

Extreme weather salience as a climate crisis signal: Examining the role of extreme weather fear in adaptive and maladaptive responses to eco-anxiety

Sam S.S. Lau^{a,b,*}, Jason W.L. Fong^a, Emma L. Lawrance^c, Angel W.L. Chui^a, Wangjian Zhang^d, Shao Lin^e, Bahtiyar Yıldız^f, Andras N. Zsido^{f,g}

^a Research Centre for Environment and Human Health, School of Continuing Education, Hong Kong Baptist University, Hong Kong Special Administrative Region, China

^b College of International Education, School of Continuing Education, Hong Kong Baptist University, Hong Kong Special Administrative Region, China

^c Climate Cares Centre, Institute of Global Health Innovation and Grantham Institute for Climate Change and the Environment, Imperial College London, London SW7 2BX, United Kingdom

^d Department of Medical Statistics and Center for Health Information Research and Guangdong Key Laboratory of Medicine, School of Public Health, Sun Yat-Sen University, Guangzhou 510080 Guangdong, China

^e Department of Environmental Health Sciences & Department of Epidemiology and Biostatistics, College of Integrated Health Science, University at Albany, The State University of New York, Albany, NY, USA

^f Institute of Psychology, University of Pécs, Pécs, Hungary

^g Contemporary Challenges Research Centre, University of Pécs, Baranya, Hungary

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ABSTRACT

Personal salience regarding extreme weather events may be crucial for recognising the profound effects of anthropogenic climate change. However, efforts to understand how individuals attribute extreme weather events to anthropogenic climate change, and their implications for eco-anxiety, have not effectively integrated psychological perspectives. Following Hong Kong's wettest storm on record in 2023, we recruited a cross-sectional sample of adults ($n = 376$, ages 18–83) immediately after typhoon season onset (from 3 June to 11 September) in 2024. We aimed to examine (1) how extreme weather experiences and socio-demographic factors influence individuals' subjective attribution of extreme weather to anthropogenic climate change, and (2) how extreme weather fear (i.e. storm fear), weather salience, uncertainty intolerance, anxiety control, nature connectedness, and future risk awareness of local climate disasters are associated with two distinct subdimensions of eco-anxiety, conceptualised as 'habitual ecological worry' and 'negative consequences of eco-anxiety', which may be associated respectively with adaptive and maladaptive responses to eco-anxiety. Our results suggest that only the personal salience of day-to-day local weather patterns significantly affected respondents' subjective attribution of local weather patterns to anthropogenic climate impacts, rather than their extreme weather event experiences. Future risk awareness and nature connectedness were mainly associated with adaptive responses to eco-anxiety, while only storm fear was strongly associated with both adaptive and maladaptive responses. This finding underscores the dual effects of extreme weather fear, namely motivating action-oriented aspects of eco-anxiety and exacerbating functionally impairment of eco-anxiety. Promoting future risk awareness and increasing nature connectedness – independent of fear – could improve urbanised populations' perceived efficacy in engaging in pro-climate actions.

* Corresponding author at: Research Centre for Environment and Human Health, School of Continuing Education, Hong Kong Baptist University, Hong Kong Special Administrative Region, China.

E-mail addresses: samlau@hkbu.edu.hk (S.S.S. Lau), jasonfongwl@hkbu.edu.hk (J.W.L. Fong), e.lawrance@imperial.ac.uk (E.L. Lawrance), angelchui@hkbu.edu.hk (A.W.L. Chui), zhangwj227@mail.sysu.edu.cn (W. Zhang), slin@albany.edu (S. Lin), bahtiyar.yildiz@pte.hu (B. Yıldız), zsido.andras@pte.hu (A.N. Zsido).

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1. Introduction

1.1. How extreme weather events represent the climate crisis

Extreme weather events (EWEs) of magnitudes considered exceptionally unlikely without human influence have become increasingly frequent worldwide (Intergovernmental Panel on Climate Change, 2023). Robust evidence from the emerging field of extreme event attribution links anthropogenic climate change to rising frequency and severity of severe storms, heatwaves, wildfires, rainfall, and droughts globally (Clarke et al., 2022; Intergovernmental Panel on Climate Change, 2023). However, distinguishing the human contributions from natural variability in complex climate disasters (e.g., tropical cyclones, wildfires) remains challenging due to limitations in climate model cross-validity, incomplete observational records, and uncertainties in quantifying climate change mechanisms within EWEs (National Academies of Sciences, Engineering, and Medicine, 2016). Newman and Noy (2023) estimated that anthropogenic climate change attributed impacts account for up to 53% of the total EWEs damage, with annual costs approaching US\$143 billion. Intensified storms were identified as the most economically damaging climate disasters between 2000 and 2019; responsible for approximately 60% of global climate-associated losses, primarily affecting Asian communities.

With increasing frequency and severity of salient, personal, or vicarious experiences of EWEs, climate scientists suggest that such events could enhance personal and emotional relevance of the climate crisis, particularly among urbanised populations with historically less exposure to climate impacts. EWEs may narrow perceived *psychological distance* from the crisis (McDonald et al., 2015; Rudiak-Gould, 2013) and transform personal experiences into *availability heuristics*, making abstract, future-oriented risks communicated by scientists and the media more personal, imaginable, and emotionally relevant (Counou & Rahmstorf, 2012; Demski et al., 2017). Communication strategies that emphasise personal (e.g., human health risks) rather than ecological consequences can effectively convey the severity and immediacy of the climate crisis (Campbell et al., 2023). *Fear appeal* thus serves as a core mechanism for motivating behavioural changes aimed at mitigating personally relevant threats, encapsulated by the risks posed by EWEs (Tannenbaum et al., 2015).

In a systematic review, Howe et al. (2019) reveals that despite the above-described findings, *local experiences of climate change* in the context of EWEs have produced inconsistent effects on individual climate adaptations consisting of pro-climate opinions, beliefs, intentions, and actions, including collective climate activism and policy support. The review finds that experiences with EWEs have diverse effects on individual responses, ranging from positive to none, or even negative responses of individuals increasingly disengaged from the climate crisis. These inconsistent behavioural responses suggest that increased perceived personal risk may not always encourage adaptive climate actions. Because objective experiences of climate disasters represent a poor indicator of individuals' subsequent climate beliefs and actions, the perception of these events as a 'climate change experience' and unique psychological processing of these experiences demand greater focus.

The gap in behavioural outcomes may reflect how individuals respond to *eco-anxiety*, broadly defined as a chronic fear of environmental doom (Clayton et al., 2017). While extreme weather fear can be a normal response to the perceived risks posed by increasingly frequent and severe EWEs, Pihkala (2020) elaborates that experiences of eco-anxiety are predominantly non-pathological, reflecting complex and multifaceted reactions to climate-related concerns. Chiefly, eco-anxiety may manifest as motivating problem-solving actions if resolved *adaptively*, but may inhibit action if anxiety symptoms are addressed *maladaptively*. *Eco-paralysis*, defined as the inability to take meaningful actions to address the climate crisis, may arise as an overwhelming experience of eco-anxiety and coping with anxiety symptoms

emotionally, such as through climate change denial or disengagement (Albrecht, 2011; Norgaard, 2006). For example, Taylor (2020) warns that increased exposure to EWEs could induce more maladaptive responses to eco-anxiety, leading to fatalistic or dismissive attitudes to psychologically cope with and distance oneself from the perceived climate threat. However, more recent evidence from longitudinal studies demonstrates that the relationship of pro-environmental behaviours with eco-anxiety is best described by a positive linear model, suggesting that maladaptive responses may not manifest strongly even at high levels of eco-anxiety (Hogg et al., 2024; Karl & Stanley, 2024; Mathers-Jones & Todd, 2023; Pavani et al., 2023). Multidimensional constructs of eco-anxiety, such as Hogg's Eco-anxiety Scale (HEAS; Hogg et al., 2021; Hogg et al., 2024) and the Eco-Anxiety Questionnaire (EAQ; Agoston et al., 2022), suggest that certain affective or cognitive responses to eco-anxiety may involve more practical functions than others. We define these practical functions as adaptive responses that motivate pro-climate responses and manifest fewer maladaptive responses (e.g., mental health risks). It is pertinent and timely to examine the extent to which individuals perceive and process personal or vicarious experiences of EWEs as climate change experiences, and how these experiences manifest as adaptive and maladaptive responses to eco-anxiety. Examining such outcomes may provide useful insights into the uncertain relationship between EWE experiences and climate responses.

1.2. Conceptualising the research gap

Based on Howe's (2021) conceptual model, which describes how anthropogenic climate change experiences are processed and influence individual pro-climate responses, we identified two untested aspects that may be of significance to explaining the relationship between personal or vicarious experiences of EWEs and pro-climate adaptive responses:

1. The extent to which the affected person attributes their EWE experience to anthropogenic climate change (wholly or in part).
2. The extent to which an EWE experience evokes adaptive and maladaptive responses to eco-anxiety.

1.3. Experiencing extreme weather as climate change

Scientific interest in how EWE experiences promote climate change awareness and pro-climate responses has largely focused on exploring objective variations in these experiences. Globally, EWE experiences varying in type, severity, and personal proximity have been studied to determine how they contribute to pro-climate responses (Howe et al., 2019; Howe, 2021). However, the psychological processes underlying such effects are rarely addressed in detail (Brügger et al., 2021). Mounting evidence has positioned the *subjective attribution* of climate disaster experiences to anthropogenic climate change as a critical belief system that bridges the gap between objective climate risk exposure and the enactment of mitigative actions, such as pro-environmental behaviours and support for climate policies (Cologna et al., 2025; Dablander, 2025; Gould et al., 2024; Ogunbode et al., 2019; Wong-Parodi & Garfin, 2022; Wong-Parodi & Rubin, 2022). Nevertheless, it is difficult for individuals to establish causality between anthropogenic climate change and infrequent EWEs as climate scientists struggle to convey the anthropogenic climate effects of individual EWEs in isolation, rather than as a growing climate trend (McClure et al., 2022; National Academies of Sciences, Engineering, and Medicine, 2016). Thus, individuals' beliefs and decisions regarding particular EWEs may be strongly influenced by their existing climate beliefs and cultural and behavioural norms, including those modelled by acquaintances, politicians, the media, and political identities. People may draw on these norms to interpret their experiences and to formulate individual risk perceptions (Howe et al., 2019; Howe, 2021; Ogunbode et al., 2019). Furthermore, most relevant studies have been conducted in Western

countries, primarily the U.S., and report that politicised views of climate change galvanise climate beliefs and policy support to such an extent that the influence of individuals' personal experiences on their climate beliefs is diminished (Hughes et al., 2020; Ogunbode et al., 2019).

The first research gap we address concerns how individuals formulate subjective attributions of local EWEs to anthropogenic climate change. Brügger et al. (2021) identify three clusters of psychological responses that may modify subjective experiences of climate-related events: (1) how individuals notice and remember experiences, (2) how these experiences interact with and influence mental representations of climate change, and (3) how the experiences influence risk processing and decision-making. The first two clusters describe a two-step process in which individuals become aware of anthropogenic climate change. This awareness typically arises through the salience of EWEs, either due to severe impacts that draw public attention and are personally relevant, or through noticeable patterns of increasingly frequent day-to-day local weather extremes, such as increasing temperatures, precipitation, or visible air pollution. Next, specific climate-related experiences may resonate differently with individuals, reinforcing, contradicting, or changing their mental representations of the relationship between anthropogenic climate change and EWEs. For example, record-breaking EWEs that follow rising global temperatures may reinforce beliefs in human-caused consequences. However, Zanocco et al. (2024) note a disparity between the extreme event attribution patterns of the U.S. population and scientific consensus, such as the public's overconfidence in attributing wildfires to climate change due to an oversimplified perception of rising temperatures as the cause (see Joireman et al., 2010). As storms are amongst the least understood climate disasters in relation to climate change causes (McClure et al., 2022; Zanocco et al., 2024), past empirical experiences of storms may strongly influence subjective attribution patterns. Individuals who underestimate anthropogenic climate change as a causal factor may lack motivation to take action to mitigate future climate risks. However, overestimation may lead individuals to overlook systemic, manmade climate vulnerabilities and misdirect their support toward more direct solutions, such as enhancing disaster mitigation through improved infrastructure (McClure et al., 2022; Zanocco et al., 2024). Here, we refrain from extrapolating whether stronger or weaker anthropogenic climate attribution is inherently beneficial, recognising that climate risks cannot be addressed solely by controlling the climate crisis itself, but also by mitigating pre-existing climate vulnerabilities.

1.4. Eco-anxiety outcomes

Specific eco-anxiety dimensions can uniquely predict pro-environmental behaviours and mental health symptoms (Hogg et al., 2024; Karl & Stanley, 2024). However, Hogg et al. (2024) find that the relationships between these dimensions in the HEAS are longitudinally intertwined, i.e., interventions aiming to increase eco-anxiety responses associated with pro-environmental behaviours, namely rumination and personal impact anxiety, may also increase affective and behavioural symptoms over the long term and, in turn, increase mental health risks. In the EAQ, Agoston et al. (2022) present an alternative two-dimensional structure of eco-anxiety that distinguishes between normative, externally focused climate concerns and the individual levels of pathological symptoms toward the climate crisis. This two-dimensional structure includes 1) normative responses, i.e., negative emotions around climate change consequences that can be distressing but may not necessarily be functionally impairing (e.g. more frequent EWEs), and 2) pathological symptoms that manifest as behavioural, functional, or social impairments. Some evidence supports a link between greater pro-environmental behaviours and fewer mental health outcomes with the normative dimension, (i.e. an adaptive response), while maladaptive responses to eco-anxiety may be associated with the pathological dimension (Micoulaud-Franchi et al., 2024; Zeier & Wessa, 2024). However, the actual relationships with pro-environmental

behaviours may be more complex than previously described (Agoston et al., 2024).

In order to understand the complexities of eco-anxiety, it is important to consider the cognitive and emotional factors that affect how individuals perceive environmental threats and how they cope with them. The second research gap therefore examines how different coping mechanisms can result in different adaptive and maladaptive responses to eco-anxiety. Pihkala (2020) suggests that while eco-anxiety is formed from feelings of uncertainty, unpredictability and uncontrollability, the experience of eco-anxiety is rarely just pathological, but also existential, with moral and practical dimensions which can positively influence people's responsiveness to climate change. Perceived risk and concern about extreme weather can motivate individuals to seek information and prepare for disasters (Armstrong et al., 2021). According to Brügger et al. (2021), an individual's risk perception and decision-making may be positively affected by negative emotions triggered by experiences of EWEs. These negative emotions (e.g. fear) may motivate adaptive behavioural responses, including information-seeking behaviour, the adoption of strategies to improve disaster preparedness or support for climate adaptation and mitigation policies. However, the shift from experiencing an EWE to engaging in climate action is not straightforward, but rather it is mediated by an individual's psychological disposition (Bradley et al., 2020; Ogunbode et al., 2019; Yildiz et al., 2026). While fear can be a powerful force for change, it can also immobilise people if they lack the coping mechanisms to deal with it in an adaptive way (Boluda-Verdu et al., 2022), or if the fear is extreme. Specific phobias of the natural environment, such as storm phobia, are recognised as irrational degrees of fear toward distinct environmental stimuli, e.g. paralysing thoughts of injury or death from a storm warning over five days away (Gabbard, 2007; Nelson et al., 2014). Further, individuals with strong intolerance to uncertainty may overestimate risk and lack a sense of control, experiencing information processing biases (Carleton et al., 2007; Dugas et al., 2005). One way in which people seek information about weather conditions is through their weather salience, which refers to the attentional processes of noticing, monitoring, and engaging with weather-related information (Stewart, 2009). Studies have found that a connection to nature is beneficial for motivating individual and collective climate action, but is also associated with greater eco-anxiety (Thomson & Roach, 2023).

We investigate a non-exhaustive list of psychological factors that may influence individuals' strategies for psychologically coping with EWEs and their eco-anxiety, including the effects of extreme weather fear (i.e. storm fear), weather salience, perceived control of anxiety, intolerance of uncertainty, and nature connectedness. Using the EAQ (Agoston et al., 2022), we examine how these psychological factors are associated with the eco-anxiety dimensions associated with adaptive (normative dimension) and maladaptive (pathological dimension) responses.

2. Research aims

The aims of this study are to provide insights into how differences in personal experiences with EWEs and local weather are differentially associated with the extent to which local EWEs are subjectively attributed to anthropogenic climate change, and how subjective attributions and psychological factors behind coping strategies are related to adaptive and maladaptive responses to eco-anxiety. We thus propose two research questions, illustrated in Fig. 1. (A) When controlling for socio-demographic factors, what roles do EWE experiences and local weather perceptions play in individuals' subjective attribution of local EWEs to anthropogenic climate change? (B) How are adaptive and maladaptive responses to eco-anxiety associated with subjective attribution, storm fear, weather salience, intolerance of uncertainty, anxiety control, nature connectedness, and future risk awareness?

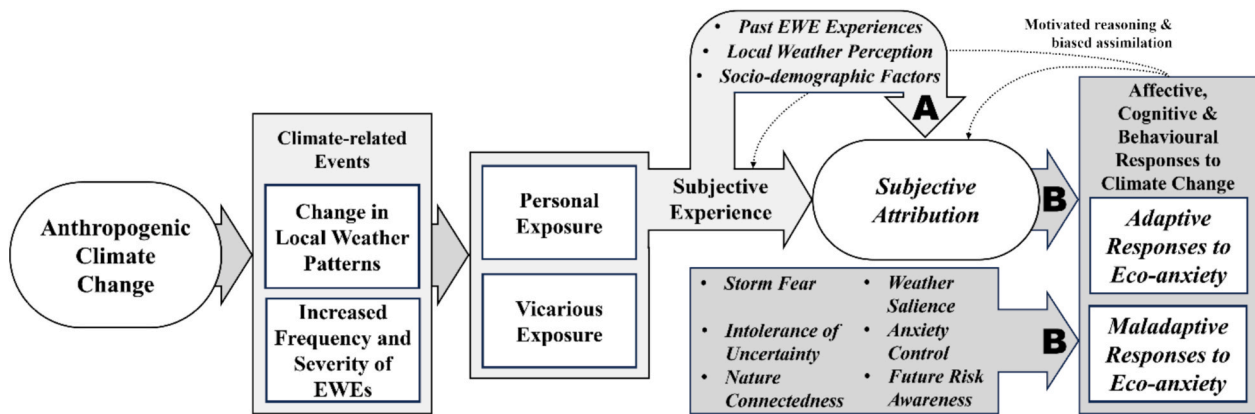


Fig. 1. Conceptual model of the proposed research questions (A, B) within the paradigm of anthropogenic climate change experience processing. *Note:* This conceptual model is adapted from [Howe \(2021\)](#). Terms shown in *italics* denote additional measures of interest in the present study.

3. Methods

3.1. Study site

Hong Kong, a metropolis characterised by high-rise buildings along the southern coast of China, is located in the subtropical climate zone at an approximate latitude of 22°N. Hong Kong has a long history of typhoons, with an annual typhoon season typically running from May to early November. The intensification of typhoons over the western North Pacific Ocean, plausibly due to climate-induced ocean warming, has increased East and Southeast Asia's risk of catastrophic typhoon impacts ([Chen et al., 2021](#)). Severe typhoon events have increased Hong Kong's vulnerability to *compound floods*, which are floods amplified by factors such as extreme sea levels and heavy rainfall ([Lai et al., 2023](#)). Although Hong Kong has a total land area of 1,114.57 km², only a quarter of the land is developed due to its mountainous topography, resulting in clusters of residential areas in low-lying, flood-prone coastal areas. Urban risk factors, such as a population density of 7,062 people per km², surface water accumulation on the impervious surfaces of highly urbanised areas, and substandard drainage systems in older urban areas, have exacerbated the risks of flooding due to storms ([Gu & Liu, 2024](#); [Zhang et al., 2023](#)).

On 7–8 September 2023, the trough left by Typhoon Haikui produced historic levels of rainfall not seen in Hong Kong since 1999. As shown in [Fig. 2A](#), exceptionally severe rainstorms (ESRs) occurred in Hong Kong for the first time since 2015, affecting six Hong Kong districts. These ESRs featured an extreme rainfall rate of over 140 mm in 1 h, a rate that was repeated during an isolated rainfall event in 2024 ([Wong et al., 2024](#)). In 2023, several other districts were also affected by torrential rainfall at rates exceeding 600 mm in 24 h. This event necessitated the highest (Black) rainstorm warning level to remain in effect for 16 h and 35 min, breaking all previous records since the inception of the warning system in 1992. Images and videos of pedestrians trapped in a flooded mall and metro station made news headlines, and the Hong Kong government likened the extreme rainfall conditions to an unprecedented 'once in 500 years' event.

In recent decades, Hong Kong has experienced increases in other extreme weather patterns, namely very hot days (maximum temperatures $\geq 33^{\circ}\text{C}$), hot nights (minimum temperatures $\geq 28^{\circ}\text{C}$) and extreme precipitation events ([Hong Kong Observatory 2025](#)). While EWEs are defined using a fixed threshold that categorises them as infrequent, non-extreme local weather patterns in temperature changes or precipitation may also contribute to personal salience of climate change impacts.

3.2. Study design and sample

Using the online QuestionPro platform, 675 Hong Kong residents

who could read Chinese and were >18 years of age were surveyed as the 2024 typhoon season commenced, from 3 June (1 day after the first typhoon of the season hit) to 11 September 2024. We performed data cleaning to remove 83 respondents who failed attention check questions, 171 speeders that completed the survey below half of the median time (<761 s), 24 straightlining responses, and 21 incomplete responses to retain 376 responses, with a completion rate of 55.9%. This collected sample surpassed the minimum required sample size of 238, determined by estimating the statistical power for multiple linear regression with a maximum of 24 predictors with medium effect sizes ($f^2 = 0.15$, $\beta > 0.8$, $\alpha = 0.05$) using G*Power Version 3.1.9.7. As shown in [Fig. 2B](#), half of our sample (49.7%, $n = 187$) resided in districts that experienced an ESR over 600 mm within 24 h during the previous year. Our sample collected from Hong Kong's three regions was adequately representative of the true population distribution during the same year of 2024 with at most margins of 1.6–6.4% differences (Census and Statistic Department, 2025). The mean sample age was 30.13 years ($SD = 13.31$), with a range of 18–83 years. The respondents were predominantly female (70.5%, $n = 265$), and students (45.7%, $n = 172$) and employed individuals (46.5%, $n = 175$) were evenly represented. The respondents were highly educated, with most holding a university degree or higher education (90.2%, $n = 339$); however, compared with the average household in Hong Kong, more respondents perceived themselves to be worse off (23.1%, $n = 87$) than better off socioeconomically (6.1%, $n = 23$). Less than a quarter of our respondents were married (22.1%, $n = 83$).

3.3. Measures

3.3.1. Socio-demographic factors

Respondents were asked to report their age, gender, education level, marital status, current employment, perceived social status relative to the average household, and district of residence in Hong Kong.

3.3.2. Eco-Anxiety Questionnaire (EAQ-8)

We used the eight-item EAQ ([Agoston et al., 2022; 2024](#)) to measure two dimensions of eco-anxiety associated respectively with adaptive and maladaptive responses to eco-anxiety. This corresponds to what Agoston et al. call (1) *habitual ecological worry* (HEW) measured with statements capturing strong emotional responses toward and worry about normative concerns about climate consequences and the ecological crisis (e.g. "I am terrified by how many things have changed in just a few years because of climate change"), and (2) *negative consequences of eco-anxiety* (NCoE) measured with statements such as "I am so anxious about climate change that it affects my performance at school/work." pertaining to personal consequences of eco-anxiety that can cause behavioural, functional, and social impairments in daily life. Both subscales comprise four items, and respondents indicate their agreement with the

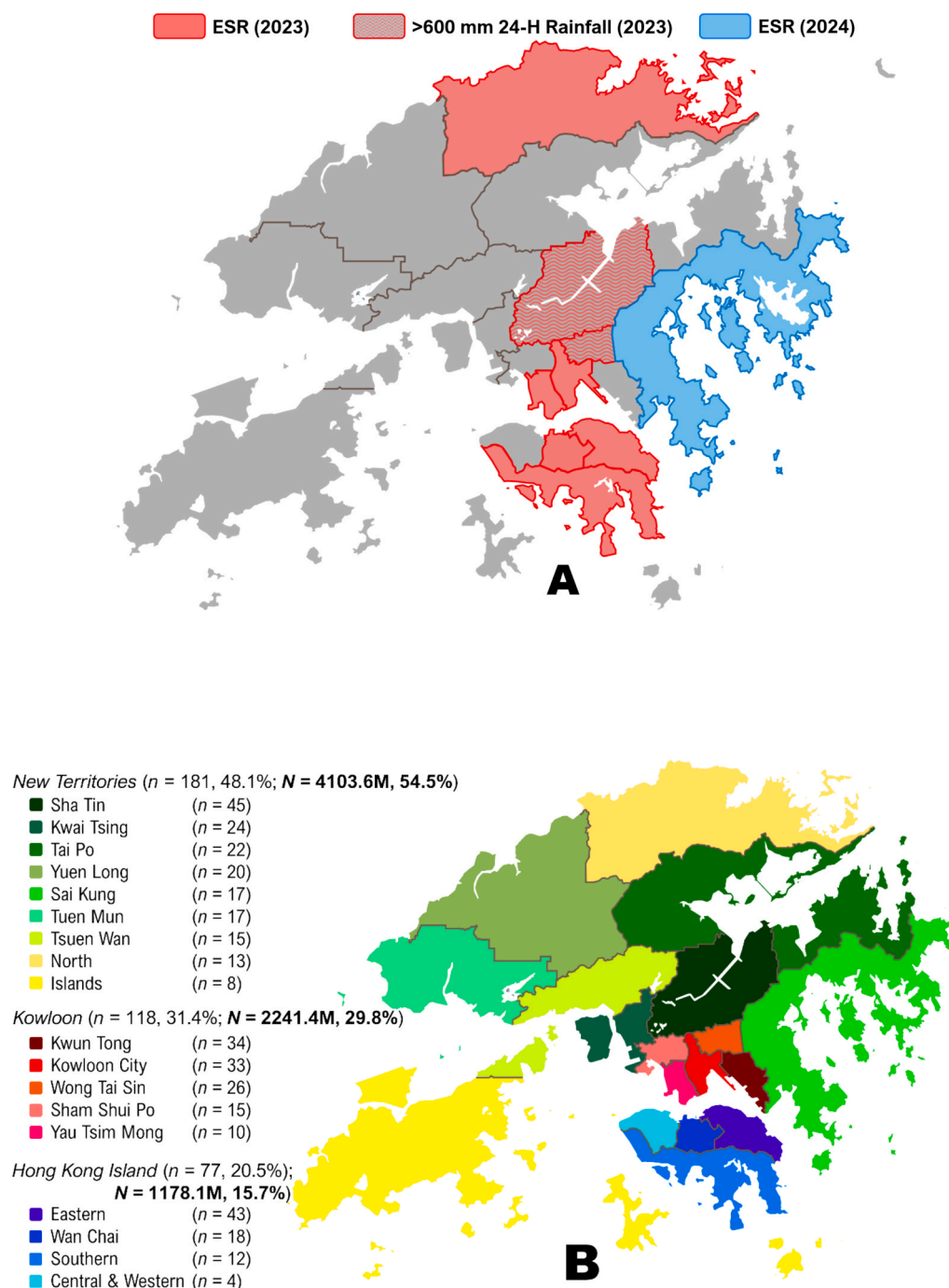


Fig. 2. Hong Kong district maps of (A) occurrences of extreme precipitation events in 2023–2024 and (B) sample distribution by district and region. Note: ESR = exceptionally severe rainstorm. N represents 2024 mid-year population estimates from [Census and Statistics Department \(2025\)](#).

items using a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). Total scores range from 4 to 16, where higher scores indicate a greater prevalence of the eco-anxiety component. To validate the two-factor structure and distinctiveness of cognitive/emotional (adaptive) and functionally impairing (maladaptive) eco-anxiety as captured by the EAQ in our sample, we conducted a principal component analysis and parallel analysis after confirming the suitability of the items for analysis using the criteria of a Kaiser–Meyer–Olkin measure greater than 0.8 and a significant Bartlett’s sphericity test (0.887 and $\chi^2(28) = 1,817.65, p < 0.001$ in this analysis). A scree plot and parallel analysis (**Supplementary Fig. 1**) was used to identify two principal components that should be retained for having eigenvalues larger than

random eigenvalues, which also verified the original scale structure of subscale items when fitted using an oblimin rotated matrix (**Supplementary Table 1**).

3.3.3. Storm fear Questionnaire (SFQ)

The 15-item SFQ is used to assess adults’ self-reported cognitive, affective, and behavioural processes indicative of a phobia of storms ([Nelson et al. 2014](#)). Studies suggested that EWEs pose substantial personal threats to human health and can elicit pro-climate responses when interpreted using fear appeal models ([Campbell et al., 2023](#); [Tannenbaum et al., 2015](#)). According to the extended parallel process model (EPPM; [Witte, 1992](#)), fear-inducing stimuli are processed both cognitive

(via efficacy appraisal) and emotional (via threat appraisal) pathways, leading to two types of behavioural motivations. These are distinguished as *protection motivations* (when the perceived behaviour efficacy is high), prompting adaptive responses, such as changing one's behaviour to mitigate storm risks (i.e., danger control processes), and *defensive motivations* (i.e., fear control), which arise when perceived efficacy is low, leading to maladaptive responses such as climate denial or fatalism (i.e., fear control processes) (Witte, 1992; Witte & Allen, 2000). However, research has not yet explored how extreme weather fear mediates adaptive and maladaptive responses to eco-anxiety. The SFQ employs a *specific phobia* framework, measuring storm fear through somatic symptoms and excessive behavioural adjustments. Example items include 'When there is a storm, my anxiety is so high that I question whether I can handle it,' and 'When a storm is approaching, I tend to seek safety in a certain room.' Responses were self-reported on a 5-point Likert scale from 0 (not at all true) to 4 (almost always true), yielding a total score between 0 and 60. Although validation studies have mainly been conducted in the West but not for Chinese populations, a comparable cutoff score of 31 was adopted, aligning with a US study that identified high storm fear at a score of 30, one standard deviation (SD) above the mean (Krause et al., 2018).

3.3.4. Weather salience Questionnaire (WxSQ): Attention to weather and to weather information

Weather salience refers to awareness of the atmospheric environment and psychological or emotional significance attached to weather conditions, which may manifest as weather-oriented behavioural adaptations (Stewart, 2009). We used the nine-item *Attention to Weather and Weather Information* subscale to assess respondents' tendency to seek, retain, and act on weather forecast information. High weather salience has been shown to be psychologically important for individuals with storm fear when managing anticipatory anxiety (Westefeld et al., 2006). Items were rated on a 6-point Likert scale (0 = strongly disagree/never; 5 = strongly agree/always), yielding total scores from 0 to 45.

3.3.5. Intolerance of uncertainty scale (IUS-12)

The 12-item IUS-12 measures responses to uncertainty (Carleton et al., 2007; Zsido et al., 2021). Two subscales measure *prospective anxiety* (i.e., the anxiety caused by anticipating uncertain future events, or anticipatory anxiety) and *inhibitory anxiety* (i.e., the extent to which this anxiety inhibits experiences or actions). High intolerance of uncertainty can result in dysfunctional coping mechanisms when facing uncertain future situations and may contribute to the development of maladaptive eco-anxiety symptoms (Rosen et al., 2014). Responses were scored on a 5-point Likert scale from 1 (not at all characteristic of me) to 5 (entirely characteristic of me), yielding total scores from 12 to 60, with higher scores indicating greater intolerance of uncertainty.

3.3.6. Anxiety control Questionnaire (ACQ-15)

The ACQ measures the respondent's perceived control over emotional reactions and external threats (Rapee et al., 1996), exemplified by their control over emotional responses to EWEs or perceived efficacy to mitigate individual climate risks. In the revised 15-item ACQ, Brown et al. (2004) identified a three-factor solution comprising *emotional control*, *threat control*, and *stress control* subscales. These measure perceived control over ones' emotional state, avoidance of stressful situations, and emotional regulation during stressful situations. Higher anxiety control may reduce an individual's maladaptive symptoms of eco-anxiety when anticipating future EWEs, while enhancing their perceived self-efficacy to engage with pro-climate actions. All items were rated on a 6-point Likert scale (0 = strongly disagree; 5 = strongly agree) assessing perceived anxiety control. The subscales include five, six, and four items, respectively, yielding total scores of 0–30, 0–36, and 0–24, with higher scores indicating greater perceived anxiety control in each domain.

3.3.7. Nature Relatedness scale (NR-6)

The six-item NR-6 measures nature connectedness (Nisbet & Zelenski, 2013) across two subscales: *Self* (4 items; self-identity) and *Experience* (2 items; contact with nature). Although nature connectedness can heighten eco-anxiety by amplifying perceived ecological risks due to climate change, it also effectively buffers stress and may reduce maladaptive eco-anxiety symptoms (Jalin et al., 2024). Items were rated on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree), with total score obtained by averaging item responses; higher scores indicate stronger nature connectedness.

3.3.8. Extreme weather event experience, local weather perception, future risk awareness, and subjective attribution of local EWEs to anthropogenic climate change

EWE experience was evaluated using the question 'Have you ever personally experienced a severe storm or weather-related catastrophe?' The respondents rated the attitudinal impact of these experiences by responding to the item 'How has your personal experience with severe storms or catastrophes influenced your feelings about and perceptions of such events in the future?' using a 7-point Likert scale ranging from –3 (very positive) to 3 (very negative). They also indicated whether the experiences constituted a 'core negative experience' during childhood (≤ 12 years), after childhood (> 12 years), or both.

Personal salience regarding negative changes in weather patterns was assessed by asking 'Have you noticed any changes in local weather patterns or conditions in recent years?' The respondents rated this item using a 7-point Likert scale ranging from –3 (very positive changes) to 3 (very negative changes). The respondents then indicated how they would 'Rate the predictability of the weather in your region' on a scale from 1 (completely predictable) to 9 (extremely unpredictable) and responded to 'How anxious or worried do you feel when there is a forecast of extreme weather in your region?' using a scale from 1 (not at all) to 7 (extremely).

Three items were used to assess the respondents' perceived future risk of being affected by future storm events: 'What do you think is the likelihood of a super typhoon disaster in Hong Kong?', 'Generally speaking, do you think storms will have a serious impact on you and your family?', and 'Generally speaking, do you think storms will have a serious impact on Hong Kong?' These items demonstrated acceptable internal reliability ($\alpha = 0.673$, $\omega = 0.691$) and were aggregated into a single scale for measuring future risk awareness.

Subjective attributions of local EWEs to anthropogenic climate change were assessed using the question 'To what extent do you think the frequency and severity of extreme weather in your region is affected by climate change?' The respondents provided their responses using a scale from 1 (not at all) to 9 (extremely).

3.4. Data analysis

Data analysis was performed using IBM SPSS Statistics for Windows, version 29 (IBM Corp., Armonk, N.Y., USA) and R for Windows, version 4.4.1 (R Foundation for Statistical Computing, Vienna, Austria). The assumptions of all statistical tests were met, and the level of significance was set at a p -value < 0.05 for a two-tailed test. All the scale measures were found to have acceptable internal reliability (McDonald's $\omega > 0.70$), and a correlation matrix constructed using Spearman's rho revealed significant positive correlations between storm fear, intolerance of uncertainty, lower anxiety control in the domains of threat and stress (but not emotions), nature connectedness, and future risk awareness among respondents who exhibited both adaptive (HEW) and maladaptive (NCoE) responses to eco-anxiety (Supplementary Table 2).

For our first research question, multinomial regression analysis was used to compare and contrast the levels of subjective attribution of local EWEs to anthropogenic climate change (hereafter, *subjective attribution*) after binning the 9-point Likert scale responses into low (1–3), moderate (4–6), and high (7–9) groups. A correlation matrix was constructed for

our measures using Spearman's rho. For our initial analysis, one-way multivariate analysis of covariance was used to predict both dimensions of eco-anxiety based on the binned groups of subjective attribution, with all other scale measures as covariates, as the statistical test is robust to violations of normality (i.e., floor effects in the NCoE subscale). However, Pillai's trace tests were used to determine that all factors other than storm fear poorly explained the multivariate model (Supplementary Table 3). To ensure the independence of eco-anxiety dimensions, we tested a mediation model and found the effects of storm fear were only partially mediated between the two eco-anxiety outcomes, controlling for other scale factors (Supplementary Fig. 2). Therefore, we analysed three separate models of eco-anxiety: (1) a multiple linear regression model for the HEW subscale, predicted by all scale measures and subjective attribution, and (2) a two-part hurdle model analysing the likelihood of the minimum and nonminimum NCoE subscale scores using binary logistic regression, which was combined with (3) a generalised linear model (GLZM) using a gamma distribution with a log link for the nonminimum scores predicted by all scale measures and subjective attribution. This hurdle model approach can effectively handle floor effects by treating 0 (or minimal) values differently from positive values. To tailor the NCoE subscale for hurdle modelling, we shifted each Likert scale item score range down by 1 point and included the value of '0' in scores, resulting in a range from 0 to 12. In Model 1, our full sample was used for binary logistic regression to analyse the likelihood of reporting the minimum NCoE score (0; 59.8%, $n = 225$) versus a non-zero score (40.2%, $n = 151$). In the GLZM, positive NCoE scores (1–12) were simultaneously predicted using a gamma distribution with a log link. Data analysis and visualisation were performed

using the glmmTMB (Brooks et al., 2017), DHARMA (Hartig, 2016), broom (Robinson, 2014), and dotwhisker (Solt and Hu, 2024) packages in R.

4. Results

4.1. Overview of sample characteristics and self-reported experiences

Table 1 includes the descriptive statistics of participant responses ($n = 376$) to their extreme weather experiences, local weather perceptions, and future risk awareness. Only 19.7% ($n = 74$) of the respondents believed that they had personally experienced a severe storm in their lifetime, even though 49.7% ($n = 187$) lived in districts affected by ESRs during the previous year. Local weather patterns were generally perceived to have changed negatively (89.4%, $n = 336$) but were considered to be more predictable (68.1%, $n = 256$) than unpredictable (16.2%, $n = 61$) or neither predictable or unpredictable (15.7%, $n = 59$). Half of the respondents believed that Hong Kong was likely to be affected by another super typhoon (50.5%, $n = 190$), and many felt that this storm would have a serious impact (46.8%, $n = 176$); however, a minority of the participants believed that such a storm would pose a significant personal threat (21.0%, $n = 79$). The respondents most frequently described local EWE impacts as being somewhat (4), moderately (5), or considerably (6) attributable to anthropogenic climate change (63.8%, $n = 240$). We calculate that approximately 19.4% ($n = 73$) of our sample met the criterion of exhibiting clinical levels of storm fear based on their SFQ scale scores (≥ 31).

Table 1

Descriptive statistics on self-reported extreme weather experiences, local weather perceptions, and future risk awareness.

Survey Questions	N (%) of Responses								
Extreme Weather Experiences									
	Yes				No				
Have you ever personally experienced a severe storm or weather-related catastrophe?	74 (19.7%)				302 (80.3%)				
–3 = <i>Very Positive</i> ; 3 = <i>Very Negative</i>	–3	–2	–1		0	1	2		3
How your personal experience with severe weather or catastrophes has influenced your feelings and perceptions toward such events in the future.	2 (0.5%)	11 (2.9%)	22 (5.9%)		112 (29.8%)	153 (40.7%)	73 (19.4%)		3 (0.8%)
	Yes				No				
Did you have any core negative experiences with storms or weather-related catastrophes during your childhood (before age 12)?	30 (8.0%)				346 (92.0%)				
Did you have any core negative experiences with storms or weather-related catastrophes during your adulthood (after age 12)?	67 (17.8%)				309 (82.2%)				
Local Weather Perceptions									
	Yes				No				
Living in a district impacted by ESRs in the last year ^a	187 (49.7%)				189 (50.3%)				
–3 = <i>Very positive changes</i> ; 3 = <i>Very negative changes</i>	–3	–2	–1		0	1	2		3
Have you noticed any changes in local weather patterns or conditions over the past few years?	13 (3.5%)	3 (0.8%)	0 (0.0%)		24 (6.4%)	22 (5.9%)	176 (46.8%)		138 (36.7%)
1 = <i>Completely predictable</i> ; 9 = <i>Extremely unpredictable</i>	1	2	3	4	5	6	7	8	9
How would you rate the predictability of weather in your region?	9 (2.4%)	22 (5.9%)	98 (26.1%)	127 (33.8%)	59 (15.7%)	48 (12.8%)	11 (2.9%)	1 (0.3%)	1 (0.3%)
1 = <i>Not at all</i> ; 7 = <i>Extremely</i>	1	2	3		4	5	6		7
How anxious or worried do you feel when there is a forecast of extreme weather in your district?	17 (4.5%)	95 (25.3%)	140 (37.2%)		89 (23.7%)	28 (7.4%)	6 (1.6%)		1 (0.3%)
Future Risk Awareness									
1 = <i>Low [likelihood / impact]</i> ; 5 = <i>High [likelihood / impact]</i>	1	2		3	4		5		
How likely do you think it is that a super typhoon disaster will happen in Hong Kong?	15 (4.0%)	61 (16.2%)		110 (29.3%)	146 (38.8%)		44 (11.7%)		
In general, do you think a typhoon would have a severe impact on you and your family?	66 (17.6%)	115 (30.6%)		116 (30.9%)	63 (16.8%)		16 (4.3%)		
In general, do you think typhoons have a severe impact on Hong Kong	14 (3.7%)	53 (14.1%)		133 (35.4%)	121 (32.2%)		55 (14.6%)		
Subjective Attribution of Anthropogenic Climate Change									
1 = <i>Not at all</i> ; 9 = <i>Extremely</i>	1	2	3	4	5	6	7	8	9
To what extent do you think the frequency and severity of extreme weather in your region is affected by climate change?	1 (0.3%)	13 (3.5%)	51 (13.6%)	93 (24.7%)	71 (18.9%)	76 (20.2%)	44 (11.7%)	17 (4.5%)	10 (2.7%)

^a Measured based on data from self-reported districts of respondents and past data on ESR events.

4.2. Predictors of subjective attribution

The assumptions of the proportional odds model (i.e., treatment of subjective attribution as ordinal) were avoided in favour of a multinomial model (Table 2), recognising that the nominal categories of psychological attribution may better illustrate the relationships between factors leading to potential under- or over-attribution of anthropogenic climate change. This is supported in our data by the improved model fit when comparing the multinomial regression model (McFadden's $R^2 = 0.134$, AIC = 645.49) and treating subjective attribution as a continuous variable in OLS regression (Adjusted $R^2 = 0.144$, AIC = 1363.64) using the same predictors. The respondents' initial responses indicated near-unanimous agreement that local EWE impacts are at least partly attributable to anthropogenic climate change. Only 0.3% of the respondents expressed climate denial, as indicated by responses of 'not at all' to items regarding the frequency and severity of local EWEs being attributable to climate change. We grouped scores of 1–3 (not at all, very little, slightly), 4–6 (somewhat, moderately, considerably), and 7–9 (very, quite a bit, extremely) into the respective categories of low (17.3%), moderate (63.8%), and high (18.9%) subjective attribution while maintaining a normal distribution (skewness = -0.006, kurtosis = -0.222). Reducing the number of groups increased the statistical power and improved the interpretability of our analysis.

The moderate group was chosen as the reference group for our analysis. Our model had a significant predictive effect compared with the null model ($\chi^2(34) = 91.31$, $p < 0.001$). Odds ratios (OR) with 95% confidence intervals (95% CI) and p -values indicated the strengths and directions of the associations between subjective attribution levels and corresponding factors. Respondents who reported noticing more negative changes in local weather were more likely to exhibit higher subjective attribution than moderate attribution (OR = 3.226, 95% CI [2.028, 5.128], $p < 0.001$). Interestingly, respondents reporting that their personal experiences caused more negative (or less positive) attitudinal changes towards future EWEs exhibited more moderate over high subjective attributions (OR = 0.654, 95% CI [0.485, 0.882], $p =$

0.005). Compared with the moderate group, lower subjective attribution was observed among both respondents who perceived the local weather to be more predictable (OR = 0.778, 95% CI [0.611, 0.992], $p = 0.043$) and those who felt less anxiety or worry due to extreme weather forecasts (OR = 0.620, 95% CI [0.455, 0.844], $p = 0.002$). Self-reported higher perceived social status was associated with both low (OR = 3.445, 95% CI [1.027, 11.560], $p = 0.045$) and high subjective attribution (OR = 4.121, 95% CI [1.353, 12.554], $p = 0.013$) in our model, however this finding is difficult to interpret due to confounding explanations such as socioeconomic class differences in the ability to mitigate personal climate risks or perceived social responsibility. Overall, respondents who reported previous negative experiences with storms, during either childhood or adulthood, were not more likely to differ from others in their degree of subjective attribution. Instead, attitudinal changes due to personal experiences and day-to-day perceptions of local weather patterns over time (i.e., perceived negative changes and unpredictability) were related to the level of subjective attribution. Unlike anxiety or worry due to extreme weather forecasts, living in a district affected by extreme precipitation in the past year did not affect subjective attribution via perceived local risks (e.g., an increased likelihood of district-level floods).

4.3. Eco-anxiety prediction models

Table 3 presents our multiple linear regression model, which identified several factors associated with greater HEW. These were (in order of largest explained variance) storm fear ($\beta = 0.346$, $p < 0.001$), connectedness to nature ($\beta = 0.219$, $p < 0.001$), future risk awareness ($\beta = 0.140$, $p = 0.003$), and high subjective attribution ($\beta = 0.097$, $p = 0.028$). The only factor that negatively predicted HEW was low subjective attribution ($\beta = -0.094$, $p = 0.031$), suggesting that a linear relationship could be approximated between high, moderate, and low subjective attribution levels.

Table 4 displays the odds ratio of each variable fitted to a binary logistic regression model of having minimum vs. non-minimum NCoE

Table 2

Multinomial regression analysis of the likelihood of subjective attribution levels based on socio-demographic factors, extreme weather event experiences, and local weather perceptions.

Factors	Low Subjective Attribution (vs Moderate)			High Subjective Attribution (vs Moderate)		
	OR	95% CI for OR[LL, UL]	p -value	OR	95% CI for OR[LL, UL]	p -value
<i>Socio-demographics</i>						
Age	0.989	[0.954, 1.024]	0.524	1.021	[0.988, 1.054]	0.219
Gender (0 = Male):						
Female	1.165	[0.597, 2.276]	0.654	1.034	[0.524, 2.039]	0.924
Non-binary	— ^a			— ^a		
Undisclosed	0.425	[0.045, 3.994]	0.454	0.996	— ^a	0.996
Education Level:						
Secondary or below (1)	0.784	[0.225, 2.728]	0.702	2.518	[0.838, 7.571]	0.100
Tertiary level (2)	0.713	[0.333, 1.530]	0.386	0.805	[0.357, 1.816]	0.602
Above tertiary level (3)	—			—		
Perceived Social Status:						
Worse off (1)	1.122	[0.542, 2.323]	0.757	0.951	[0.457, 1.977]	0.892
Similar to other households (2)	—			—		
Better off (3)	3.445	[1.027, 11.560]	0.045	4.121	[1.353, 12.554]	0.013
Marriage Status (0 = No)	1.297	[0.468, 3.596]	0.617	0.618	[0.221, 1.729]	0.360
<i>Extreme Weather Event Experience</i>						
Personal experience (0 = No)	0.838	[0.316, 2.220]	0.723	2.255	[0.963, 5.280]	0.061
Negative attitudinal impact on future events	0.960	[0.692, 1.332]	0.807	0.654	[0.485, 0.882]	0.005
Childhood experience (0 = No)	0.937	[0.235, 3.744]	0.927	1.387	[0.467, 4.122]	0.556
Adulthood experience (0 = No)	0.777	[0.276, 2.188]	0.632	0.898	[0.353, 2.286]	0.822
Living in district impacted by extreme precipitation within the previous year (0 = No)	0.890	[0.494, 1.605]	0.700	1.032	[0.555, 1.922]	0.920
<i>Local Weather Perception</i>						
Perceived negative changes in local weather	0.821	[0.582, 1.159]	0.263	3.226	[2.028, 5.128]	<0.001
Perceived unpredictability of local weather	0.778	[0.611, 0.992]	0.043	1.105	[0.888, 1.375]	0.370
Anxiety or worry from extreme weather forecasts	0.620	[0.455, 0.844]	0.002	1.069	[0.805, 1.420]	0.645

Note: OR = odds ratio. CI = confidence interval. LL = lower limit. UL = upper limit. Moderate subjective attribution is the reference group for levels of subjective attribution outcomes. **Bolded** values indicate a significant effect. ^aValues for non-binary ($n = 1$) and undisclosed ($n = 7$) could not be computed due to low group sizes.

Table 3

Multiple linear regression model predicting habitual ecological worry (HEW) according to subjective attribution levels and scale measures.

Independent Variable	B (SE)	β	95% CI of β		t	p -value	VIF
			LL	UL			
Subjective Attribution (Moderate = 2):							
Low Subjective Attribution (1)	-0.76 (0.35)	-0.094*	-0.179	-0.008	-2.17	0.031	1.08
High Subjective Attribution (3)	0.76 (0.34)	0.097*	0.011	0.183	2.21	0.028	1.11
Storm Fear	0.10 (0.01)	0.346***	0.249	0.442	7.04	<0.001	1.39
Weather Salience	-0.01 (0.03)	-0.017	-0.109	0.075	-0.37	0.713	1.26
Intolerance of Uncertainty	0.02 (0.02)	0.044	-0.064	0.153	0.81	0.421	1.75
Emotional Control	-0.02 (0.03)	0.031	-0.124	0.062	-0.66	0.508	1.29
Threat Control	-0.01 (0.04)	-0.010	-0.134	0.115	-0.16	0.877	2.31
Stress Control	-0.08 (0.05)	-0.106	-0.234	0.021	-1.64	0.102	2.43
Nature Relatedness	0.80 (0.17)	0.219***	0.129	0.308	4.81	<0.001	1.19
Future Risk Awareness	0.18 (0.06)	0.140**	0.050	0.231	3.04	0.003	1.23
$F_{(10, 365)} = 21.10, p = 0.001, R^2 = 0.366, \text{Adjusted } R^2 = 0.349$							

Note: B = unstandardised coefficient. SE = standard error. β = standardised coefficient. CI = confidence interval. LL = lower limit. UL = upper limit. t = t -test statistic. VIF = variance inflation factor. *** $p < 0.001$; ** $p = 0.01$; * $p = 0.05$.

Table 4

Binary logistic regression of the minimal and nonminimal negative consequences of eco-anxiety (NCoE) scores.

	Model 1: Binary Logistic Regression (<i>n</i> = 376)						Model 2: Zero-Truncated Gamma Model (<i>n</i> = 151)				
IndependentVariable	B (SE)	OR	95% CI for OR		<i>p</i> -value	B (SE)	β	95% CI for β		<i>p</i> -value	
			LL	UL				LL	UL		
Subjective Attribution (Moderate = 4–6):											
Low (0–3)	−0.13 (0.34)	0.875	0.447	1.714	0.698	0.00 (0.13)	0.002	−0.130	0.134	0.977	
High (7–9)	−0.29 (0.33)	0.750	0.390	1.444	0.389	−0.25 (0.13)	−0.134	−0.271	0.002	0.053	
Storm Fear	0.10 (0.02)	1.105***	1.073	1.138	<0.001	0.02 (0.01)	0.265***	0.110	0.419	<0.001	
Weather Salience	−0.05 (0.03)	0.950*	0.905	0.997	0.039	−0.01 (0.01)	−0.055	−0.209	0.100	0.486	
Intolerance of Uncertainty	−0.02 (0.02)	0.985	0.945	1.026	0.455	0.02 (0.01)	0.256*	0.048	0.464	0.016	
Emotional Control	−0.02 (0.03)	0.979	0.922	1.039	0.480	0.02 (0.01)	0.117	−0.042	0.276	0.149	
Threat Control	−0.10 (0.04)	0.903**	0.843	0.966	0.003	−0.00 (0.02)	−0.005	−0.226	0.216	0.967	
Stress Control	0.04 (0.05)	1.036	0.943	1.139	0.456	0.00 (0.02)	0.009	−0.211	0.230	0.933	
Nature Relatedness	0.33 (0.16)	1.385*	1.007	1.903	0.045	−0.12 (0.07)	−0.123	−0.275	0.030	0.114	
Future Risk Awareness	0.07 (0.06)	1.073	0.960	1.200	0.216	0.02 (0.02)	0.084	−0.059	0.228	0.248	
Goodness of fit	Hosmer–Lemeshow $\chi^2(8) = 13.44, p < 0.098$					Likelihood Ratio $\chi^2(10) = -298.8, p < 0.001$					
Pseudo <i>R</i> ²	Nagelkerke’s <i>R</i> ² = 0.345					Nagelkerke’s <i>R</i> ² = 0.286					
Complete model	Log Likelihood = -496.7, Deviance = 993.3, AIC = 1039.3, BIC = 1129.7										

Note: B = unstandardised regression coefficient. SE = standard error. OR = odds ratio. CI = confidence interval. LL = lower limit. UL = upper limit. *** $p < 0.001$; ** $p = 0.01$; * $p = 0.05$. The hurdle model was split using a minimum NCoE subscale of 4 (59.8%), and scores of 5–16 (40.2%) were categorized as positive values.

scores for our full sample (Model 1), followed by a zero-truncated gamma model fitted to respondents with non-minimum NCoE scores only (Model 2). The effect of storm fear reached a high level of significance in both Model 1 (OR = 1.105, 95% CI [1.073, 1.138], $p < 0.001$) and Model 2 ($\beta = 0.265$, 95% CI [0.110, 0.419], $p < 0.001$). In Model 1, weather salience (OR = 0.950, 95% CI [0.905, 0.997], $p = 0.039$) and threat control (OR = 0.903, 95% CI [0.843, 0.966], $p = 0.003$) were negatively associated with the prevalence of a nonminimal NCoE score, whereas nature connectedness (OR = 1.385, 95% CI [1.007, 1.903], $p = 0.045$) was positively associated. In Model 2, higher intolerance of uncertainty ($\beta = 0.256$, 95% CI [0.048, 0.464], $p = 0.016$) predicted a higher NCoE score. Model diagnostics provided by the DHARMA package (Hartig, 2016) in R indicated that our full model sufficiently fitted the hurdle gamma distribution (Kolmogorov–Smirnov test statistic = 0.032, $p = 0.848$) and had no significant outliers (total outliers = 1, observations = 376, $p = 0.382$) or signs of overdispersion or underdispersion (dispersion test statistic = 0.792, $p = 0.144$) (Supplementary Fig. 3). Fig. 3 compares the standardised coefficients and significance levels with 95% confidence intervals for each eco-anxiety outcome.

5. Discussion

Following the wettest storm on record in Hong Kong, this study

examined how individual EWE experiences and local weather perceptions influenced Chinese adult respondents' subjective attribution of local EWE impacts to anthropogenic climate change and role the psychological factors in this subjective process. Surprisingly, the personal salience of day-to-day local weather patterns, which were typically perceived negatively, had the strongest effect on respondents' subjective attribution of anthropogenic climate change on the frequency and severity of local EWE impacts. In spite of pervasive ESRs and floods within the previous year affecting approximately half of the districts where respondents resided, no significant effects on subjective attribution were found. Only one fifth of respondents reported the perceived experience of a severe storm (or other extreme weather event), which suggests that objective experiences may be unreliable in influencing subjective attributions. In a U.S. study, perceived experiences were shown to be the more reliable predictor of climate policy support than measures of objective exposure (Gould et al., 2024). We subsequently examined the relationships between levels of subjective attribution and psychological factors, including adaptive (emotional/cognitive) and maladaptive (functionally impairing) responses to eco-anxiety. Our findings revealed strong relationships between storm fear and both eco-anxiety dimensions. Adaptive responses to eco-anxiety, or habitual ecological worry, was positively associated with the psychological factors of future risk awareness and nature connectedness, which were largely independent of maladaptive symptoms, or negative

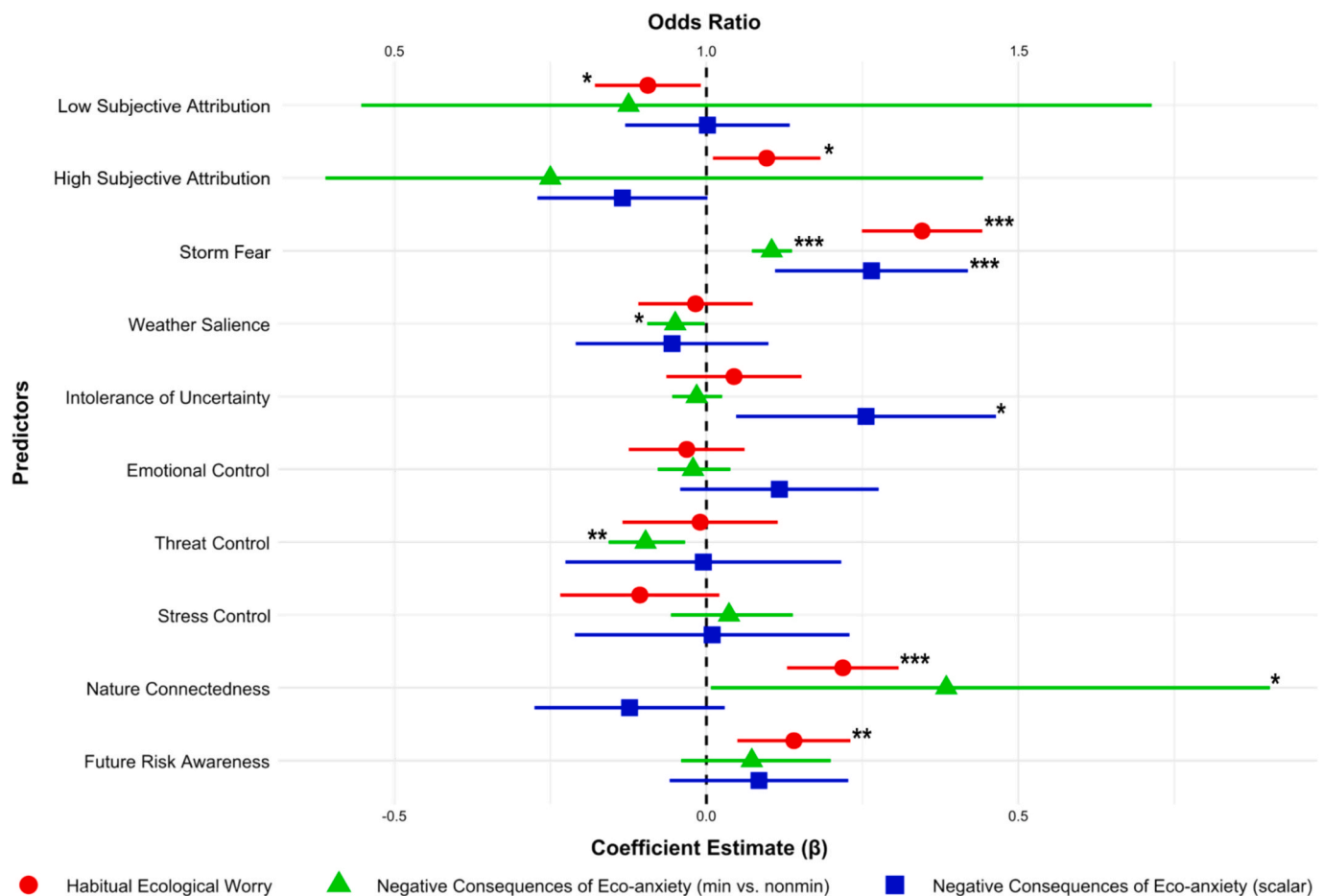


Fig. 3. Dot whisker plot comparing the effect size measures with 95% confidence intervals for habitual ecological worry (β), the minimal vs non-minimal negative consequences of eco-anxiety scores (odds ratio), and the scalar levels of negative consequences of eco-anxiety (β). Note: *** $p < 0.001$; ** $p = 0.01$; * $p = 0.05$.

consequences of eco-anxiety.

Stronger subjective attributions were associated with greater adaptive responses to eco-anxiety relative to the reference response (moderate level of subjective attribution) among nearly two thirds of the respondents. Those who displayed low subjective attribution (i.e., greater climate scepticism) were likely to downplay the role and culpability of human activity in climate consequences, which reduced their negative emotions and worries towards future climate change concerns. Perceiving oneself with a better socioeconomic status was associated with fewer moderate levels of subjective attribution in both directions. Well-off individuals may experience less climate change risks and struggle to attribute anthropogenic climate change to personal experiences, or alternatively, perceive greater efficacy or responsibility for climate change and pay greater attention to the trends of EWEs. Maladaptive eco-anxiety symptoms were not associated with subjective attributions, suggesting that the respondents were not negatively affected by more strongly attributing extreme weather events to anthropogenic causes (e.g., anticipating greater climate consequences due to globally rising temperatures). Findings from a global study suggests that on average, Hong Kong residents exhibit comparatively strong support for climate policy relative to other countries, independent of their weaker degrees of subjective attribution (Cologna et al., 2025). Nevertheless, our study finds that teaching stronger subjective attributions can help individuals cope better with eco-anxiety arising from storms, extreme precipitation, and floods which are frequently not strongly attributed to anthropogenic causes (Marlon et al., 2021). Given individuals' tendency to single out anthropogenic climate change as the main cause of the increasingly severe impacts of EWEs (McClure et al., 2022; Zanooco et al., 2024), attempting to reconcile the gap between public and

scientific attributions of anthropogenic effects on worsening storms may unintentionally impede adaptive responses to eco-anxiety.

Pidgeon (2012) cautions that uncertainty in aspects of climate messaging, such as identifying multifaceted EWE causes, projected climate risks, or variability in climate models of anthropogenic climate effects, can create an *uncertainty transfer* effect whereby the known, factual aspects of climate science may face increased scrutiny when communicated alongside unknowable or uncertain aspects. McClure et al. (2022) suggest that climate scientists must communicate probabilistic and necessary causal evidence (e.g., 'unlikely to occur or be this severe without climate change') in ways that appeal to the preferences of the general public who seek sufficient causes (e.g., 'anthropogenic climate change is a primary cause of EWEs'). While Typhoon Haikui did not substantially shift the respondents' subjective attributions beyond the personal salience of day-to-day local weather patterns, the salience of EWEs has encouraged individuals to reassess their perceived personal risks and renewed media discussion concerning Hong Kong's disaster preparedness (Lee & Feng, 2023). These efforts have led to support for infrastructural policies intended to reduce flooding risks in severely affected districts. Hence, unprecedented EWE impacts can still encourage the identification of alternative causes and strategies to reduce climate impacts (i.e. disaster preparedness and mitigation strategies), which may be overlooked when over-attributing EWEs to anthropogenic climate effects (Zanooco et al., 2024).

Fear of extreme weather was found to contribute strongly to increases in both adaptive and maladaptive responses to eco-anxiety. This finding suggests that storm fears may simultaneously be processed under two pathways, as described in the extended parallel process model (EPPM; Witte, 1992). Fear of extreme weather evokes emotional/

cognitive responses, which may positively influence protective motivations to mitigate climate risks through pro-climate adaptive responses, or manifest as an overwhelming level of functionally impairing, which may lead to defensive motivations to cope with the behavioural, functional, or social impairments maladaptively (Witte & Allen, 2000). According to the EPPM, how individuals perceive the efficacy of their pro-climate responses in mitigating normative concerns of the climate crisis (i.e., response efficacy) may affect their willingness to adopt pro-environmental norms such as recycling, energy conservation, or green purchasing intentions (Witte & Allen, 2000). Fears of extreme weather are expected to grow due to increases in personal and vicarious EWE experiences (Micka et al., 2023; Ogunbode et al., 2022). However, some people may not prioritise or experience sufficient degrees of perceived efficacy that would motivate their practical uses of eco-anxiety (Howe et al., 2019; Howe, 2021).

Our findings suggest that future risk awareness and nature connectedness may strongly promote more adaptive responses without being associated with greater maladaptive responses, and thus promote a predominantly adaptive experience of eco-anxiety. Nature connectedness may lead to greater ecological concern, while future risk awareness may shape expectations of more concrete climate consequences, leading individuals to perceive the climate crisis as more severe or urgent. The importance of individuals' perceptions of future climate effects could be noted from other factors, such as high subjective attributions in promoting adaptive responses to eco-anxiety, and being more intolerant of uncertainty as a risk factor of more maladaptive responses to eco-anxiety. Future risk awareness may bolster individuals' beliefs that their pro-climate actions will be necessary for the predictable increase in storm disasters, thus elevating the perceived response efficacy of pro-climate solutions under the EPPM framework. Adaptive responses to eco-anxiety could therefore come from elevating awareness of future extreme weather risks, such as by strengthening the causal relationship between EWE patterns and anthropogenic climate change through clearer communication of how human activities affect less understood EWEs over time (National Academies of Sciences, Engineering, and Medicine, 2016). Our finding that nature connectedness predominantly encourages adaptive effects may be inconsistent with the results of other studies (e.g. Agoston et al., 2024). In our study, nature connectedness was a marginally significant predictor of the prevalence of functional impairments, but had a negative but non-significant effect (11.4% significance level) on the severity of these functional impairments. The protective effects of weather salience and threat control against functional impairments from eco-anxiety suggests that maladaptive responses may emerge from perceived vulnerabilities to personal climate risks. Individuals with stronger nature connections may find it difficult to avoid greater personal consequences mediated through other eco-emotions (Agoston et al., 2024), such as intense feelings of loss through eco-grief or negative self-evaluation through eco-guilt; these consequences may present mental health risks (Zeier & Wessa, 2024). Consistent with our models, however, the direct mental health benefits of nature connectedness may largely neutralise the risk of maladaptive responses to eco-anxiety (Jalin et al., 2024). Studies have suggested that individual differences in nature connectedness may not positively moderate the effectiveness of threat or efficacy messages in fear appeal strategies (Tang et al., 2024; Xue et al., 2016). However, nature connectedness may directly affect pro-climate responses through increased perceived efficacy to combat climate change (Xue et al., 2016). This effect may be external to the processing of fear messages, as positive emotions and prosocial attitudes may function as secondary motivators of climate change mitigation (Zelenski & Desrochers, 2021).

6. Strengths and limitations

A key strength of our study is that the data were collected immediately after the onset of Hong Kong's typhoon season following the arrival of Tropical Storm Maliksi, the first storm to hit Hong Kong in

2024. This timing enabled us to assess the relationships between variables while considering residents' recent experience with the record-breaking Typhoon Haikui. However, this approach limited our data collection period and sample size.

The findings of our study should be interpreted cautiously outside the Asia-Pacific region, as storms occur predictably during the typhoon season (May–November) and thus constituted a significant portion of our respondents' experiences with climate disasters. The relationships between less predictable climate disasters, such as wildfires, and cultural experiences of eco-anxiety may vary. Even then, the three-month data collection period of our study could not fully account for respondents' differences in EWE experiences occurring after the highly salient Tropical Storm Maliksi. Our measure of subjective attribution for locally occurring extreme weather may also have had broader interpretations beyond storm-related disasters such as heatwaves, which may have weakened the overall effect of extreme weather event experiences. Due to the pressing nature of the subject and limited prior studies, non-probability sampling was our chosen approach, and a non-representative sample of the adult Hong Kong population was collected. A low completion rate of 55.9% also introduces potential biases with respondents' engagement or interest in climate disasters, or non-response biases due to the sensitive nature of questions on climate disaster experiences. Over 70% of our respondents were female, which may have contributed to higher self-reported levels of both adaptive and maladaptive responses to eco-anxiety (Agoston et al., 2022). Less-educated respondents were underrepresented in our sample, which may have led to a greater homogeneity of preexisting climate attitudes, potentially affecting the relationship between extreme weather exposure and its attribution to anthropogenic climate change, as well as responses to eco-anxiety in general. Hoekstra et al. (2024) suggests that higher education levels promote less climate scepticism and more trust climate science due to a greater accuracy of scientific knowledge on climate change, however climate attitudes are also mediated by perceived social status, which was relatively centrally distributed in our study. Furthermore, the lack of strong politicisation of the climate crisis in Hong Kong may have obscured how pre-existing climate beliefs, including political identities, influence subjective attributions of local EWEs to anthropogenic climate change. We note that the EAQ subscales measuring normative (HEW) and pathological (NCoE) responses could have cross-lagged effects on each other (similar to the HEAS), but we were unable to examine the longitudinal relationship between these variables due to the cross-sectional study design.

7. Conclusion

Our findings from a sample of Hong Kong residents reveal a highly urbanised population without significant climate scepticism of local anthropogenic climate impacts and robust beliefs of the likelihood of future storm impacts. Our study enhances the understanding of how EWE experiences and fears lead to adaptive and maladaptive responses to eco-anxiety. Our findings emphasise the need to reassess a multifaceted concept of 'eco-anxiety' in relation to motivating pro-climate responses. Additionally, climate disasters may not always represent the most salient impacts of climate change; recognising the personal salience of day-to-day weather patterns may be equally or even more important. Our research suggests that extreme weather fear simultaneously evokes emotional and cognitive responses to normative concerns and functionally impairing aspects of eco-anxiety. As the global population is exposed to more frequent and severe EWEs, future risk awareness and nature connectedness appear to be beneficial to promoting adaptive responses to eco-anxiety, with minimal effects on exacerbating maladaptive responses to eco-anxiety.

CRedit authorship contribution statement

Sam S.S. Lau: Writing – review & editing, Writing – original draft,

Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jason W.L. Fong:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Emma L. Lawrance:** Writing – review & editing. **Angel W.L. Chui:** Writing – review & editing, Methodology. **Wangjian Zhang:** Writing – review & editing. **Shao Lin:** Writing – review & editing. **Bahtiyar Yıldız:** Writing – review & editing, Methodology. **Andras N. Zsido:** Writing – review & editing, Methodology, Conceptualization.

Declaration of competing interest

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

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Ethics approval

Approval for the study was obtained from the research ethics committee of the first author's university (REC/23-24/0068/A2). The study adhered to the Declaration of Helsinki and was conducted and reported in accordance with the STROBE guidelines for observational studies.

Consent to participate

All participants were required to read an information page detailing study rationale, approximate length of the study, the confidentiality and anonymity of the data collected, and withdrawal process prior to consenting to participate in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.17605/OSF.IO/QZ93U>.

Data availability

Data will be made available on request.

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