BMC Public Health

RESEARCH | Article in Press

Prevalence and correlates of climate and natural disaster anxiety among adolescents in Mbarara, Southwestern Uganda: a school-based cross-sectional study

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Received: 26 June 2026 / Accepted: 4 November 2026
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Abstract

Background Climate change is increasingly recognized as a threat to mental health, particularly among adolescents who are highly aware of environmental challenges and their future implications. Evidence on climate-related anxiety among young people in sub-Saharan Africa remains limited. This study aimed to determine the prevalence of climate anxiety and natural disaster anxiety and to identify associated factors among adolescents attending ten selected secondary schools in Mbarara City and Mbarara District, Southwestern Uganda.

Methods A cross-sectional study was conducted among secondary school students aged 13–19 years from selected urban and rural schools in Mbarara City and Mbarara District, Southwestern Uganda. The participating schools were geographically concentrated in central and southern Mbarara City, with only one school located in Mbarara District. Data were collected using items taken without modification from the standardized instrument of a multi-country adolescent mental health survey (described in Methods), capturing self-reported concern and emotional responses to climate change and natural disasters. Logistic regression analyses were performed to identify factors independently associated with climate anxiety and natural disaster anxiety. Multivariable models used complete-case data ($n=764$) and cluster-robust standard errors; modified Poisson regression was used as a sensitivity analysis. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were reported.

Results Of 797 enrolled adolescents, 766 with complete outcome data were included (mean age 16.6 ± 1.8 years; 59.1% male). In this sample, 88.8% reported climate anxiety and 79.2% natural disaster anxiety, defined broadly as any self-reported concern or emotional response rather than clinically significant anxiety. Factors independently associated with climate anxiety included older age and family structure; adolescents living with a biological parent had lower odds of climate anxiety than those living without a biological parent (aOR = 0.50, 95% CI: 0.29–0.86). In unadjusted descriptive comparisons, climate anxiety was also more prevalent among adolescents attending rural than urban schools (93.1% vs. 85.7%) and private than public schools (92.1% vs. 85.6%); natural disaster anxiety did not differ by school context. Natural disaster anxiety was independently associated with female sex (aOR = 1.49, 95% CI: 1.09–2.03) and emotional and behavioural problems (aOR = 1.60, 95% CI: 1.11–2.33).

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https://doi.org/10.1186/s12889-026-30320-0

Published online: 14 November 2026

Conclusions Self-reported climate and natural disaster anxiety were highly prevalent among adolescents in the ten participating schools. Older age and living without a biological parent were associated with higher odds of climate anxiety; female sex and emotional and behavioural problems were associated with higher odds of natural disaster anxiety. Unadjusted differences by school location and ownership were modest. Because the participating schools were concentrated in central and southern Mbarara City, these findings describe the sampled schools and should not be generalised to Mbarara City or District as a whole.
Clinical trial registration Not applicable.

Keywords Climate anxiety · Eco-anxiety · Natural disaster anxiety · Adolescents · Mental health · Climate change · Health equity · Uganda · Sub-Saharan Africa

Introduction

Climate change is no longer viewed solely as an environmental issue; it is increasingly recognized as a threat to mental health and wellbeing [1]. Around the world, concerns about rising temperatures, extreme weather events, environmental degradation, and uncertainty about the future are affecting how people think and feel about their lives and communities [2, 3]. Among the psychological responses linked to these concerns are climate-related anxiety, which refers to worry or distress about climate change, and natural disaster-related anxiety, which reflects fears related to events such as floods, droughts, storms, and other environmental disasters [4, 5]. While some degree of concern may encourage positive environmental action, excessive worry may contribute to emotional distress and negatively affect wellbeing [6, 7].

Adolescents may be particularly susceptible to climate-related anxiety [8–10]. Adolescence is characterized by rapid cognitive, emotional, and social development, alongside increasing awareness of societal and global issues [10]. Young people may encounter climate-related information through schools, social media, news outlets, and direct experiences within their communities [8]. Consequently, their concerns may extend beyond current environmental conditions to uncertainty about their future, livelihoods, health, and communities [11]. Studies from several settings have documented fear, worry, frustration, helplessness, and other forms of emotional distress among young people in relation to climate change and environmental disasters [2, 3, 10, 11].

Understanding why some adolescents experience greater climate- and disaster-related anxiety than others requires consideration of both their appraisal of environmental threats and the social contexts within which these appraisals occur. This study was therefore informed by two complementary perspectives: the cognitive stress-appraisal model [12] and the socio-ecological perspective on adolescent development [13–15]. The cognitive stress-appraisal model proposes that psychological distress is influenced not only by exposure to a potential stressor but also by how individuals evaluate its threat relative to their perceived capacity and resources to cope [12]. Thus, adolescents who perceive climate change or natural disasters as highly threatening while perceiving limited resources to manage these threats may experience greater anxiety. The socio-ecological perspective complements this individual appraisal process by situating adolescents within interconnected family, school, community, and wider societal contexts [13–15]. Climate-related anxiety may therefore reflect interactions between individual-level characteristics, such as age, sex, and emotional and behavioural difficulties; relational and family factors, including loneliness, social connectedness, and family structure; and broader contextual factors, including the school and environmental settings in which adolescents live and learn [2, 5, 8–10, 16]. Within the stress-appraisal perspective, these individual and relational characteristics may shape perceived vulnerability to environmental threats or the coping resources available to respond to them [12]. Together, the two perspectives provide a framework for examining climate and natural disaster anxiety as psychological responses arising within both personal and social contexts [12–15]. However, because threat appraisal and perceived coping resources were not directly measured in this study, these constructs are used as an interpretive framework rather than as directly tested mechanisms.

These concerns may be particularly relevant in Uganda, where communities experience climate variability and climate-related hazards, including floods, prolonged droughts, landslides, food insecurity, and disruptions to livelihoods [17, 18]. Adolescents living in such settings may be affected directly through their own or their families' experiences or indirectly through awareness of current and anticipated environmental threats [18]. Exposure to these hazards is unlikely to be uniform. Rural households, whose livelihoods depend more directly on rain-fed agriculture and livestock, may experience climate variability as an immediate threat to food, income, and schooling, whereas urban households may be partly buffered by more diversified incomes [17, 18]. Differences between rural and urban settings, and between households with different financial resources, may therefore shape how adolescents experience climate change. Despite this growing relevance, empirical evidence on climate-related anxiety among young people in Uganda remains limited. Two recent scoping reviews examining young people's perceptions of climate change and its relationship with mental health in sub-Saharan Africa identified relatively few empirical studies, with much of the available evidence being qualitative or focused on perceptions rather than quantitative measures of mental health [7, 19]. The reviews highlighted the limited quantitative evidence from East Africa and the need for further research estimating climate-related mental health outcomes and examining associated factors among young people [7, 19]. A small but growing body of evidence from East Africa has begun to address this gap. A survey among Kenyan high-school students found that emotional responses to climate change, including anxiety, fear, anger, and powerlessness, were common [20]. In Uganda, a cohort study among young women living in Kampala's urban settlements assessed climate anxiety using a validated measure [21], while another study among Ugandan adolescents examined the mediating role of perceived government response in the relationship between climate information and eco-anxiety [9].

Nevertheless, important gaps remain in understanding climate and natural disaster anxiety among secondary-school-going adolescents in Uganda. Evidence from school-based adolescent samples drawn from diverse educational contexts remains limited, as does research examining demographic, family, and psychosocial correlates simultaneously. Climate-related anxiety is unlikely to occur independently of adolescents' broader psychosocial circumstances [22, 23]. Loneliness, emotional and behavioural difficulties, suicidal thoughts, self-harm, and family circumstances have been associated with adverse mental health outcomes among young people and may also be relevant to how adolescents perceive and respond to environmental threats [24–27]. Examining these factors across individual and relational levels may therefore help identify adolescents who experience greater climate- and disaster-related distress and inform approaches to strengthening psychological and social resources [28].

Climate-related distress may also overlap phenomenologically with features observed in established anxiety problems, including persistent worry, heightened vigilance, and, when severe, functional impairment [29–31]. Climate anxiety itself should not necessarily be regarded as a psychiatric disorder, as concern about genuine environmental threats may represent an understandable response to climate change. However, persistent or impairing climate-related anxiety may be particularly relevant among adolescents already experiencing emotional or behavioural difficulties [31]. Understanding these experiences is therefore important both in characterizing young people's responses to environmental change and in identifying potential psychosocial vulnerabilities that may warrant support.

Given the growing global attention to the mental health impacts of climate change and the limited evidence from Uganda, there is a need to understand the extent of climate anxiety and natural disaster anxiety among adolescents and the factors associated with these concerns [32]. Therefore, this study aimed to determine the prevalence of climate anxiety and natural disaster anxiety and identify associated demographic, family, and psychosocial factors among secondary-school-going adolescents attending ten selected schools in Mbarara, Southwestern Uganda, and to describe how these outcomes varied across rural and urban, public and private, and single-sex and mixed-sex school contexts within this sample. By examining these factors within cognitive stress-appraisal and socio-ecological perspectives, the study seeks to contribute context-specific evidence that may inform school-, community-, and public health approaches to supporting adolescent well-being in the context of a changing climate.

Methods

Study design and setting

This study utilized a cross-sectional analytical design to investigate the prevalence of climate anxiety and natural disaster anxiety and the associated factors among adolescents in Southwestern Uganda. Data were collected from secondary school students attending ten selected schools in Mbarara City and Mbarara District, in Southwestern Uganda. Mbarara City and the surrounding district are located in Southwestern Uganda and comprise both urban and rural communities [33].

Mbarara attained city status on 1 July 2020 and is the main commercial and administrative centre of Southwestern Uganda. The city comprises six divisions: Kakoba, Kamukuzi, and Nyamitanga, which form the densely populated urban core, and Biharwe, Kakiika, and Nyakayojo, which were annexed in 2014 and retain substantial peri-urban and agricultural areas [33]. According to the 2024 National Population and Housing Census, Mbarara City had a population of 264,425 and Mbarara District 174,039 [34]. Mbarara District lies to the north and west of the city and is predominantly rural. It comprises one county (Kashari), with six sub-counties (Bubaare, Bukiro, Kagongi, Kashare, Rubaya, and Rubindi) and five town councils [34]. Most households in the district depend on rain-fed crop farming and livestock, particularly dairy cattle, so that household food supply and income are closely tied to rainfall [32, 34]. The area receives an average annual rainfall of approximately 1,200 mm in two rainy seasons (February–May and September–December), with temperatures ranging from about 17 °C to 30 °C [34], and it experiences recurrent droughts, prolonged dry spells, flooding, and landslides [33, 35, 36]. The contrast between the urban core of the city and the agriculture-dependent rural district could, in principle, provide a setting in which adolescents' exposure to climate-related stressors may differ according to where they live and go to school. However, as described below, the participating schools did not span this contrast evenly: most were located in central Mbarara City, and only one was located within Mbarara District itself. The main geographic and demographic characteristics of the study area are summarised in Table 1.

Secondary education in Uganda comprises ordinary level (Senior One to Senior Four) and advanced level (Senior Five and Senior Six) [37], with students typically aged 13–19 years. The participating schools included urban and rural, public and private, and mixed-sex and single-sex schools area, as described below, were not geographically representative of Mbarara City or Mbarara District. Of the ten participating schools, seven were classified as urban and three as rural. Classification was based on the setting of each school: urban schools were located in the built-up centre of Mbarara City, whereas rural schools were in predominantly agricultural surroundings, one in Bukiro sub-county of Mbarara District and two in the outlying southern parts of Mbarara City. Four schools were public and six private; all four single-sex schools (two boys' and two girls' schools) were urban. The locations of the schools are shown in Fig. 1, and their distribution by classification is shown in Table 1.

The sampling frame comprised 75 secondary schools across Mbarara City and Mbarara District. Of these, 37 schools were located in Mbarara City, including 9 public and 28 private schools, while 38 schools were located in Mbarara District, comprising 14 public and 24 private schools [38]. Overall, the sampling frame included 23 public and 52 private secondary schools. Ten schools were selected for the study, representing approximately 13.3% of the total sampling frame. Nine participating schools were located in Mbarara City and one in Mbarara District. The proportion of frame schools sampled was 24.3% in Mbarara City (9/37) and 2.6% in Mbarara District (1/38). Frame and sample counts are given in Table 1.

As Fig. 1 shows, the participating schools were geographically concentrated: seven were located close to one another (within approximately 10 km) in central Mbarara City, two were in the outlying southern part of the city, and one was in Bukiro sub-county of Mbarara District. No schools were sampled from the northern and western sub-counties of Mbarara District (Bubaare, Kagongi, Kashare, Rubaya, and Rubindi). Mbarara District, which accounts for approximately 39.7% of the combined population of the city and district (174,039 of 438,464), was

Table 1 Geographic and demographic characteristics of the study area, sampling frame, and distribution of participants

A. Study area		
Characteristic	Mbarara City	Mbarara District
Administrative status	City since 1 July 2020	Rural district
Administrative units	Six divisions: Kakoba, Kamukuzi, Nyamitanga (urban core); Biharwe, Kakiika, Nyakayojo (peri-urban)	One county (Kashari); six sub-counties (Bubaare, Bukiro, Kagongi, Kashare, Rubaya, Rubindi); five town councils
Setting and main livelihoods	Commercial and administrative centre; trade and services, with agriculture in the peri-urban divisions	Predominantly rural; rain-fed crop farming and livestock, particularly dairy cattle
Climate	Bimodal rainfall (February–May and September–December); approximately 1,200 mm per year; temperatures about 17–30 °C	As for the city
Principal climate-related hazards	Flooding and prolonged dry spells	Drought and prolonged dry spells affecting crops and livestock; flooding and landslides
Population (2024 census) n = 438,464	264,425 (60.3%)	174,039 (39.7%)
Secondary schools in sampling frame, n = 75 (23 public / 52 private)	37 (9 public / 28 private)	38 (14 public / 24 private)
Participating schools, n = 10 (7 urban / 3 rural; 4 public / 6 private)	9 (7 urban in central city; 2 rural in outlying southern city)	1 (rural, Bukiro sub-county)
Proportion of frame sampled, 13.3% (10/75)	24.3% (9/37)	2.6% (1/38)
B. **Participants by school classification**		
School classification	**Urban schools**	**Rural schools**
Schools	7 (all in central Mbarara City)	3 (1 in Bukiro sub-county, Mbarara District; 2 in outlying southern Mbarara City)
Ownership	2 public, 5 private	2 public, 1 private
Sex composition	3 mixed, 4 single sex (2 boys', 2 girls')	3 mixed
Students analysed (n = 766)	448 (58.5)	318 (41.5)
Climate anxiety, 680 (88.8%)	384 (85.7)	296 (93.1)
Natural disaster anxiety, 607 (79.2%)	346 (77.2)	261 (82.1)

Sources: Uganda Bureau of Statistics, National Population and Housing Census 2024 [34]; Mbarara District Local Government ; [34] references [33, 35, 36]. Across all ten schools, 378 students (49.3%) attended private and 388 (50.7%) public schools, and 483 (63.0%) attended mixed-sex and 283 (37.0%) single-sex schools. The participating schools were concentrated in central and southern Mbarara City (Fig. 1) and are not representative of all schools in Mbarara City or Mbarara District

therefore represented by a single school. Consequently, the sample cannot be regarded as geographically representative of secondary-school students in Mbarara City or Mbarara District as a whole.

Figure 1: presents the study area encompassing Mbarara City and Mbarara District in Southwestern Uganda

Study population and eligibility criteria

The study population comprised adolescents aged 13–19 years enrolled in selected secondary schools in Mbarara City and Mbarara District, Southwestern Uganda. Students were eligible to participate if they were enrolled in one of the selected schools, fell within the specified age range, and were present during the data collection period. Adolescents who were unable to complete the questionnaire because of severe illness or cognitive impairment were excluded. For participants younger than 18 years, written parental or guardian consent and adolescent assent were required before enrolment. Participants aged 18 years and above provided written informed consent for their own participation.

To support inclusivity, eligibility did not depend on sex, class level, day or boarding status, religion, academic performance, orphanhood, or living arrangement, and students living with non-parental caregivers were eligible on the same basis as those living with their parents. Both urban and rural schools, public and private schools, and single-sex and mixed-sex schools were included, so that adolescents from different school contexts were

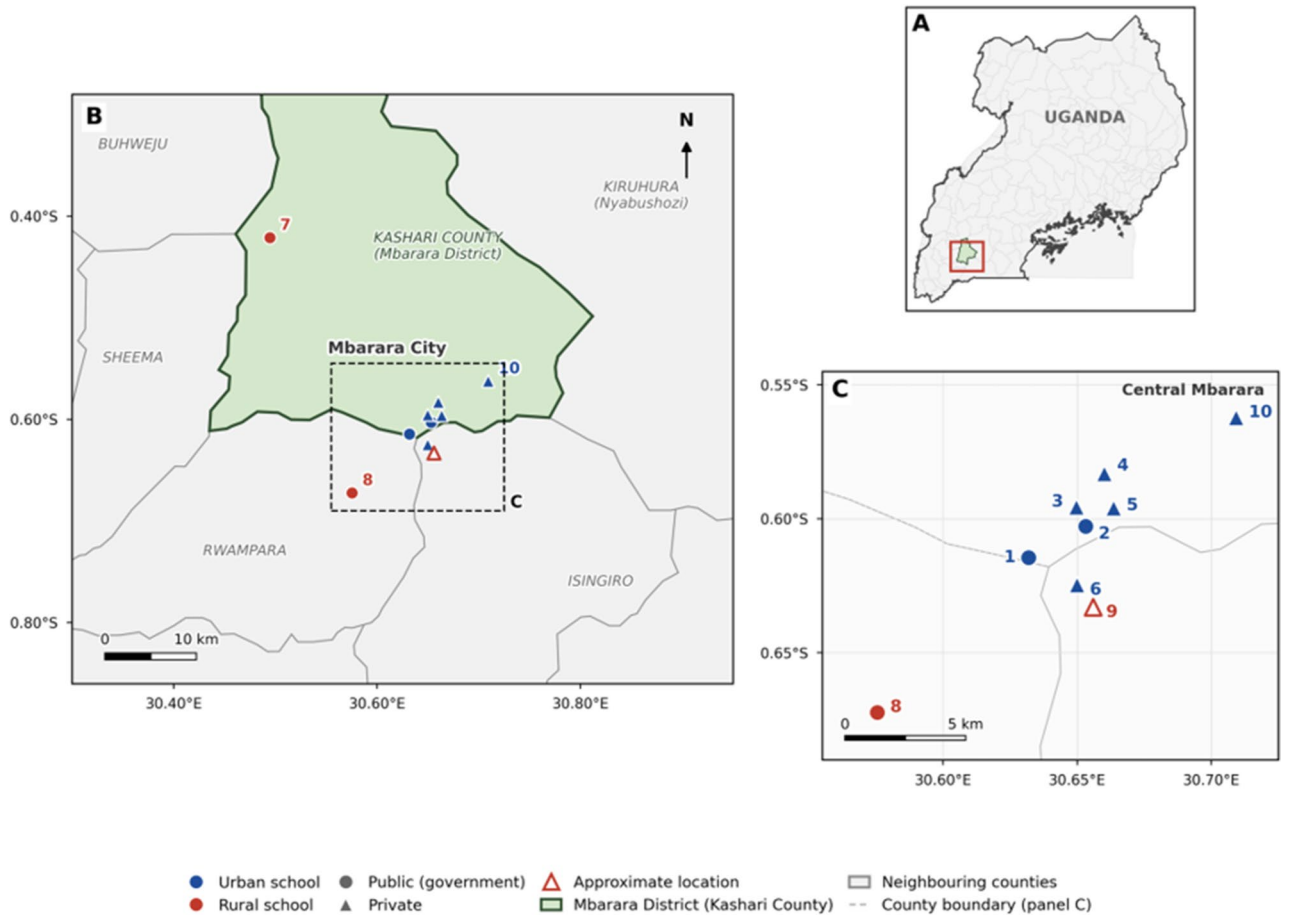


Fig. 1 Map of the study area. **A** Location of the study area in Uganda. **B** Mbarara District (Kashari County), neighbouring counties, and the ten participating secondary schools; Mbarara City lies at the southern edge of the district and extends across former county boundaries. **C** Enlarged view of central Mbarara. Marker colour indicates school classification (urban or rural) and marker shape indicates ownership (public or private); the open symbol indicates an approximate location. Numbers are school identifiers. Nine of the ten participating schools lie within central or southern Mbarara City; no schools were sampled from the northern and western sub-counties of Mbarara District. Administrative boundaries: geoBoundaries [39], generalised; boundaries of Mbarara City and its divisions are not available in this dataset.

represented within the sample. Research assistants were available during data collection to clarify questions for students who needed assistance. Adolescents who were not enrolled in school, and enrolled students who were absent during data collection, could not be included; the implications of this are considered in the Limitations.

Sampling and recruitment

Participants were selected using a multistage stratified sampling procedure. First, secondary schools in Mbarara City and Mbarara District were listed and stratified by location (urban or rural), ownership (government or private), and school type (day or boarding). Schools were then selected proportionately from each stratum using simple random sampling by the lottery method to ensure representation across the different school categories. Stratification by location and ownership was used because these characteristics reflect differences in community setting and household resources that were expected to shape adolescents' exposure to climate-related stressors and their access to support. School sex composition (single-sex or mixed-sex) was not a stratification variable but was recorded because it varied across the selected schools. Geographic spread across city divisions and district sub-counties was not a stratification criterion, and the random selection of ten schools resulted in a sample

concentrated in central and southern Mbarara City **(**Fig. 1**).** The number of schools in the sampling frame is reported in Table 1.

Within each selected school, students were stratified by class level, from Senior 1 to Senior 6. The number of students selected from each school was allocated proportionately to the school's total student population. Class registers were used as sampling frames, from which eligible students aged 13–19 years were randomly selected.

A total of 850 eligible students were approached for participation, of whom 797 enrolled and completed at least part of the questionnaire, corresponding to a participation rate of 93.8%. The remaining 53 students (6.2%) did not participate. Reasons for non-participation, recorded in the field coordination records, included absence during data collection, and failure to return parental/guardian consent.

Of the 797 participants who enrolled, 31 (3.9%) had missing data for one or both primary outcomes and were excluded, giving an analytical sample of 766 for prevalence estimates and descriptive and bivariable analyses. Of these, 764 had complete data on all covariates and were included in the multivariable logistic and modified Poisson regression models; the two excluded participants had missing responses on suicidal ideation and/or suicide attempt.

Eligible students received information about the study objectives, procedures, potential risks, and benefits from trained research assistants during scheduled sessions at their respective schools. Participation was voluntary, and students were informed that declining participation or withdrawing from the study would have no consequences for their academic standing or access to school services. Data collection was conducted in private locations within the school premises, without teachers or parents present, to protect confidentiality and facilitate open responses.

Sample size adequacy

A formal a priori sample size calculation was not documented during the design of the study. Therefore, a retrospective calculation was conducted to assess whether the achieved sample was reasonably adequate for estimating the prevalence of the study outcomes.

Using the standard single-population proportion formula, $n = Z^2p(1-p)/d^2$, with $Z = 1.96$ for a 95% confidence level [40], an anticipated prevalence of $p = 0.80$, and an absolute precision of $d = 0.035$, the estimated minimum sample size was approximately 502 participants. After applying a design effect of 1.3 to account for clustering arising from the multistage school-based sampling design, the estimated minimum sample increased to approximately 653 participants. The analytical sample of 766 adolescents, and the complete-case regression sample of 764, both exceeded this retrospective benchmark.

This calculation is presented solely as a post hoc assessment of sample size adequacy and should not be interpreted as an a priori power calculation that informed the original study design. It concerns the precision of prevalence estimates for students in the sampled schools and does not imply that the sample is representative of the adolescent population of Mbarara City or Mbarara District.

Outcome variables

The primary outcome variables were climate anxiety and natural disaster anxiety. Although related, these were treated as distinct constructs. Climate anxiety represented emotional responses to the broader and longer-term threat posed by climate change, whereas natural disaster anxiety represented emotional responses to specific environmental hazards.

Both outcomes were assessed using items from the standardized questionnaire of the Global School Survey on Adolescent Psychosocial Well-Being and Mental Health (GCAMHS), a multi-country initiative in which Uganda participated. GCAMHS uses a harmonized questionnaire across participating countries to facilitate cross-country comparisons, and country teams were not permitted to add, remove, or substitute items in the core instrument.

Climate anxiety

Climate anxiety was assessed using questions in the GCAMHS questionnaire, adapted from a previously published study among adolescents in Kenya [41]. The questions assessed both concern about climate change and emotional responses to it. Participants were first asked to indicate the extent to which they agreed with the statement, "I am concerned that climate change threatens people and the planet." Response options were "No," "Little moderate," "Moderate," "Very much," and "I prefer not to say." Responses of "Moderate" or "Very much" were classified as indicating climate-related concern, while "No" and "Little moderate" were classified as not indicating such concern.

Participants were also asked whether climate change made them experience anxiety, fear, anger, or feelings of weakness, with response options of "Yes," "No," or "I prefer not to say" for each emotion. These items were considered together because climate-related distress may manifest through several emotional responses, including anxiety, fear, anger, and helplessness [35].

For analysis, participants were classified as having climate anxiety if they reported moderate or high concern about climate change or endorsed at least one of the four emotional responses (anxiety, fear, anger, or feeling weak). Participants who did not meet either criterion were classified as not having climate anxiety. "I prefer not to say" responses were treated as missing data. The questionnaire items are provided in Supplementary File 1.

Natural disaster anxiety

Natural disaster anxiety was assessed using standardized GCAMHS questions addressing emotional responses to wildfires, earthquakes, heavy rains, droughts, and tsunamis. Participants were asked about their concern that natural disasters threaten people and the planet and whether natural disasters made them experience anxiety, fear, anger, or feelings of weakness. Responses to each emotional item were "Yes," "No," or "I prefer not to say."

For analysis, participants were classified as having natural disaster anxiety if they responded "Yes" to at least one of the four emotional response items. Those who responded "No" to all four items were classified as not having natural disaster anxiety, while "I prefer not to say" responses were treated as missing data. This approach reflects literature describing disaster-related psychological distress as encompassing emotional responses such as anxiety, fear, anger, and helplessness [41–45]. The relevant questionnaire items are provided in Supplementary File 1.

The disaster categories included in the GCAMHS questionnaire were standardized across participating countries rather than selected according to their relevance to individual study sites. This is important in the Ugandan context because Southwestern Uganda, including Mbarara City and District, experiences recurrent droughts, prolonged dry spells, flooding, and landslides, whereas hazards such as wildfires, earthquakes, and particularly tsunamis are comparatively uncommon [33, 35, 36]. Consequently, the standardized instrument included some hazards of limited local relevance while omitting others, such as landslides and extreme heat. The implications of this limitation are discussed further in the Limitations section.

Independent variables

Guided by the stress-appraisal and socio-ecological perspectives [12, 14, 15], we examined correlates representing different aspects of adolescents' individual and relational environments. Independent variables included age, sex, family structure, loneliness, emotional and behavioural problems, suicidal ideation, suicide attempts, and self-harm.

Family structure was determined from participants reported living arrangements during the preceding month. Participants were categorized as living with a biological parent if they lived with both biological parents, their biological mother only, or their biological father only. Those living with stepparents, grandparents, other relatives, or other caregivers were categorized as living without a biological parent.

Loneliness was assessed using the question, "During the past 12 months, how often have you felt lonely?" Responses were categorized as never/rarely, sometimes, or always/most of the time.

Emotional and behavioural problems were assessed using the self-reported question, "In general, do you think you have problems in any of the following areas: emotions, concentration, behavior, or getting along with others?" Response options were "No," "Yes - partial problems," "Yes - definite problems," and "Yes – severe problems." Participants reporting partial, definite, or severe problems were classified as having emotional and behavioural problems, while those reporting no problems were classified as not having emotional and behavioural problems.

Suicidal ideation was assessed by asking participants whether they had seriously experienced suicidal thoughts, while suicide attempts were assessed by asking whether they had attempted suicide. Self-harm was assessed by asking whether participants had intentionally harmed themselves, including behaviours such as cutting or burning.

Suicidal ideation, suicide attempts, and self-harm were included as standardized components of the GCAMHS questionnaire. Previous studies indicate that these experiences are important mental health concerns among Ugandan adolescents. For example, 21.6% of school-going adolescents in rural Uganda reported seriously considering suicide during the preceding 12 months [46], while a study among adolescents accessing services in Kampala's urban settlements reported prevalences of 30.6% for suicidal ideation and 24.2% for suicide attempts [47]. Suicidality has also been documented among people receiving mental health care in Uganda [48]. Given the sensitivity of these questions, data collection was conducted by trained research assistants, with established referral pathways for participants requiring mental health support, as described under Ethical Considerations.

School location (urban or rural), ownership (public or private), and sex composition (mixed-sex or single-sex) were recorded as school-level contextual characteristics.

Data collection procedures

Data were collected using a structured self-administered questionnaire. The questionnaire gathered information on socio-demographic characteristics, family structure, loneliness, emotional and behavioural problems, suicidal ideation, suicide attempts, self-harm, climate anxiety, and natural disaster anxiety. Data collection was conducted by trained research assistants under the supervision of the investigators. Prior to fieldwork, research assistants received training on study procedures, ethical conduct of research, confidentiality, administration of questionnaires, and management of sensitive topics involving adolescent mental health and suicidality. Questionnaires were administered in classroom settings that ensured privacy and minimized distractions. Participants completed the questionnaires anonymously and were assigned unique identification numbers to protect confidentiality. Research assistants were available to clarify questions without influencing participants' responses.

Ethical considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the Research Ethics Committee of Mbarara University of Science and Technology (Reference Number: MUST-2022–673). Additional administrative permission was obtained from the participating schools before the commencement of data collection. Written informed consent was obtained from participants aged 18 years and above. For participants younger than 18 years, written parental or guardian consent and participant assent were obtained prior to enrolment. Participation was voluntary, and participants were informed of their right to decline participation or withdraw from the study at any time without penalty. To ensure confidentiality, no personal identifiers were collected on the questionnaires. Data were stored securely and were accessible only to members of the research team. Given the sensitive nature of questions relating to self-harm and suicidal thoughts, arrangements were made to provide support and referral to appropriate mental health services for participants who experienced distress or required further assessment.

Data analysis

Data were entered into a database, cleaned, and analyzed using Stata version 17 (StataCorp, College Station, TX, USA). Prior to analysis, data were checked for completeness, consistency, and outliers. Participants with missing data on the outcome variables were excluded from the relevant analyses. Descriptive statistics were used to summarize participant characteristics. Continuous variables were summarized using means and standard deviations (SDs), while categorical variables were summarized using frequencies and percentages. The prevalence of climate anxiety and natural disaster anxiety was calculated as the proportion of participants meeting the respective outcome definitions described above. Bivariable analyses were conducted to examine associations between participant characteristics and the two outcomes. Independent sample t-tests were used to compare the mean age between participants with and without climate anxiety and natural disaster anxiety. Pearson's chi-square tests were used to assess associations between categorical variables and the outcomes. Separate logistic regression models were fitted for climate anxiety and natural disaster anxiety. All eight candidate variables (age, sex, family structure, loneliness, emotional and behavioural problems, suicidal ideation, suicide attempt, and self-harm) were entered simultaneously in each multivariable model, regardless of bivariable p-values. Models used complete-case data ($n=764$). Because participants were sampled within schools, observations from students attending the same school could not be assumed to be completely independent. The regression analyses therefore accounted for clustering of participants at the school level when estimating standard errors, confidence intervals, and p-values. Adjusted odds ratios (aORs) and corresponding 95% confidence intervals (CIs) are reported. School location (urban/rural), school ownership (public/private), and school type (mixed-sex/single-sex) were examined descriptively and in bivariate analyses but were not included in the individual-level multivariable regression models. These variables represented school-level characteristics incorporated into the sampling strategy to ensure representation across different school contexts and were not prespecified as individual-level predictors. Furthermore, because these characteristics were shared by students within the same schools and only ten schools participated, the study was not designed to estimate independent school-level effects. Statistical significance was assessed using two-sided tests, with a p-value of less than 0.05 considered statistically significant. Results are presented as crude odds ratios (cORs) and adjusted odds ratios (aORs) with 95% confidence intervals. Further sensitivity analysis using modified Poisson regression was conducted.

Results

A total of 766 adolescents participated in the study, with a mean age of 16.6 years (SD = 1.8), and 358 (46.7%) were living without a biological parent. More than half of the participants were male (59.1%). Regarding psychosocial characteristics, most participants reported never or rarely experiencing loneliness (59.0%), while 30.0% reported feeling lonely sometimes and 11.0% reported always feeling lonely. Nearly half of the adolescents reported emotional and behavioural problems (46.0%). Suicidal ideation was reported by 29.5% of participants, whereas 12.2% reported a previous suicide attempt. More than one-third of the adolescents reported a history of self-harm (35.5%). Regarding school characteristics, more adolescents attended urban schools ($n=448$, 58.5%). Approximately half attended public schools (50.7%) while 63.0% attended mixed-sex schools. See Table 2.

Prevalence and correlates of climate anxiety and natural disaster anxiety among adolescents in the participating schools

Among the 766 adolescents included in the analysis, 680 (88.8%) reported climate anxiety, while 607 (79.2%) reported natural disaster anxiety.

At bivariate analysis, climate anxiety was significantly associated with age, sex, family structure, suicidal ideation, self-harm, and all three school characteristics. Adolescents with climate anxiety were slightly older

Table 2 Prevalence and correlates of climate anxiety and natural disaster anxiety among adolescents ten selected secondary schools in Mbarara, Southwestern Uganda

Variable	*n*(%)	Climate anxiety		X^2 t(*p*-value)	Natural disaster anxiety		X^2/ t(*p*-value)
		No 86 (11.2)	Yes 680 (88.8)		No 159 (20.8)	Yes 607 (79.2)	
Age (mean/ SD)	16.6 (1.8)	15.7 (2.0)	16.7 (1.8)	**-4.81 (<0.001)**	16.5 (1.9)	16.6 (1.8)	-0.51 (0.611)
Sex (*n* = 766)							
Male	453 (59.1)	66 (14.6)	387 (85.4)	**12.43 (<0.001)**	107 (23.6)	346 (76.4)	**5.52 (0.019)**
Female	313 (40.9)	20 (6.4)	293 (93.6)		52 (16.6)	261 (83.4)	
Family structure (*n* = 766)							
Living without biological parent	358 (46.7)	27 (7.5)	331 (92.5)	**9.16 (0.002)**	85 (23.7)	273 (76.3)	3.64 (0.056)
Living with biological parent	408 (53.3)	59 (14.5)	349 (85.5)		74 (18.1)	334(81.9)	
Experienced loneliness (*n* = 766)							
Never/Rarely	452 (59.0)	48 (10.6)	404 (89.4)	1.17 (0.556)	111 (24.6)	341 (75.4)	**10.48 (0.005)**
Sometimes	230 (30.0)	30 (13.0)	200 (87.0)		38 (16.5)	192 (83.5)	
Always	84 (11.0)	8 (9.5)	76 (90.5)		10 (11.9)	74 (88.1)	
Emotional and behavioural problems (*n* = 766)							
No	414 (54.0)	54 (13.0)	360 (87.0)	2.98 (0.084)	106 (25.6)	308 (74.4)	**12.87 (<0.001)**
Yes	352 (46.0)	32 (9.1)	320 (90.9)		53 (15.1)	299 (84.9)	
Suicidal ideation (*n* = 765)							
No	539 (70.5)	71 (13.2)	468 (86.8)	**6.82 (0.009)**	126 (23.4)	413 (76.6)	**7.45 (0.006)**
Yes	226 (29.5)	15 (6.6)	211 (93.4)		33 (14.6)	193 (85.4)	
Suicide attempt (*n* = 764)							
No	671 (87.8)	80 (11.9)	591 (88.1)	2.45 (0.118)	146 (21.8)	525 (78.2)	**3.91 (0.048)**
Yes	93 (12.2)	6 (6.5)	87 (93.5)		12 (12.9)	81 (87.1)	
Self-harm (*n* = 766)							
No	494 (64.5)	64 (13.0)	430 (87.0)	**4.17 (0.041)**	115 (23.3)	379 (76.7)	**5.38 (0.020)**
Yes	272 (35.5)	22 (8.1)	250 (91.9)		44 (16.2)	228 (83.8)	
School location							
Rural	318 (41.5)	22 (6.9)	296 (93.1)	**10.13 (0.001)**	57 (17.9)	261 (82.1)	2.65 (0.103)
Urban	448 (58.5)	64 (14.3)	384 (85.7)		102 (22.8)	346 (77.2)	
School ownership							
Private	378 (49.3)	30 (7.9)	348 (92.1)	**8.11 (0.004)**	78 (20.6)	300 (79.4)	0.01 (0.934)
Public	388 (50.7)	56 (14.4)	332 (85.6)		81 (20.9)	307 (79.1)	
School sex composition							
Mixed sex	483 (63.0)	34 (7.0)	449 (93.0)	**23.00 (<0.001)**	104 (21.5)	379 (78.5)	0.48 (0.490)
Single sex	283 (37.0)	52 (18.4)	231 (81.6)		55 (19.4)	228 (80.6)	

The overall analytic sample comprised 766 participants. Denominators vary slightly across variables because of item-level non-response. Percentages are calculated using the number of participants with available data for each variable. Specifically, data were available for 765 participants for suicidal ideation and 764 participants for suicide attempt. Complete-case data (*n* = 766) were available for sex, family structure, loneliness, emotional and behavioural problems, and self-harm

χ^2 tests were used for categorical variables and independent-samples t-tests for continuous variables

Bold values indicate $p < 0.05$. School-level comparisons are descriptive and refer to the ten participating schools only

on average than those without climate anxiety (mean age 16.7 ± 1.8 years versus 15.7 ± 2.0 years; t = −4.81, $p < 0.001$). The prevalence of climate anxiety was higher among females than males (93.6% versus 85.4%; $\chi^2 = 12.43$, $p < 0.001$) and among adolescents living without a biological parent compared with those living with a biological parent (92.5% versus 85.5%; $\chi^2 = 9.16$, $p = 0.002$). Climate anxiety was also more prevalent among adolescents reporting suicidal ideation than among those without suicidal ideation (93.4% versus 86.8%; $\chi^2 = 6.82$, $p = 0.009$), and among adolescents reporting self-harm compared with those who did not report self-harm (91.9% versus 87.0%; $\chi^2 = 4.17$, $p = 0.041$). Regarding school characteristics, climate anxiety was more prevalent among adolescents attending rural than urban schools (93.1% vs. 85.7%; $\chi^2 = 10.13$, $p = 0.001$), private than public schools (92.1% vs. 85.6%; $\chi^2 = 8.11$, $p = 0.004$), and mixed-sex than single-sex schools (93.0% vs. 81.6%; $\chi^2 = 23.00$, $p < 0.001$); the corresponding absolute differences were 7.4, 6.5, and 11.4% points, and prevalence

exceeded 80% in every school category. In contrast, natural disaster anxiety did not differ significantly by school location (82.1% vs. 77.2%; $p=0.103$), ownership (79.4% vs. 79.1%; $p=0.934$), or sex composition (78.5% vs. 80.6%; $p=0.490$).

Natural disaster anxiety was significantly associated with sex, loneliness, emotional and behavioural problems, suicidal ideation, suicide attempts, and self-harm. The prevalence was higher among females than males (83.4% versus 76.4%; $\chi^2 = 5.52$, $p=0.019$). Natural disaster anxiety also varied significantly by loneliness status, increasing from 75.4% among adolescents who never or rarely experienced loneliness to 83.5% among those who sometimes experienced loneliness and 88.1% among those who always or most of the time experienced loneliness ($\chi^2 = 10.48$, $p=0.005$). Similarly, natural disaster anxiety was more prevalent among adolescents with emotional and behavioural problems than among those without such problems (84.9% versus 74.4%; $\chi^2 = 12.87$, $p<0.001$). Higher prevalence was also observed among adolescents reporting suicidal ideation (85.4% versus 76.6%; $\chi^2 = 7.45$, $p=0.006$), a history of suicide attempts (87.1% versus 78.2%; $\chi^2 = 3.91$, $p=0.048$), and self-harm (83.8% versus 76.7%; $\chi^2 = 5.38$, $p=0.020$) compared with their respective reference groups. Age was not significantly associated with natural disaster anxiety ($p=0.611$) **(**Table 2**).**

Factors associated with climate anxiety among adolescents in the participating schools

Older adolescents were significantly more likely to report climate anxiety than younger adolescents (aOR = 1.25, 95% CI: 1.07–1.45, $p=0.004$). Family structure was significantly associated with climate anxiety. Adolescents living with a biological parent had 50% lower odds of reporting climate anxiety compared with those living without a biological parent (aOR = 0.50, 95% CI: 0.29–0.86, $p=0.012$). See Table 3.

Table 3 Factors associated with climate anxiety among adolescents in ten selected secondary schools in Mbarara, Southwestern Uganda

Variable	Bivariable analysis	*p*-value	Multivariable analysis	*p*-value
	Crude Odds ratio (95% confidence interval)		Adjusted odds ratio (95% confidence interval)	
Age	1.34 (1.16–1.55)	<0.001	**1.25 (1.07–1.45)**	**0.004**
Sex				
Male	1		1	
Female	2.50 (1.31–4.78)	0.006	2.00 (0.98–4.05)	0.056
Family structure				
Living without biological parent	1		1	
Living with biological parent	0.48 (0.25–0.93)	0.029	**0.50 (0.29–0.86)**	**0.012**
Experienced loneliness				
Never/Rarely	1		1	
Sometimes	0.79 (0.38–1.67)	0.540	0.65 (0.30–1.38)	0.259
Always	1.13 (0.48–2.64)	0.780	0.80 (0.36–1.79)	0.591
Emotional and behavioural problems				
No	1		1	
Yes	1.50 (0.81–2.77)	0.194	1.38 (0.77–2.49)	0.280
Suicidal ideation				
No	1		1	
Yes	2.13 (1.07–4.26)	0.032	1.86 (0.80–4.35)	0.150
Suicide attempt				
No	1		1	
Yes	1.96 (0.81–4.73)	0.133	1.03 (0.31–3.37)	0.965
Self-harm				
No	1		1	
Yes	1.69 (0.79–3.63)	0.178	1.18 (0.49–2.83)	0.718

Multivariable regression analyses were based on 764 participants with complete data for all variables. Standard errors were adjusted for clustering of participants within the 10 participating schools; consequently, the reported 95% confidence intervals and *p*-values are cluster-robust

Table 4 Factors associated with natural disaster anxiety among adolescents in ten selected secondary schools in Mbarara, Southwestern Uganda

Variable	Bivariable analysis	*p*-value	Multivariable analysis	*p*-value
	Crude Odds ratio (95% confidence interval)		Adjusted odds ratio (95% confidence interval)	
Age	1.02 (0.94–1.11)	0.559	0.99 (0.91–1.08)	0.829
Sex				
Male	1		1	
Female	1.55 (1.15–2.09)	0.004	**1.49 (1.09–2.03)**	**0.013**
Family structure				
Living without biological parent	1		1	
Living with biological parent	1.41 (0.82–2.40)	0.214	1.28 (0.78–2.09)	0.333
Experienced loneliness				
Never/Rarely	1		1	
Sometimes	1.64 (1.19–2.27)	0.002	1.37 (0.98–1.90)	0.063
Always	2.41 (1.12–5.18)	0.025	1.81 (0.85–3.84)	0.122
Emotional and behavioural problems				
No	1		1	
Yes	1.94 (1.40–2.69)	<0.001	**1.60 (1.11–2.33)**	**0.013**
Suicidal ideation				
No	1		1	
Yes	1.78 (0.94–3.39)	0.077	1.36 (0.66–2.79)	0.401
Suicide attempt				
No	1		1	
Yes	1.88 (0.95–3.69)	0.068	1.04 (0.42–2.56)	0.933
Self-harm				
No	1		1	
Yes	1.57 (1.03–2.40)	0.036	1.14 (0.76–1.70)	0.522

Multivariable regression analyses were based on 764 participants with complete data for all variables. Standard errors were adjusted for clustering of participants within the 10 participating schools; consequently, the reported 95% confidence intervals and *p*-values are cluster-robust

Factors associated with natural disaster anxiety among adolescents in the participating schools

Female adolescents had higher odds of reporting natural disaster anxiety compared with males (aOR = 1.49, 95% CI: 1.09–2.03, $p = 0.013$). Those with emotional and behavioural problems had significantly higher odds of having natural disaster anxiety (aOR = 1.60, 95% CI: 1.11–2.33, $p = 0.013$). See Table 4.

Sensitivity analysis

Given the high prevalence of climate anxiety (88.8%) and natural disaster anxiety (79.2%), sensitivity analyses were conducted using modified Poisson regression with standard errors adjusted for clustering of participants within schools to estimate adjusted prevalence ratios (aPRs). For climate anxiety, increasing age (aPR = 1.03, 95% CI: 1.01–1.04; $p = 0.001$) and female sex (aPR = 1.07, 95% CI: 1.01–1.14; $p = 0.027$) were significantly associated with a higher prevalence of climate anxiety, while living with a biological parent was associated with a lower prevalence (aPR = 0.93, 95% CI: 0.88–0.98; $p = 0.009$).

For natural disaster anxiety, female sex (aPR = 1.08, 95% CI: 1.02–1.14; $p = 0.010$) and emotional and behavioural problems (aPR = 1.10, 95% CI: 1.03–1.17; $p = 0.004$) were significantly associated with a higher prevalence. Loneliness was not significantly associated with natural disaster anxiety after accounting for clustering, although the estimate for adolescents who reported always or most of the time experiencing loneliness approached statistical significance (aPR = 1.10, 95% CI: 0.99–1.23; $p = 0.072$). Overall, the sensitivity analyses were broadly consistent with the cluster-adjusted logistic regression findings for the principal associations, while the prevalence

ratios were closer to the null than the corresponding odds ratios, as expected given the high prevalence of both outcomes (Supplementary Table 1).

Discussion

This study examined the prevalence and correlates of climate anxiety and natural disaster anxiety among adolescents in ten selected secondary schools in Mbarara, Southwestern Uganda. We found that climate anxiety and natural disaster anxiety were highly prevalent, affecting nearly nine in ten (88.8%) and four in five (79.2%) adolescents, respectively. Older age and living without a biological parent were independently associated with climate anxiety, while female sex and emotional and behavioural problems were independently associated with natural disaster anxiety. Climate anxiety, but not natural disaster anxiety, was also more prevalent among adolescents attending rural and private schools, although these differences were modest in absolute terms and were observed in a geographically concentrated sample of schools. The findings can be interpreted through the complementary stress-appraisal and socio-ecological perspectives that informed this study. At the individual level, associations with age, sex, and emotional and behavioural problems suggest that adolescents may differ in their vulnerability to, and appraisal of, climate-related threats [49, 50]. From a stress-appraisal perspective, such characteristics may influence how threatening environmental change is perceived and the extent to which adolescents feel able to respond to it [51, 52]. At the family level, the association with family structure suggests that household circumstances may shape exposure to climate-related stressors and the resources available to cope. The unadjusted differences by school context are consistent with this but could not be separated from other school and community characteristics.

A finding that requires cautious interpretation is the distribution of the two outcomes across school contexts. Climate anxiety was more prevalent among adolescents attending rural than urban schools and private than public schools, whereas natural disaster anxiety differed little by school location or ownership. These differences were modest in absolute terms (7.4% points for location and 6.5 for ownership), and prevalence was very high in both rural and urban schools. This pattern is not unexpected given the sampling design. The urban and rural schools were located relatively close to one another, mostly within or on the fringe of Mbarara City, and share the same bimodal rainfall, moderate temperatures, and regional hazard profile; only one school was located in the wider, more drought-prone rural district. The rural–urban contrast captured in this study is therefore narrow, and the broadly similar patterns across school locations, particularly for natural disaster anxiety, may largely reflect this geographic concentration rather than a genuine absence of rural–urban differences across Mbarara City and District. With these caveats, one possible explanation for the higher climate anxiety in rural schools is that the rural schools in this study were located in predominantly agricultural surroundings, in Bukiro sub-county and in the outlying southern parts of the city, within an area that forms part of Uganda's cattle corridor, where household livelihoods depend heavily on rain-fed crop production and livestock. For adolescents from these households, prolonged dry spells and erratic rainfall can translate directly into reduced food availability, lower household income, and uncertainty about paying school fees, making climate change a personal and immediate concern rather than an abstract one [32, 36]. Urban households, with more diversified sources of income, may be partly buffered from these direct effects. The higher prevalence in private schools may reflect a related financial pathway: students in private schools typically pay higher fees than those in government-aided schools, and in rural areas these fees often depend on agricultural income, so that climate shocks may threaten continued schooling itself. Rural schools may also have more limited infrastructure, such as reliable water supply, shade, and on-site counselling, with which to buffer students from climate-related stress. In contrast, the natural disaster items largely referred to hazards that are uncommon in Southwestern Uganda, such as wildfires, earthquakes, and tsunamis, and would be expected to be similarly distant for rural and urban adolescents. This may also explain why natural disaster anxiety did not show the same contextual gradient, and it is consistent with the distinction between climate anxiety as a livelihood-linked, future-oriented concern and natural disaster anxiety as a response

to specific hazards. The higher prevalence of climate anxiety in mixed-sex than single-sex schools should be interpreted cautiously. All four single-sex schools were urban, and female adolescents had a higher prevalence of climate anxiety, so this difference may reflect school location and the sex composition of students rather than an independent effect of school type. Because household socioeconomic status and direct hazard exposure were not measured, and because the sample of schools was small and geographically concentrated, the pathways proposed here are hypotheses that should be tested in future studies with a larger and more geographically dispersed sample of schools.

The prevalence of climate anxiety (88.8%) and natural disaster anxiety (79.2%) was remarkably high in our study, suggesting that concerns about climate change and environmental disasters are widespread among adolescents in the participating schools, using a broad definition that captures any self-reported concern or emotional response. Because these schools were concentrated in central and southern Mbarara City, the estimates should not be extrapolated to all adolescents in Mbarara City or District. Direct cross-country prevalence comparisons should be interpreted cautiously because of differences in study populations, settings, and, in particular, measurement approach: our single-item "any positive emotional response" classification is a substantially lower bar than clinically calibrated multi-item scales, and this almost certainly explains much of the spread in reported prevalence across studies rather than true differences in underlying distress. For instance, among young women living in the urban slums of Kampala, Uganda, 21% reported moderate-to-severe climate anxiety using the 13-item Climate Anxiety Scale (CAS) [21]. In Kenya, a survey of 2,600 high school students using a self-report questionnaire found that emotional responses to climate change were common, with 35% reporting anxiety, 36% fear, 25% anger, and 22% feelings of powerlessness [41]. In contrast, a Canadian study that assessed clinically significant climate change anxiety using the Climate Change Anxiety Scale reported a prevalence of only 2.35% (95% CI: 1.49%–3.68%) [53]. Studies examining anxiety related to environmental disasters have also documented substantial psychological impacts among young people. For example, two years after severe flooding in Northern Namibia, more than half of children aged 12 years and below and over 70% of those older than 12 years reported significant symptoms of post-traumatic stress disorder [54]. Despite these methodological differences, our findings are consistent with evidence from Europe, Australia, and North America demonstrating that many young people are worried about climate change and perceive it as a threat to their future [8, 55, 56]. A large multinational survey conducted across ten countries similarly found that more than half of young people experienced emotions such as worry, sadness, anger, helplessness, or guilt in relation to climate change, with many reporting that these concerns negatively affected their daily functioning [57]. The high prevalence observed in our study may reflect increasing exposure to climate-related information through schools, social media, and news outlets, as well as the direct experiences of environmental disruptions such as droughts, floods, food insecurity, and changing weather patterns that increasingly affect communities in Uganda [58]. Unlike adolescents in many high-income settings who may perceive climate change primarily as a future threat, adolescents in the participating schools may already be witnessing its consequences within their communities, which could make these concerns more immediate. Because direct hazard exposure was not measured, this explanation remains to be tested [35].

Older adolescents were more likely to report climate anxiety than younger adolescents. This finding is consistent with previous studies suggesting that climate-related concerns tend to increase with age during adolescence [8, 57]. Older adolescents often have greater cognitive maturity and a better understanding of the long-term implications of climate change, including its potential effects on education, employment, health, and future life opportunities [23]. They may also be more exposed to climate-related information through formal education, social media, and public discourse [58]. As adolescents develop the capacity to think about future societal challenges, concerns regarding environmental sustainability and climate-related risks may become increasingly salient [59]. Similar age-related trends have been reported in studies from Europe and Australia, where older adolescents and young adults generally report greater awareness of climate change and higher levels of climate-related distress than younger adolescents [8, 59].

Female adolescents had significantly higher odds of natural disaster anxiety than males. Female sex was also associated with a higher prevalence of climate anxiety in the modified Poisson sensitivity analysis, although the

corresponding association in the logistic model did not reach statistical significance. This finding aligns with a growing body of literature demonstrating that females consistently report higher levels of environmental concern, risk perception, and climate-related anxiety [6, 21, 57, 60]. Several explanations have been proposed for this sex difference. Females generally report higher levels of anxiety disorders and internalizing symptoms than males and may therefore be more likely to experience emotional responses to perceived environmental threats [61]. In addition, women and girls often perceive themselves and their families as being more vulnerable to the social, economic, and health consequences of climate-related events [62]. Previous studies from Sweden [63], Australia [8], the United Kingdom [64], and the United States [65] have similarly reported higher levels of climate concern and eco-anxiety among female adolescents and young adults. Our findings suggest that gender-sensitive approaches may be necessary when designing interventions aimed at supporting adolescents experiencing climate-related distress.

Adolescents living without a biological parent had higher odds of climate anxiety than those living with at least one biological parent, and this association persisted in the modified Poisson sensitivity analysis. To our knowledge, family structure has received limited attention in the climate anxiety literature, making direct comparisons difficult. From a stress-appraisal perspective, adolescents living with grandparents, other relatives, or non-parental caregivers may perceive fewer resources for coping with environmental threats. In Uganda, such living arrangements often follow parental death, separation, or labour migration, and may be accompanied by greater economic insecurity, caregiving instability, and reduced emotional support, circumstances that have been linked to psychological distress among orphaned children in Uganda [66]. Where caregivers are older relatives who depend on crop farming or livestock, climate variability may also be experienced as a direct threat to household food, income, and continued schooling. Conversely, biological parents may buffer climate-related worry by offering reassurance, helping adolescents interpret climate information, and providing more stable material support. Because household socioeconomic status, the reasons for adolescents' living arrangements, and caregiver characteristics were not measured, these explanations remain hypotheses that should be examined in future research.

Natural disaster anxiety was independently associated with emotional and behavioural problems: adolescents reporting such difficulties had 60% higher odds of natural disaster anxiety. This finding is consistent with broader evidence linking pre-existing mental health difficulties to heightened vulnerability to environmental stressors [23]. Adolescents with emotional and behavioural problems may be more sensitive to perceived threats and uncertainty and may have fewer coping resources available when confronted with concerns about disasters such as floods, droughts, or storms. Previous research has shown that young people with anxiety, depression, emotional dysregulation, and behavioural difficulties often exhibit stronger psychological reactions to environmental disasters and disaster-related information [10, 67]. Our findings suggest that climate-related mental health concerns may be particularly important among adolescents already experiencing psychological difficulties.

The two outcomes had different correlates. Whereas climate anxiety was independently associated with age and family structure, (and with sex in the sensitivity analysis), natural disaster anxiety was primarily associated with female sex and emotional and behavioural problems. Other factors, including loneliness, suicidal ideation, suicide attempts, and self-harm, showed associations at the bivariable level but generally did not remain independently associated after accounting for demographic and psychosocial factors. This distinction may suggest that climate anxiety, as a broader and future-oriented concern, is more closely related to demographic, household, and contextual factors, while natural disaster anxiety may be more strongly linked to underlying emotional and behavioural vulnerability. The attenuation of several associations after adjustment is also noteworthy. In contrast to some studies from high-income settings, where climate-related distress has remained independently associated with broader mental health difficulties [23, 31], our findings suggest that relationships with suicidality, self-harm, and loneliness may partly reflect shared demographic and psychosocial vulnerabilities rather than independent associations with climate-related distress. These findings support treating climate and natural disaster anxiety as distinct constructs and suggest that adolescents with existing emotional and behavioural difficulties may warrant particular attention when addressing disaster-related psychological distress. Nevertheless, the substantial levels

of suicidality and self-harm within the study population highlight the importance of considering climate-related concerns within a broader adolescent mental health framework [48].

Overall, the findings indicate that climate anxiety and natural disaster anxiety are common experiences among adolescents in the participating schools and are associated with demographic, family, school-context, and mental health factors. As climate change continues to affect communities across Uganda, mental health consequences may become increasingly important components of climate adaptation and public health planning [35]. Schools may provide an important platform for climate education, resilience-building, and psychological support. Integrating discussions about climate change into existing adolescent mental health programs may help young people develop adaptive coping strategies while reducing feelings of helplessness and distress associated with environmental threats [68].

Policy Implications and Equity-Focused Recommendations

Because the participating schools were geographically concentrated and are not representative of Mbarara City or Mbarara District, the implications below are offered as considerations arising from the sampled schools rather than as recommendations for the city or district as a whole. The high prevalence of climate anxiety (88.8%) and natural disaster anxiety (79.2%) across the study population suggests that climate-related psychological concerns should not be approached solely as problems affecting narrowly defined subgroups. At the school level, this supports consideration of climate-related mental health within broader adolescent mental health promotion, climate education, and disaster-preparedness activities. However, the present findings do not establish that a particular type of intervention, such as psychoeducation, will reduce climate-related anxiety, and intervention effectiveness should therefore be evaluated rather than assumed.

At the same time, the findings identify differences that may be relevant to equitable implementation. Female adolescents had a higher prevalence of both climate anxiety and natural disaster anxiety in the modified Poisson sensitivity analyses, while adolescents with emotional and behavioural problems had a higher prevalence of natural disaster anxiety. Increasing age and living without a biological parent were also associated with a higher prevalence of climate anxiety. These findings do not imply that support should be restricted to these groups. Rather, universal school-based approaches could be accompanied by proportionate additional attention to adolescents experiencing greater psychological or social vulnerability. Such an approach would preserve access for all students while recognizing that climate-related distress may not be experienced equally.

Climate anxiety also was more prevalent among adolescents attending rural and private schools. These differences were statistically significant but modest in absolute terms, and because the participating schools were concentrated in central and southern Mbarara City, they describe the sampled schools rather than the distribution of climate-related distress across Mbarara City or District. They are consistent with possible differences in livelihood dependence on climate-sensitive agriculture, household financial vulnerability, and school resources between these settings. School-based climate and mental health initiatives in Mbarara could therefore take these settings into account when initiatives are piloted and evaluated, while remaining available to all students given the high overall prevalence; decisions about geographic prioritisation should, however, await confirmation in a representative sample of schools drawn from across the city and district. Because only ten schools participated, school characteristics could not be fully separated from the characteristics of the communities and students each school serves; future studies with more and more geographically dispersed schools, multilevel designs, and direct measures of hazard exposure and household socioeconomic status should confirm and explain these contextual differences.

An important implication for future research and policy is the need to move beyond general measures of climate concern toward impact-based assessment of locally relevant hazards. Adolescents in Southwestern Uganda may encounter different climate-related hazards, including extreme heat, drought, flooding, and landslides, with potentially different consequences for schooling, household livelihoods, food security, health, and psychological well-being. Impact-based assessment would therefore examine not only whether adolescents are concerned about

climate change, but also the specific hazards they experience or perceive, the consequences of those hazards, and the individual, family, school, and community resources available for adaptation. This approach is consistent with emerging research examining how perceptions of specific climate hazards, including heat, relate to experienced impacts and adaptive behaviours [69].

To interpret these differences through an explicit equity lens, we drew on two established frameworks. The PROGRESS-Plus framework identifies socially stratifying characteristics across which health outcomes may be unequally distributed, including place of residence, gender, socioeconomic position, and social capital, together with additional factors such as age, disability, and family circumstances [70]. The risk framework of the Intergovernmental Panel on Climate Change (IPCC) describes climate-related risk as arising from the interaction of hazards, exposure, and vulnerability, with vulnerability encompassing sensitivity to harm and limited capacity to cope and adapt [71].

Viewed through these frameworks, the findings suggest that climate-related distress among adolescents in the participating schools is unequally distributed along several dimensions. Differences by place of residence and school ownership, with higher climate anxiety in rural and private schools, may reflect differences in exposure, since rural households depend more directly on climate-sensitive livelihoods, and in household financial vulnerability, since school fees may depend on agricultural income. Differences by gender, with higher natural disaster anxiety among female adolescents and higher climate anxiety in sensitivity analyses, and by pre-existing emotional and behavioural difficulties point to differences in sensitivity. The higher prevalence among adolescents living without a biological parent, points to differences in capacity to cope, including family support and material resources. An equitable response would therefore combine universal school-based climate and mental health promotion with proportionately greater support for female adolescents, adolescents with emotional and behavioural difficulties, and adolescents living without a biological parent, with additional attention to rural and private schools if the contextual differences observed here are confirmed in a more representative sample. In practice, this could include strengthening teacher training in psychosocial support and linkage with district health and education services, and ensuring that school counselling and pastoral care systems identify and support students in non-parental care.

Because hazard exposure, experienced impacts, and household socioeconomic status were not measured in this study, these pathways remain to be tested. For example, two schools categorized as rural may have substantially different exposure to drought, heat, flooding, or livelihood disruption, and adolescents within the same school may differ in family resources, social support, and capacity to cope. Future longitudinal and multilevel research that measures these dimensions directly, in schools sampled across all divisions of Mbarara City and all subcounties of Mbarara District, would allow resources to be directed to where exposure, sensitivity, and limited coping capacity intersect.

Limitations

This study has some limitations that should be considered when interpreting the findings. First, the cross-sectional design limits the ability to establish causal relationships between participant characteristics and climate anxiety or natural disaster anxiety. Consequently, it is not possible to determine whether the identified factors preceded or resulted from climate-related concerns. Nevertheless, the study provides important epidemiological evidence regarding the prevalence and correlates of climate-related anxiety among adolescents, thereby generating hypotheses for future longitudinal research. Second, all data were collected through self-report questionnaires, which may have introduced reporting and social desirability biases. Participants may have underreported or overreported sensitive experiences such as suicidal ideation, suicide attempts, self-harm, and emotional difficulties. Similarly, responses regarding climate and natural disaster anxiety may have been influenced by individual interpretations of the questions. However, the use of anonymous self-administered questionnaires likely reduced social desirability bias and may have encouraged more honest reporting of sensitive experiences. Third, climate and natural disaster anxiety were assessed using brief standardized items from the GCAMHS questionnaire rather

than validated multidimensional measures of climate anxiety. Accordingly, the prevalence estimates represent broadly defined emotional responses to climate change and natural disasters and should not be interpreted as estimates of clinically significant anxiety. Although the standardized GCAMHS instrument is intended to facilitate harmonized cross-country assessment, comparable GCAMHS findings from other participating countries have not yet been published. This currently limits cross-country comparison and means that the prevalence estimates from this study should be interpreted cautiously until comparable data become available. The standardized natural disaster items also included hazards of limited relevance to Southwestern Uganda, such as tsunamis, while excluding locally important hazards such as landslides and extreme heat. Although this standardization supports cross-country comparisons, it limits local specificity. Future studies should complement standardized measures with validated, context-specific assessments of locally relevant hazards.

Fourth, the study was conducted among school-going adolescents in ten selected secondary schools in Mbarara City and Mbarara District. Adolescents who were not attending school, and who may experience different environmental and psychosocial stressors, were not represented. Importantly, the participating schools were geographically concentrated: nine of the ten were in central or southern Mbarara City, only one was in Mbarara District, and no schools were sampled from the northern and western sub-counties of the district, even though the district accounts for approximately 40% of the combined population. The sample is therefore not representative of secondary schools or adolescents in Mbarara City or Mbarara District, and the "rural" schools largely represent the agricultural fringe of the city. This concentration narrowed the urban–rural contrast and probably contributed to the broadly similar patterns observed across school locations. Therefore, the findings may not be generalizable to all adolescents in Uganda, Mbarara City or Mbarara District as a whole, or to schools outside the area sampled. In addition, because only ten schools participated, school location, ownership, and sex composition could not be fully separated from one another or from the characteristics of the communities and students each school serves, and the contextual differences observed should be confirmed in studies with a larger number of geographically dispersed schools. The small number of clusters may also have caused cluster-robust standard errors to be somewhat underestimated. In addition, the multivariable models were restricted to 764 participants with complete covariate data; given that only two participants were excluded, this is unlikely to have affected the estimates materially. Despite these limitations, the inclusion of adolescents from multiple secondary schools in both rural and urban settings provides useful insights into climate-related anxiety among school-going adolescents in the sampled area. Finally, although several psychosocial factors were assessed, other potentially important determinants of climate anxiety, such as direct exposure to climate-related disasters, household socioeconomic circumstances, the reasons for adolescents' living arrangements and caregiver characteristics, media exposure, environmental knowledge, and perceptions of governmental responses to climate change, were not evaluated and may have influenced the observed associations. Moreover, no a priori sample size calculation was documented; although a retrospective adequacy assessment was conducted, future GCAMHS studies should incorporate prospective sample size calculations during study design. In addition, no formal psychometric evaluation, including internal consistency, test–retest reliability, cognitive interviewing, or measurement-equivalence testing, was undertaken for these items, and the wording of the response option 'Little moderate' may have introduced additional ambiguity. Nevertheless, the study examined a broad range of demographic and psychosocial factors, allowing for adjustment for several potential confounders and strengthening confidence in the observed associations.

Conclusion and recommendations

Self-reported climate anxiety and natural disaster anxiety were highly prevalent among adolescents in ten selected secondary schools in Mbarara City and District, Southwestern Uganda, and were associated with age, sex, family structure, and emotional and behavioural difficulties. Climate anxiety was independently associated with living without a biological parent, and in unadjusted comparisons was more common in rural and private schools; these patterns may reflect household circumstances and livelihood dependence on climate-sensitive agriculture, which were not measured directly. Because the participating schools were geographically concentrated in central and

southern Mbarara City, these findings describe the sampled schools and should not be generalised to the city or district as a whole. In the participating schools, climate-related distress was common and overlapped with existing psychosocial vulnerabilities. Integrating climate-related mental-health considerations into school-based adolescent services could be piloted and evaluated, with attention to female adolescents, those with emotional and behavioural difficulties, and adolescents living without a biological parent, and to rural and private schools if these contextual differences are confirmed in a representative sample. Targeted support is particularly important for female adolescents, those with emotional and behavioural difficulties, and adolescents living without a biological parent, with further attention to rural and private schools if these contextual differences are confirmed, using the equity-informed recommendations outlined above. Future research should use validated measures, include diverse and out-of-school youth, measure hazard exposure and household socioeconomic status directly, use multilevel designs with more and more geographically dispersed schools sampled across all divisions and sub-counties, and examine longitudinal links between climate-related distress and mental-health outcomes to inform context-appropriate interventions.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1186/s12889-026-30320-0.

Acknowledgements The authors sincerely thank all the adolescents who participated in this study, as well as the research assistants and school administrators whose cooperation and commitment made this work possible. Their valuable contributions were essential to the successful completion of the study.

Patient and public involvement Patients and members of the public were not involved in the design, conduct, reporting, or dissemination of this research.

Use of AI-assisted technologies During the preparation of this work, the authors used an AI for language editing and drafting of the response to reviewers. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication. All scientific content and analyses were made by the authors.

Authors' contributions J.A. conceived the study, conducted the analyses, and drafted the manuscript. E.A. prepared Tables 1, 2 and 3 and contributed to data interpretation. All authors critically reviewed the manuscript for important intellectual content, approved the final version, and agreed to be accountable for all aspects of the work.

Funding This study was supported by Mbarara University of Science and Technology and the University of Turku. The funding bodies had no role in the study design, data collection, data analysis, interpretation of findings, manuscript preparation, or the decision to submit the manuscript for publication.

Data availability Data generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (2013). Ethical approval was obtained from the Mbarara University of Science and Technology Research Ethics Committee. Participation in the study was voluntary, and all data were collected anonymously to ensure confidentiality and protect participants' privacy. Written informed consent was obtained from all participants aged 18 years and above. For participants younger than 18 years, written informed consent was obtained from parents or legal guardians, and written assent was obtained from the adolescent participants prior to enrolment.

Consent for publication Not Applicable.

Competing interests The authors declare no competing interests.

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