytic strategy, we can examine the predictive power of each subscale on each outcome in each country (by examining its regression coefficient); we can also examine how much variance of the outcome variable

Table 6
Descriptive statistics of climate change anxiety and its correlations with other variables.

	Country			
	China	India	Japan	US
Cognitive-emotional impairment				
Mean	2.223	2.690	1.644	1.637
standard deviation	.860	.856	.636	.866
t-test again scale mid-point	−28.572***	−11.444***	−67.399***	−49.749***
r with demographic variables				
gender (0 = female, 1 = male)	.151***	−.062*	−.049	.196***
Age	.242***	−.183***	.048	−.417***
Income	.165***	.013	−.068*	.045
Education	−.019	.084**	−.030	.039
r with climate change beliefs				
belief in happening	−.043	.028	.119***	.166***
belief in scientific consensus	−.033	.113***	.127***	.084*
Worry	.333***	.333***	.283***	.330***
perceived harm to self	.311***	.319***	.261***	.409***
perceived harm to country	.222***	.248***	.225***	.308***
r with climate action				
resource conservation	.147***	.218***	.208***	.156***
sustainable diet	.396***	.349***	.419***	.476***
climate activism	.507***	.444***	.551***	.542***
support for climate policy	.325***	.182***	.278***	.282***
Functional impairment				
Mean	2.044	2.621	1.467	1.548
standard deviation	.930	.983	.604	.896
t-test against scale mid-point	−32.525***	−12.179***	−80.316***	−51.265***
r with demographic variables				
gender (0 = female, 1 = male)	.178***	−.053	−.031	.222***
Age	.297***	−.181***	−.003	−.406***
Income	.164***	.030	−.100**	.036
Education	−.050	.040	−.036	.032
r with climate change beliefs				
belief in happening	−.106***	−.031	.093**	.123***
belief in scientific consensus	−.080*	.044	.105**	.045
Worry	.224***	.235***	.200***	.246***
perceived harm to self	.209***	.244***	.202***	.334***
perceived harm to country	.109***	.174***	.142***	.234***
r with climate action				
resource conservation	.058	.137***	.131***	.102**
sustainable diet	.406***	.317***	.352***	.433***
climate activism	.433***	.353***	.489***	.463***
support for climate policy	.300***	.061	.217***	.211***
r between cognitive-emotional impairment and function impairment	.854***	.798***	.811***	.893***

Note. ***$p < .001$; **$p < .01$; *$p < .05$.

climate change anxiety as a whole can additionally explain, on top of what the covariates can do (by examining the R^2 change from the baseline model).

Table 7 shows the results. The following observations can be made. First, cognitive-emotional impairment was consistently a positive and significant predictor of the four types of climate action in all four countries. Among the 16 models tested, the only exceptions in which cognitive-emotional impairment was not a significant predictor were the model regarding resource conservation in the U.S. and that regarding support for climate policy in China. Second, functional impairment had a much less robust effect. Among the 16 models tested, it was not a significant predictor in 10 of them. Interestingly, in the remaining six models, it was found to be a significant negative predictor in two of them (resource conservation in China, and support for climate policy in India). It was significantly positive only in four models (sustainable diet in China, India, and the U.S., and climate activism in Japan). Taken together, these observations suggest that the cognitive-emotional impairment dimension of climate change anxiety appear to be a consistent and robust motivating factor behind all types of climate action in all four countries. In contrast, functional impairment appears to be less relevant in motivating behavior and could even interfere with the ability for some people to take action that addresses their concern about climate change.

Another observation worth noting is that climate change anxiety as a whole (i.e., both dimensions considered together) improved the prediction of sustainable diet and climate activism by a significant and substantial extent in all four countries. Regarding sustainable diet, it improved the prediction by 8.41%–10.05%. Regarding climate activism, the improvement ranged from 6.86% to 21.26%. The effect was noticeably weaker for resource conservation and support for climate policy. For resource conservation, it significantly improved the prediction in the three Asian countries by only 0.51%–0.80% and did not significantly improve the prediction in the U.S. (0.46%). Regarding support for climate policy, it significantly improved the prediction in the three Asian countries by only 1.63%–2.80% and did not significantly improve the prediction in the U.S. (0.34%).

4. General discussion

Climate change anxiety can be triggered by direct experience of the impacts of climate change or just the mere thought and perception about such impacts (Clayton, 2020; IPCC, 2022). For this reason, it is becoming a truly global issue that requires attention. Research on this phenomenon is urgently needed; unfortunately, to date, previous studies were mostly done in WEIRD societies. In response to this limitation, using the Climate Change Anxiety Scale (Clayton & Karazsia, 2020), we conducted a cross-national study of climate change anxiety with participants from four of the top emitters in the world: China, India, Japan, and the U.S. This sample of countries allowed us to examine the phenomenon in both Western and non-Western contexts and in societies with different climate change-related landscapes. In the following, we discuss the contributions of our findings.

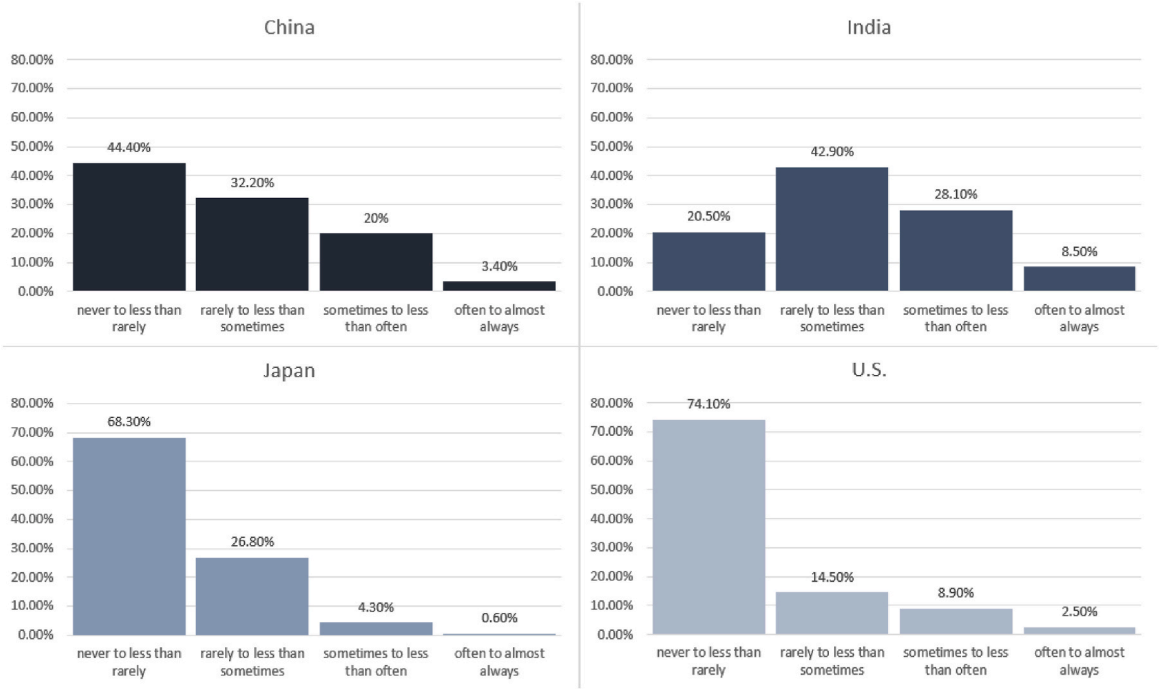

Fig. 1. Distribution of responses of cognitive-emotional impairment in each country.

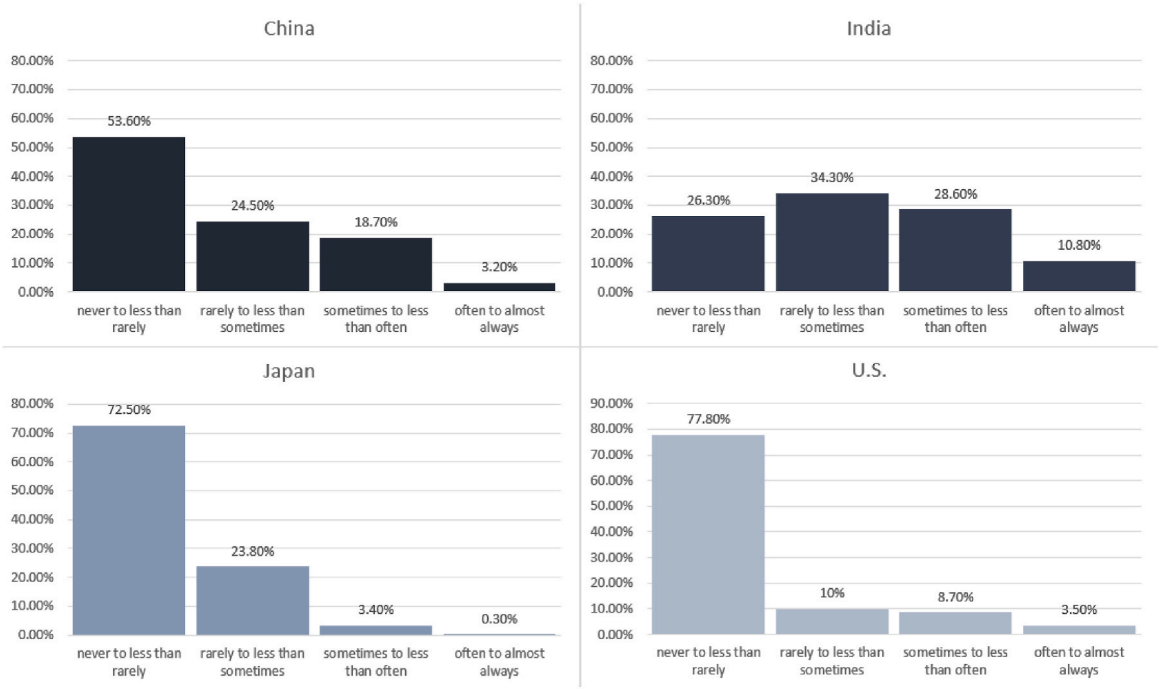

Fig. 2. Distribution of responses of functional impairment in each country.

4.1. Contributions

First, this is the only study of which we are aware that presented evidence of cross-national measurement invariance regarding climate change anxiety. All previous studies using the Climate Change Anxiety Scale were single-country (except Heeren, Mouguiama-Daouda, & Contreras (2022), which was multi-country but based on predominantly French and Belgium participants); establishing the cross-national invariance of the measure was therefore not possible. As a result, it remains uncertain whether we can interpret the findings based on different populations from these studies in a similar manner. The same problem also applies to studies on negative emotional responses to climate change in general. There were some multi-country studies (e.g., Hickman et al., 2021; Ogunbode et al., 2021), but the factor structure of the measures used usually was not examined, and there was no evidence of cross-national measurement invariance. In the present study, taking advantage of our four-country sample, we validated the two-factor structure of the Climate Change Anxiety Scale. We further found that the scale exhibited both configural invariance and metric invariance. Configural invariance of the scale suggests that the model structure was

Table 7
Results of regression models testing the main effects of climate change anxiety.

	Country			
	China	India	Japan	US
Resource conservation				
gender (0 = female, 1 = male)	−.040 (.037)	−.111** (.037)	−.258*** (.047)	−.216*** (.049)
age	.032* (.014)	.021(.013)	.052** (.017)	.082*** (.016)
income	.042* (.019)	.065** (.021)	.057*(.025)	.088** (.026)
education	.080** (.023)	−.022 (.024)	.048*(.023)	.020(.025)
belief in happening	−.044 (.055)	−.136* (.060)	.151*(.062)	.086(.065)
belief in scientific consensus	.004** (.001)	.002(.001)	.001(.001)	.0002(.001)
worry	.096*** (.024)	.105*** (.025)	.176*** (.040)	.151*** (.033)
perceived harm to self	.069* (.029)	.070*(.031)	.040(.040)	.048(.036)
perceived harm to country	.073(.029)	.152*** (.032)	.124** (.040)	.121** (.036)
cognitive-emotional impairment	.116** (.041)	.095*(.037)	.130*(.062)	.094(.061)
functional impairment	−.107** (.037)	−.033 (.031)	−.057 (.063)	−.023 (.056)
R^2	.180	.215	.280	.317
R^2 *change from baseline model*	.008*	.007*	.005*	.005
Sustainable diet				
gender (0 = female, 1 = male)	−.047 (.063)	−.168** (.063)	−.220*** (.058)	−.252** (.072)
age	.149*** (.024)	.045*(.022)	.066** (.021)	.002(.024)
income	−.033 (.033)	−.025 (.035)	−.025 (.031)	.008(.038)
education	−.004 (.040)	.037(.040)	.039(.028)	.096*(.038)
belief in happening	−.023 (.093)	−.220* (.100)	.047(.077)	.360*** (.097)
belief in scientific consensus	−.001 (.001)	.002(.002)	.003(.002)	−.001 (.002)
worry	.056(.040)	.094*(.041)	.157** (.049)	.133** (.049)
perceived harm to self	.054(.049)	.077(.052)	.107*(.049)	.068(.054)
perceived harm to country	−.024 (.049)	−.073 (.054)	−.068 (.050)	.106*(.053)
cognitive-emotional impairment	.177* (.069)	.241*** (.062)	.432*** (.078)	.361*** (.090)
functional impairment	.213** (.062)	.140** (.052)	.081(.078)	.176*(.084)
R^2	.215	.150	.255	.370
R^2 *change from baseline model*	.089***	.084***	.101***	.098***
Climate activism				
gender (0 = female, 1 = male)	−.021 (.032)	−.001 (.030)	.062(.032)	.014(.040)
age	.022(.012)	−.032** (.010)	.024*(.011)	−.038** (.014)
income	.009(.016)	.037*(.016)	.014(.017)	−.006 (.022)
education	.046* (.020)	.016(.019)	.019(.015)	.022(.021)
belief in happening	−.071 (.047)	.013(.047)	.117** (.042)	.247*** (.056)
belief in scientific consensus	−.0001 (.001)	−.001 (.001)	.001(.001)	.001(.001)
worry	.026(.020)	.084*** (.020)	.063*(.027)	.123*** (.027)
perceived harm to self	.039(.025)	.048(.024)	.071** (.027)	.083** (.030)
perceived harm to country	.038(.025)	.034(.026)	.021(.027)	.117*** (.030)
cognitive-emotional impairment	.256*** (.035)	.196*** (.029)	.325*** (.042)	.297*** (.050)
functional impairment	.015(.031)	.005(.025)	.133** (.043)	−.001 (.048)
R^2	.270	.261	.398	.550
R^2 *change from baseline model*	.150***	.090***	.213***	.069***
Support for climate policy				
gender (0 = female, 1 = male)	−.0004 (.042)	−.001 (.053)	−.128* (.050)	−.134* (.066)
age	.085*** (.016)	.051** (.019)	−.0001 (.018)	−.002 (.022)
income	.036(.022)	.068*(.029)	.045(.027)	−.011 (.035)
education	.027(.026)	−.0003 (.034)	.035(.024)	−.043 (.034)
belief in happening	−.083 (.062)	.056(.085)	.240*** (.066)	.451*** (.088)
belief in scientific consensus	.003* (.001)	.004** (.002)	.004*** (.001)	.005** (.002)
worry	.107*** (.027)	.123** (.036)	.226*** (.042)	.283*** (.044)
perceived harm to self	.029(.033)	.103*(.044)	.030(.042)	.039(.048)
perceived harm to country	.101** (.033)	.175*** (.046)	.051(.042)	.261*** (.048)
cognitive-emotional impairment	.075(.046)	.231*** (.052)	.197** (.066)	.161*(.082)
functional impairment	.073(.041)	−.170*** (.044)	.019(.067)	−.074 (.077)
R^2	.217	.208	.280	.499
R^2 *change from baseline model*	.028***	.016***	.024***	.003

Notes. ***$p < .001$; **$p < .01$; *$p < .05$. Shown are unstandardized coefficients, with standard errors in brackets. Baseline model = model with covariates only.

invariant across the four countries, implying that participants from these different populations conceptualized the construct being measured in the same way. Metric invariance suggests that the relations between specific items and their underlying construct (i.e., factor loadings) were invariant across the four countries; it indicates that each item contributed to the latent factor to a similar degree across the countries. Based on these findings, we conclude that the Climate Change Anxiety Scale carries similar psychological structure and meanings for the Chinese, Indian, Japanese, and American populations.

Due to resource constraints, we were not able to include even more countries in our study. For this reason, we cannot conclude from our findings that the two-factor structure is universal. In fact, Innocenti et al. (2021) found the one-factor model more acceptable, whereas Wullenkord et al. (2021) did not find any viable factor model. Taking our findings and previous findings together, the lesson we have learned is that it is unjustifiable to just assume that the Climate Change Anxiety Scale carries similar structure and psychological meanings in any population. This assumption has to be empirically evaluated, as we demonstrated in our study.

Second, the prevalence of climate change anxiety may vary across societies. It should be noted that a direct comparison of the mean scores of the Climate Change Anxiety Scale between our four countries is not justifiable, given our failure to obtain evidence of scalar invariance. We proceeded to compare prevalence across the four countries only in a descriptive and intuitive manner. We observed that in all four countries, cognitive-emotional impairment and functional impairment scores were significantly below the scale mid-point, implying a generally low level of prevalence of the experience of climate change anxiety in these countries, a pattern similar to those reported in previous studies (e.g., Clayton & Karazsia, 2020; Schwartz et al., 2022). Nevertheless, an

examination of the distributions of scores in the four countries descriptively (Figs. 1 and 2) highlights that a larger percentage of people in our Chinese and Indian samples reported that they at least sometimes experienced cognitive-emotional impairment and functional impairment. Coupled with the findings from the two previous studies conducted in the Philippines (Reyes et al., 2021; Simon et al., 2022) and a recent multi-country study on negative emotions toward climate change (Clayton, Pihkala, Wray, & Marks, 2023), our observation hints at the possibility that climate change anxiety is more prevalent in countries with stronger climate vulnerabilities and weaker readiness to adapt (see Table 1 for information regarding the low rankings of China and India internationally in these respects). Admittedly, this possibility remains speculative. A study with a bigger sample of countries, coupled with evidence of scalar invariance of the anxiety measure, will allow us to directly examine the covariation between country-level climate change vulnerabilities and prevalence of climate change anxiety.

Future studies also need to examine the mechanisms through which a country's objectively pessimistic climate landscapes might be associated with heightened climate change anxiety in its people. We suggest that these two candidates be considered: personal experience and vicarious experience. Some recent evidence suggests that direct experience of the impacts of climate change is associated with more climate change anxiety (Clayton & Karazsia, 2020; Heeren, Mouguiama-Daouda, & McNally, 2023; Schwartz et al., 2022). For example, in a natural experiment, Bratu et at. (2022) observed that British Columbians experienced a significant increase of climate change anxiety after the 2021 Western North American heat dome. However, other evidence speaks against this effect. Both Ogunbode et al. (2022) and Whitmarsh et al. (2022) found that past experience of flooding specifically (as a proxy of impacts of climate change) failed to predict climate change anxiety. Interestingly, these two studies also revealed that vicarious experience (in terms of exposure to climate change information on media and social media) significantly predicted stronger climate change anxiety. We believe it is conceivable to consider in future research whether climate change anxiety is indeed more prevalent in countries facing stronger climate risks and vulnerabilities and to what extent this difference is attributable to stronger personal experience of climate change impacts and/or higher exposure to climate change information among the peoples in those countries.

Third, our findings suggest that within a country, some demographic groups are more prone to the experience of climate change anxiety. Anxiety was stronger among younger people in India and the U.S., but it was stronger among older people in China and had no relationship with age in Japan. Men displayed stronger anxiety, but this gender difference was generally small and observed only in China and the U.S. Anxiety mostly had no significant or only negligible relationships with income or educational levels. It is notable that we already used samples that were representative in terms of age and gender and diverse in terms of income and educational levels, unlike what most previous studies did, but we were still unable to observe a consistent or robust pattern of the demographic correlates of climate change anxiety. This observation, coupled with the inconsistencies already documented in the literature, suggests that the way climate change anxiety varies across demographic groups probably is very sensitive to societal contexts. We can tentatively conclude that there is not a universal pattern to be identified in terms of demographic correlates of climate change anxiety. Practically, based on this conclusion, we argue that it is dangerous for a government to assume that certain demographic groups are more prone to climate change anxiety based on findings from foreign countries. Practical efforts in early detection of high-risk groups and timely intervention should be guided by locally informed research findings. Here is an example: The third *Lancet* Countdown report on China (Cai et al., 2022) revealed that in China, older adults, compared to younger age groups, experienced a larger increase in exposure to wildfires, extreme rainfalls, and drought and a higher rate of mortality attributed to heatwaves and indoor air pollution. At the same time, older adults in China were marginally represented in media coverage about health and climate change (e.g., less than 1% of media articles on the topic in 2021 mentioned older age groups). That older populations in China are more vulnerable but overlooked publicly may explain why a unique pattern of the age-anxiety relationship was observed in the country in our study.

Fourth, with the inclusion of different forms of climate action (resource conservation, sustainable diet, climate activism, support for climate policy), we demonstrated that both dimensions of climate change anxiety were quite robustly correlated with climate action in all four countries. Notably, in a series of regression analysis, we observed that when both dimensions were considered together (along with demographic factors and climate change beliefs as covariates), climate change anxiety significantly improved the prediction of climate action, but this effect was less substantial in the cases of resource conservation and support for climate policy than sustainable diet and climate activism. Also, we additionally observed that this potential behavioral effect of climate change anxiety was mainly driven by the cognitive-emotional impairment dimension but not the functional impairment dimension. These patterns were consistent across all four countries. This distinction further validates the conclusion that the Climate Change Anxiety Scale represents two factors rather than a single factor, at least within the current samples. These findings are novel, as previous studies rarely elaborated on the relationship between climate change anxiety and climate action; they mostly examined zero-order correlations only. Our findings suggest that climate change anxiety can motivate climate action in various forms, but more substantially for some than others. The differential effect of anxiety on different behaviors was also reported in a recent study by Whitmarsh et al. (2022) with a sample of participants from the United Kingdom. These findings can shed lights on the inconsistency of the observed behavioral effects in previous research. It is possible that climate change anxiety motivates climate action in a selective manner. It remains to be explained in future research as to how this selectivity takes place psychologically, but a likely candidate in this regard is efficacy. As a recent study revealed (Meijers et al., 2023), different pro-environmental behaviors are subject to the influence of efficacy and response efficacy beliefs regarding different agents (i.e., personal, collective, government). An interesting direction for future research is to explore how climate change anxiety interacts with these different subtypes of efficacy in determining engagement in different types of climate action.

Our findings also suggest the relative importance of cognitive-emotional impairment (compared to functional impairment) behind the behavioral effect of climate change anxiety. Interestingly, functional impairment was even found to be a negative predictor in some of our models. We are aware of a recent study that revealed a similar pattern. Heeren et al. (2023) used network analyses to understand to the relationships among climate change experience, pro-environmental behavior, general worry, and the two dimensions of climate change anxiety. Their findings show that cognitive-emotional impairment appeared to be "a potential hub" in the network of these variables; it yielded the highest expected influence in the graphical Gaussian model and emerged as a critical bridge in the directed acyclic graph. This observation implies that cognitive-emotional impairment, rather than functional impairment, is the main driver of pro-environmental behavior, just as what we also observed. It further suggests that the occurrence of functional impairment may depend on the experience of cognitive-emotional impairment, but not the reverse. Based on these studies, we argue that a more thorough analysis of the dynamics between the two dimensions of climate change anxiety is necessary in future research. As Heeren et al. (2023) argued, cognitive-emotional impairment may serve as a tipping pathway for either adaptive response (e.g., climate action) or maladaptive response (e.g., functional impairment) to the problem of climate change. This view presumes the centrality of cognitive processes in the experience of anxiety, which is in line with cognitive theories of anxiety (e.g., Eysenck, 2014). The longitudinal design will be particularly effective in this future research. It

will allow researchers to examine the extent to which cognitive-emotional impairment underlies the development of pro-environmental action as opposed to functional impairment and to explore factors that determine which response predominates.

4.2. Limitations

The present study used a sample of four countries carefully and strategically selected based on their similarities and differences in the climate change landscapes. With this small sample, we were not able to generalize our results regarding measurement invariance of the Climate Change Anxiety to other countries and regions. Notably, we also did not have enough statistical power to test the role of any country-level factors that might correlate with the apparent between-country variability in prevalence of climate change anxiety. We argue that a bigger sample of countries, under conditions of measurement invariance and representative samples, will allow researchers to examine if different countries' objective circumstances in terms of climate risks and vulnerabilities explain their differences in terms of prevalence of climate anxiety.

Also noteworthy is that our study was purely cross-sectional. Our findings are only suggestive of the effects of demographic factors on climate change anxiety or the effect of anxiety on climate action. As suggested earlier, longitudinal data will be key to future research aimed to explore how anxiety and adaptive response vs. maladaptive response to climate change are causally related to each other.

We considered only a limited range of climate action. We tried to capture multiple types of climate action, but some important behaviors were obviously omitted in the present study and should be considered in future research. For instance, research has shown that anxiety is associated with the tendency to seek information about a threat (e.g., Gadarian & Albertson, 2014), and this relationship was also observed in the context of climate change (Whitmarsh et al., 2022). Adaptation behavior (van Valkengoed & Steg, 2019), which has relatively been less explored in the psychological literature of climate change (Tam et al., 2021), is another noticeable behavioral category that we failed to capture.

Last but not least, our measures of climate action were predominantly intention-based and self-report. It goes without saying these measures were subject to various response biases and did not necessarily reflect true behavior (Lange & Dewitte, 2019). We opted for these measures as they were deemed efficient in our large-sample, survey--based study design, but we also recognize that tasks involving actual behaviors have become available, some of which (e.g., Carbon Emission Task, Berger & Wyss, 2021; Pro-Environmental Behavioral Task, Lange et al., 2018; donation, Clements et al., 2015) may also fit a survey-based research design. Future replications may consider using these measures instead.

5. Conclusion

In conclusion, echoing recent calls for more psychological research on climate change outside WEIRD countries (Tam et al., 2021; Tam & Milfont, 2020), we conducted a cross-national study of climate change anxiety with participants from four of the top emitters in the world which also vary in terms of their climate change-related landscapes. We demonstrated that a widely adopted measure of climate change anxiety carries similar structure and psychological meanings in the four countries. Climate change anxiety was potentially higher in populations more vulnerable to the impacts of climate change. There were some demographic correlates of climate change anxiety, but the pattern was inconsistent across the countries. Climate change anxiety was positively associated with climate action in all four countries. Taken together, these key observations suggest that with respect to the experience of climate change anxiety, there are both similarities and differences between different societal contexts. Future research must take these complexities into consideration.

Preregistration

This research was preregistered. The preregistration can be viewed at https://doi.org/10.17605/OSF.IO/64TBE.

Data availability

The original data is available upon request.

Research materials availability

The original research materials are available upon request.

CRediT authorship contribution statement

Kim-Pong Tam: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Funding acquisition. **Hoi-Wing Chan:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **Susan Clayton:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Acknowledgement

The work described in this study was supported by funding awarded to Kim-Pong Tamfrom the Fiscal 2019 Grant for Japan-Related Research Projects, The Sumitomo Foundation, Japan (SFJP20HS01), and HKUST Institute for Emerging Market Studies with support from EY, Hong Kong, China (IEMS19HS02). It was also partially supported by funding awarded to Hoi-Wing Chan from the MHRC Mini-seed Fund Scheme, Mental Health Research Centre, The Hong Kong Polytechnic University, Hong Kong, China (P0041569).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2023.101991.

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