The Interconnection between Eco-Anxiety and Eco-Grief in Urban and Rural Populations in Germany and the Netherlands: a cross-sectional study

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Abstract

Background: Climate change is an urgent issue impacting the physical environment and individual's mental health, potentially leading to emotions like eco-anxiety and eco-grief. Previous literature found that people living in urban areas are more likely to suffer from eco-anxiety, while rural populations experience higher levels of eco-grief. Therefore, the present study investigates whether living in rural or urban areas in Germany and the Netherlands moderates the relationship between eco-anxiety and eco-grief.

Methods: This cross-sectional study used a quantitative research design by implementing an online survey. The Eco-Anxiety Questionnaire (EAQ-22) and Ecological Grief Questionnaire (EGriQ-6) were used to measure eco-anxiety and eco-grief among rural and urban populations.

Results: The data of 242 participants was analysed in the survey. The findings demonstrated no significant relation between eco-anxiety and urban living ($p < .73$) and no significant correlation between eco-grief and rural populations ($p < .73$). Additionally, multiple regression analysis detected a positive correlation between eco-anxiety and eco-grief without rural living as a moderator ($p = .01$). Nevertheless, rural living does not moderate the relationship between eco-anxiety and eco-grief ($p = .58$ and $p = .55$).

Conclusion: This research contributed to a better knowledge of climate change emotions in the context of urban and rural living in Germany and the Netherlands. The results did not reveal an association between rural or urban living and eco-anxiety or eco-grief. Future research should aim to improve the measurement tools by taking diverse contextual factors into account.

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Introduction

Climate change is one of the largest risks to world health in the 21st century (Coffey et al., 2021). Extreme weather catastrophes like floods, droughts and hurricanes have become more severe and frequent. A major extinction event has started, and the average global temperature has risen by 1.0°C, in only one century (Van Nieuwenhuizen et al., 2021). These impacts of climate change cause injuries, coastal water swarming, and a reduction in regional crop yields which causes malnutrition (Padhy et al., 2015). Especially in the developing world, agriculture is one of the most affected sectors by climate change as rural livelihoods, food security and agricultural productivity are negatively impacted (Falco et al., 2019). This impact of climate change is also observed in further developed countries like Germany and the Netherlands.

In Germany, climate change catastrophes are happening such as the flood disaster in mid-July 2021 in which more than 180 people died and billions in property damage were caused (Bundeszentrale für politische Bildung, 2024). Additionally, experts predict an increase in extreme weather events due to climate change (Bundeszentrale für politische Bildung, 2024). In the Netherlands, the risks of climate change have also risen. This is evident from the faster sea level rise on the Dutch coast and the heightened frequency of extreme rainstorms in summer (Vermeersen et al., 2018). Hence, both countries experience climate change consequences.

Climate Change Impact on Mental Health

Furthermore, next to the physical harm caused by climate change there are also influences on mental health. According to Palinkas and Wong (2020), extreme weather incidents and natural disasters create mental health consequences such as heightened rates of anxiety and mood disorders, sleep disturbances, and suicide. In addition, a reduced sense of self and identity arises from losing their home environments or familiar places (Palinkas & Wong, 2020). This feeling is worsened by the perception that actions against the problem of

climate change seem small and ineffective compared to the complexity of the threat (Hayes et al., 2018). Accordingly, people may feel hopeless and despair about the overarching threats of climate change (Hayes et al., 2018).

These feelings can be analysed by looking at different impacts. First, direct impacts are explained as a changing environment and abrupt and traumatic consequences of extreme weather (Palinkas & Wong, 2020). Second, emotional harm caused by observing climate change impacts and the uncertainty about future threats is labelled as indirect impacts (Doherty & Clayton, 2011). Psychosocial impacts describe constant social and community consequences of heat and drought, such as migrations, climate-related conflicts, and post-disaster alterations (Doherty & Clayton, 2011).

Environmental factors have an additional impact on mental health diseases since they can cause congenital defects, hinder neurodevelopment, even trigger endogenous mental illnesses and elicit psychosomatic and neurological disorders (Loganovsky et al., 2019). Hence, conditions such as post-traumatic stress disorder (PTSD), depression, anxiety, suicide rate, substance use and aggressive behaviour tend to increase after extreme weather events caused by climate change (Cianconi et al., 2020). For instance, studies in Germany indicate a high prevalence (40-73 %) of general anxiety, sadness, and anger common in all age groups. After the floods in Germany in 2021, these feelings have risen significantly by 20 percentage points in all nations (Gebhardt et al., 2023). Thus, climate change-related events influence the mental well-being of individuals.

Eco-Anxiety and Eco-Grief

Additionally, there have been created new concepts that refer explicitly to sadness anxiety, or depression caused by climate change (Ágoston et al., 2022). First, Solastalgia is explained as the feeling of loneliness, insecurity, and powerlessness because of intense environmental changes in the surrounding environment caused by acute impacts (Albrecht, 2020). Second, the chronic fear or non-specific worry that the natural foundations of existence

are collapsing is labelled eco-anxiety (Ágoston et al., 2022). Last, eco-grief is described as grief resulting from anticipated or experienced ecological loss because of acute or long-term environmental change (Ágoston et al., 2022).

While these concepts explain different emotional responses to climate change, they are also interconnected since eco-anxiety and eco-grief influence each other (Ojala et al., 2021; Cunsolo & Landman, 2017; Pihkala 2022). By engaging with the feelings of eco-anxiety, individuals encounter emotions such as loss, grief, and sadness. Hence, worrying about the environment includes the emotional pain of its loss and threat (Pihkala 2022). Eco-grief may also produce a type of practical anxiety as individuals wonder what form of grief, they experience by considering different norms that support their health and functioning (Pihkala, 2022). Thus, climate change can influence individuals' mental health differently whereby eco-emotions help to understand it, which may also depend on individuals' surroundings, like urban and rural living.

Urban and Rural Populations

The risks of climate change impacts are experienced differently by people living in urban populations compared to the ones living in rural areas. Compared with rural populations, urban inhabitants have higher chances of experiencing the dangers of sea level rise, strong rainfalls or cyclones leading to storm surges and flooding, since urban communities live directly on or closer to the coast (Reckien et al., 2017). The biophysical attributes of urban environments differ from those of the nearby rural areas. These involve adjustments to hydrology, like increased surface drainage of rainwater, and altered energy exchange resulting in an urban heat island (Zeleňáková et al., 2015). Therefore, people living in urban areas may be more afraid of climate change. Nevertheless, in the US rural Americans have a stronger sense of place identification and value farmland conservation higher than climate change as urban/suburban Americans (Bonnie et al., 2020). This was confirmed in the study by Ágoston et al. (2022) who investigated higher ecological grief among rural

populations than urban citizens in Hungary. Rural villagers directly experience landscape and wildlife degradation, creating an elevated sense of loss (Ágoston et al., 2022). This can be accompanied by feelings of hopelessness and depression through the disappearance of animal and plant species (Cianconi et al., 2020). These contrasting factors contribute to people experiencing different climate change worries.

Furthermore, rural individuals experience eco-grief due to a stronger attachment to place and community, which is complemented by strong emotions like anger, sadness, hopelessness, depression, and anxiety (Ellis & Albrecht, 2017). For individuals maintaining close living and working with the natural world, personal and societal understandings of self-identity are often developed with the land, including its physical aspects, uses and knowledge (Cunsolo & Ellis, 2018). Thus, farmers from Australia have indicated that they have lost confidence in their ability to predict seasonal weather. Such experiences are linked with anxieties about the future in the long-term, survival of their farm and agriculture (Cunsolo & Ellis. 2018). Investigating this in Germany and the Netherlands would be interesting because of the differences in rural environments and culture.

Previous Research

There is an increased need for measuring psychological constructs as a consequence of climate change since more psychological impacts arise (Palinkas & Wong, 2020). While global dimensions of eco-anxiety and eco-grief have been explored there is a need for further research also considering rural and urban living. Exploring these differences among rural and urban populations in Germany and the Netherlands may be important since it has not been investigated yet. Furthermore, previous research found differences in eco-anxiety and eco-grief among rural and urban populations, with increased eco-anxiety levels among urban populations compared to higher eco-grief in rural areas (Bonnie et al. 2020; Ágoston et al. 2022). These findings may also apply to German and Dutch populations, where differences in socio-cultural dynamics and climate change consequences appear similar. Consequently, this

research aims to examine whether similarities occur in German and Dutch populations and verify a potential relationship between eco-grief and eco-anxiety.

Current Study

This research aims to advance previous research by applying the questionnaires created by Ágoston et al. (2022) and translated by Doyle (2024) and Gökoglan (2024) into Dutch and German. In addition, little is known about the differences between eco-anxiety and eco-grief in urban and rural areas across Germany and the Netherlands and whether these concepts are related. Taking these observations into account, this study focuses on the differences in experienced eco-anxiety and eco-grief among urban and rural populations in Germany and the Netherlands, resulting in the following research question:

To what extent does living in rural or urban populations in Germany and the Netherlands moderate the relationship between eco-anxiety and eco-grief?

Consequently, it will be hypothesised:

H1: There is a significant positive relationship between living in urban populations and eco-anxiety.

H2: There is a significant positive relationship between living in rural areas and eco-grief.

H3: Living in rural populations in Germany and the Netherlands moderates the relationship between eco-grief and eco-anxiety.

Methods

Design

To ensure the report's comprehensiveness while providing a complete overview, the study incorporates the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist, specifically designed for cross-sectional studies, as detailed in

Appendix A. Moreover, a cross-sectional online survey was conducted to investigate the relationship between living in rural or urban areas, eco-anxiety, and eco-grief. The survey explores the impact of the independent variable, rural/urban population on the dependent variable, eco-anxiety/eco-grief.

Participants

To calculate the appropriate sample size for the study the tool G*Power was used. Here, the sample size n=210 was calculated (See Appendix C). Furthermore, the study applied eligibility criteria. Participants must either be Dutch or German. Furthermore, they must currently live in Germany or the Netherlands and speak one of the languages to take part in this research. Next, participants must be at least 18 years old. Lastly, individuals currently in treatment for a mental disorder and/or who experienced suicidal ideation in the past two years are not eligible.

Procedure

Participants were sampled through snowball sampling and convenience sampling. Multiple advertisements were created for the online questionnaire in both German and Dutch (See Appendix B). These advertisements were then posted on various social media platforms to recruit participants. Those included the eligibility criteria, a brief description of the study with the appeal to participate and a link directing participants to either the Dutch or German version of the questionnaire. The researchers distributed the survey through platforms such as WhatsApp, Instagram, and Reddit and asked family and friends to forward the advertisement. Furthermore, participants were recruited through the platform SONA, which rewards students from the University of Twente with credits for their participation. The data collection took place from the 22. of March 2024 till the 08. of May 2024.

The entire data collection was conducted through Qualtrics, a platform for online surveys and data collection. Additionally, at the beginning of the questionnaire, participants received a written introduction including information regarding the procedure of the study, the

objectives, and the use of their data. Additionally, they were informed of the inclusion and exclusion criteria of the study. Lastly, participants were provided with the contact details of the researchers, in case they had any questions or remarks regarding their participation or the questionnaire.

Next, participants were presented with the informed consent sheet. Here, it was clearly stated that their participation in the research was entirely voluntary and that they had the right to withdraw from the study at any time without providing a reason and without any consequences. Further, they were informed that no personal data that could potentially identify the participant, such as their IP address, name, or address, would be collected. Following this information, they were asked for their consent to participate in the study. After participants gave their consent, their demographic data was collected.

At the end of the questionnaire, participants were asked once more if they still wanted to participate and whether their data could be used for subsequent analysis in case they changed their minds. Furthermore, after the participants finished the surveys, they were asked whether they wanted to be contacted later for research purposes to evaluate once again after 3 and 6 months how they were feeling. For this, they were required to provide an email to contact them. In the follow-up study, the same questionnaires will be applied to them again. Following their participation, their data was subject to different data analysis processes, aimed at answering the researchers' research questions and hypotheses.

Materials

Participants were asked to provide their age, gender, level of education and nationality. Furthermore, they were asked whether they live close to a body of water such as a river, whether they live below sea level, whether they have been a victim of a flood previously, whether they engage in pro-environmental behaviour, and lastly, whether they live in a rural or urban area.

Subsequently, participants were introduced to the newly translated versions of questionnaires measuring emotional experiences related to climate change, namely EAQ-22, EguiQ-11, EGriQ-6 and PEBS. Following the eco-questionnaires, they were asked to answer already well-established and validated questionnaires for comparison, namely the Guilt and Shame Questionnaire (GSQ-8), the Generalised Anxiety (GAD-7) and the Kessler Psychological Distress Scale (K-10). However, for this study, the focus will be only on EAQ-22 and EGriQ-6.

EAQ-22

The Eco-Anxiety Questionnaire is a 4-point Likert scale ranging from “strongly disagree” to “strongly agree” and was developed by Ágoston et al., (2022). This questionnaire consists of 22 items and was translated into German and Dutch by Doyle (2024) and Gökoglan (2024). It measures the level of eco-anxiety in an individual and consists of two factors, namely ecological worry, and the negative consequences of eco-anxiety. Both factors show high internal consistency with a Cronbach’s Alpha of .91 for ecological worry and .86 for negative consequences of eco-anxiety.

EGriQ-6

The Eco-Grief Questionnaire established by Ágoston et al., (2022) is a 6-item questionnaire with a 4-point Likert scale and ranges from “strongly disagree” to “strongly agree”. Statements such as “It makes me sad that I no longer see many plants and animals that I often used to see” are provided in this questionnaire. Doyle (2024) and Gökoglan (2024) translated it into Dutch and German and implemented it in 2024. This questionnaire measures ecological grief and has a single-factor structure with excellent internal consistency demonstrated by a Cronbach's alpha of .70.

Data Analysis

For applying data analysis, the software RStudio (RStudio2023.12.1+402) has been used. First, the dataset was imported in CSV file format and the working directory was set. The second step involved the installation and loading of the required packages, including "tidyverse", "dplyr", "lmtest", "ggplot2", "interactions" and "readr". Subsequently, all missing data has been excluded for example participants not finishing the survey. The next step included deleting all data that may identify the participant such as the start and end date, status, IP address, duration in seconds, recorded date, response ID, location longitude, and preview distribution channel. Additionally, columns displaying NA for instance the email address or first and last name of the participant were excluded as well.

At first, the raw scores were presented for all key variables. Therefore, variables displayed in character format were converted to numeric values to allow further analysis procedures. For example, the EAQ-22 variable 'strongly agree' was assigned a numeric factor of 4, while 'strongly disagree' was assigned a numeric factor of 1. The same process was applied to the EGriQ-6.

After preparing the different questionnaires for further analysis, the descriptive statistics were computed. The Mean (M) score and Standard Deviation (SD) were calculated for age, EAQ-22 and EGriQ-6. In line with the aim of the study, the housing conditions of participants were analysed, for instance, how many of the participants lived in rural or urban areas. The resulting new variables were then checked for normality and homoscedasticity.

G*Power Analysis

The G*Power analysis was conducted to investigate an appropriate sample size for this research. A two-tailed a priori analysis with a power level of =.95 has been conducted. Thus, a total sample size of n = 210 has been calculated with a minimal sample size of n = 105 per nationality needed for a linear regression analysis (see Appendix C).

H1: To answer the first hypothesis linear regression was applied. Thereby, it can be reviewed if the independent variable living in urban populations has a significant positive association with the dependent variable eco-anxiety.

Figure 1

Relationship between Urban Population and Eco-anxiety

H2: Furthermore, to test the second hypothesis, linear regression was implemented to indicate whether the independent variable living in the rural population has a significant positive association with the dependent variable eco-grief.

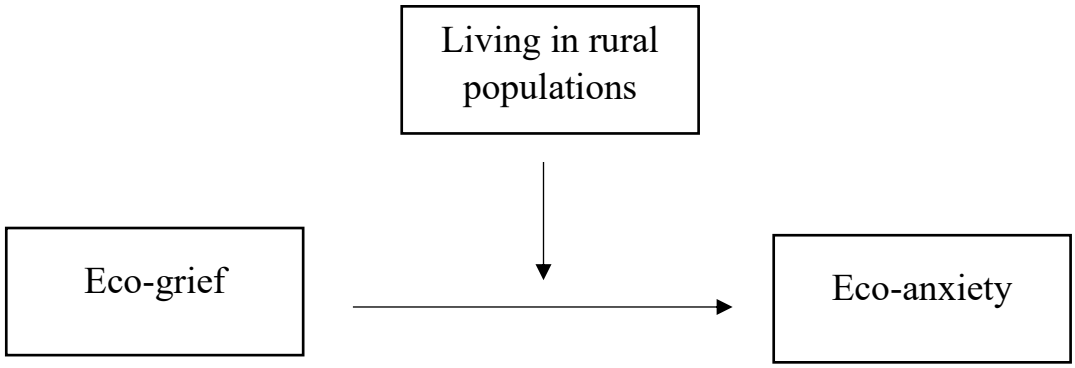
Figure 2

Relationship between Rural Population and Eco-grief

H3: A moderated multiple regression analysis was implemented to see if living in rural populations moderates the relationship between eco-grief and eco-anxiety. Here, the independent variable is eco-grief, the dependent variable is eco-anxiety and living in rural populations is the moderator variable.

Figure 3

Moderation Effect of Rural Population on the Relationship Between Eco-grief and Eco-anxiety



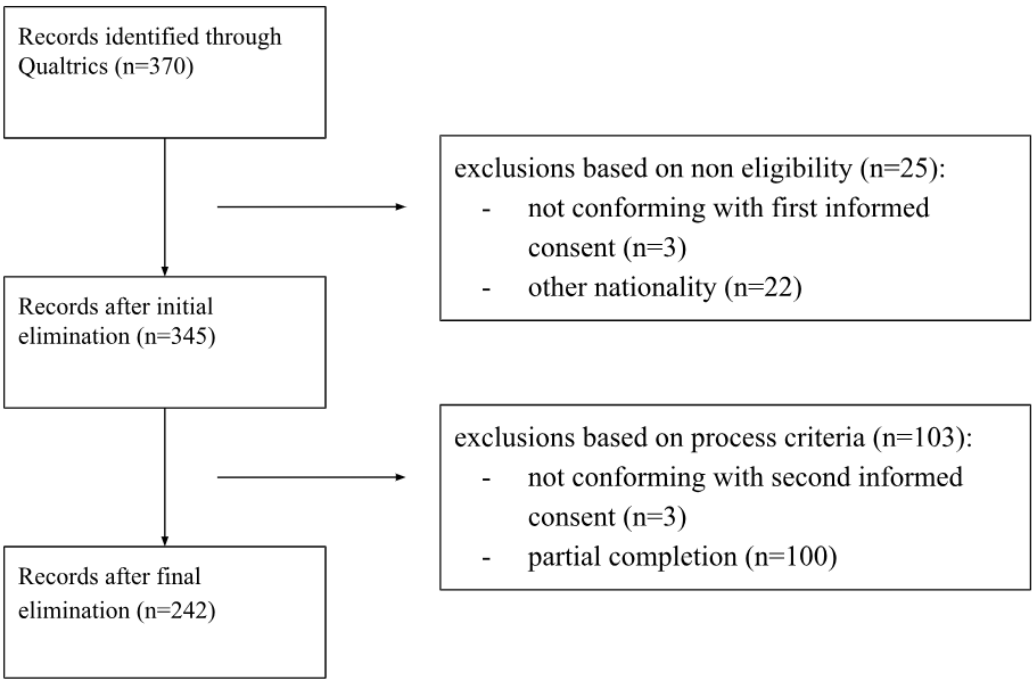
Results

Demographics

The data analysis showed that 370 participants took part in the survey. Nevertheless, after filtering out incomplete responses, non-completers, and participants from other nationalities, 128 participants (34.45%) were excluded from the sample.

Figure 4

Diagram Representing the Exclusion of Participants



Approximately, two-thirds of participants were female (64.05%) with one-third of male participants 35.12%, and a small number identifying as non-binary/other (.83%). The ages of participants ranged from 18 to 75. The sample displays an almost equal number of Dutch (50.41%) and German (49.59%) individuals. A substantial proportion of participants had higher education, with 43.80% having a bachelor's or master's degree, compared to a minor percentage (7.85%) who completed vocational training or had a PhD. Most participants lived in urban areas (73.97%), with fewer living in rural settings (26.03%). A more detailed summary can be seen in Table 1.

Table 1

Gender, Nationality Educational Level and Location of Participants

Characteristic	n(%)
Gender	
Male	85 (35)
Female	155 (64)
Non-binary/Other	2 (0.8)
Nationality	
Dutch	122 (51)
German	120 (49)
Educational Level	
Apprenticeship	19 (8)
Bachelor's Degree	75 (31)
Master's Degree	31 (13)
Secondary Education	65 (27)
University of Applied Sciences	37 (15)
PhD/Doctorate	5 (2.1)
Other	10 (4)
Location	
Urban	179 (74)
Rural	63 (26)

Linear Assumption Testing

Next, linear assumption testing was implemented. When checking for normality of the EAQ-22 Q-Q Plots were used, indicating normal distribution (Appendix B). In addition, the Shapiro-Wilk Test revealed normality ($W = .98$, $p > .01$). Regarding the EGriQ-6 the Q-Q plot showed normal distribution. The Shapiro-Wilk test confirmed this ($W = .97$, $p > .01$).

Furthermore, fitted values were analysed to estimate the assumption of homoscedasticity. For the EAQ-22 the results of the Breusch-Pagan test displayed a p-value of $p > .35$, suggesting no violation of homoscedasticity. Similarly, a p-value of $p < .31$. resulted from the Breusch-Pagan test for the EGriQ-6, supporting the absence of heteroscedasticity.

Descriptive Statistics

The EAQ-22 had a mean of 2.45 and a standard deviation of .58 indicating a moderate level of eco-anxiety among the participants. The range of the scores varied between 1.00 to 3.72. The EGri-6 displayed a mean of 2.50, a standard deviation of .70 and scores ranging from 1.00 to 4.00. In Table 2 these values are described in more detail.

Table 2

Descriptive Statistics

	SD	Minimum	1st Quartile	Median	Mean	3rd Quartile	Maximum
EAQ-22	.579	1.000	2.091	2.455	2.453	2.864	3.727
EGri-6	.698	1.000	2.200	2.600	2.502	3.000	4.000

Note. SD= Standard Deviation, EAQ-22=Eco-Anxiety Questionnaire, EGri-6 = Eco-Grief Questionnaire

Hypothesis 1

For testing the first hypothesis, a linear regression analysis was conducted. The intercept coefficient signifies the predicted eco-anxiety score for individuals residing in urban areas as 2.43. However, the coefficient for urban status did not demonstrate statistical significance ($p < .73$), indicating that the distinction between urban and rural populations did not significantly influence eco-anxiety scores. Furthermore, the model's adjusted R-squared value of -.004 suggests that the urban status variable did not explain substantial variance in eco-anxiety scores (Adjusted R-squared < 0). The F-statistic of .12 with a corresponding p-value of .73 indicated that the overall regression model was not statistically significant in predicting eco-anxiety scores. The means and standard deviation are displayed in Table 3.

Table 3

Descriptive Statistics for Eco-Anxiety in Urban and Rural Population.

Location	EAQ-22		
	n	*Mean*	*SD*
Urban	179	2.46	.593
Rural	63	2.43	.542

Note. SD = Standard Deviation, EAQ-22=Eco-Anxiety Questionnaire.

Hypothesis 2

Next, the intercept coefficient suggests that the predicted eco-grief score for individuals residing in rural areas is 2.47. However, the coefficient for urban/rural status was not statistically significant ($p < .73$), indicating that the distinction between urban and rural populations did not significantly influence eco-grief scores. The score for mean and standard deviation can be viewed in Table 4. In addition, the model's adjusted R-squared value of -.00 suggests that the urban/rural status variable did not explain a substantial amount of variance in eco-grief scores (Adjusted R-squared < 0). Furthermore, the F-statistic of .12, with a p-value of .73, suggests that the overall regression model was not statistically significant in predicting eco-grief scores.

Table 4

Descriptive Statistics for Eco-Grief in Urban and Rural Population

Location	EGri-6		
	n	*Mean*	*SD*
Urban	179	2.51	.716
Rural	63	2.48	.649

Note. SD = Standard Deviation, EGri-6 = Eco-Grief Questionnaire.

Hypothesis 3

Lastly, moderated multiple regression analysis was implemented to test the third hypothesis. The intercept coefficient indicates that the predicted eco-anxiety score for individuals living in urban areas without eco-grief is 1.05. The coefficient for eco-grief was statistically significant ($p > .01$), demonstrating the association of an increase in eco-grief with an increase in eco-anxiety. The urban/rural status coefficient and the interaction term were not statistically significant ($p = .58$ and $p = .55$). The model's adjusted R-squared value was .59, indicating that the independent variables collectively explain approximately 59.29% of the variance in eco-anxiety scores (Appendix C). The F-statistic was 117.8 with a p-value of < 2.2e-16, suggesting that the overall regression model was statistically significant in predicting eco-anxiety scores. Therefore, the hypothesis is partially supported by the results. While eco-grief was found to be a significant predictor of eco-anxiety, living in rural/urban populations does not moderate the relationship between eco-anxiety and eco-grief.

Table 5

Moderated Multiple Regression Analysis

Effect	ß	SE	95 % CI		p
			LL	UL	
Intercept	1.05	.38	.30	1.81	.01
EGri-6	1.61	.15	.26	.85	.00
Rural/Urban	.94	.21	-.53	.30	.59

Note. SE = Standard Error, LL=Lower Level, UL=Upper Level

Discussion

This research wanted to investigate the influence of the location of people (rural or urban) on eco-anxiety and eco-grief. Additionally, it was explored whether living in rural areas moderates the relationship between eco-anxiety and eco-grief. The analysis of the results indicates no significant correlation between living in urban or rural areas on eco-anxiety or eco-grief. It indicates the rejection of hypotheses one and two. Therefore, these insights imply that the location of people may not be an important factor influencing the

individuals' experience of eco-anxiety and eco-grief. Furthermore, while the research found a relationship between eco-anxiety and eco-grief, no moderation effect from the rural population could be found which rejects the third hypothesis. These findings suggest no influence of rural living on the experience of eco-anxiety and eco-grief. Thus, the results challenge the findings of Bonnie et al. (2020) and Ágoston et al. (2022) who investigated higher levels of eco-anxiety in urban populations and increased eco-grief in rural populations. Contrary to these results, this research suggests that eco-grief and eco-anxiety could be experienced similarly by urban and rural populations. Individuals living in urban areas encounter health problems through air pollution, urban heat islands and deficient green spaces (Okkels et al., 2018). These factors can contribute to individuals experiencing stress and anxiety (Sineva et al., 2021). Similarly, rural inhabitants face problems due to climate change because of extreme heat, drought and flooding which express high vulnerability characteristics in these areas (Houghton et al., 2017). Additionally, rural populations experience environmental issues such as agricultural drainage, deforestation and water deficiency which also impact an individual's mental health and well-being (Ágoston et al., 2022). Considering this information, similar fears, worries, and emotions of loss regarding climate change may affect an individual regardless of living in rural or urban populations.

Moreover, in the study of Bonnie et al. (2020) the participants living in rural areas and experiencing eco-grief were American farmers who were directly confronted with the loss of agriculture. In contrast, it is not certain whether farmers did partake in this study which would ensure a population directly affected by agricultural loss. Besides, it is unclear whether the participants in the current survey lived only in suburbs or farmlands. Suburban inhabitants may maintain a connection to natural landscapes and green spaces while still having access to metropolitan services and infrastructure (Šťastná et al., 2018). This would characterise different environmental contexts and contact with landscape degradation since individuals who live in farmlands might be more in contact with land use changes, biodiversity loss, and

agricultural practices, which might cause people to feel bereavement and grief about the state of the environment (Ágoston et al., 2022). Subsequently, people living in farmlands compared to suburban populations could be affected differently by climate change. Thus, rural living is more complex as expected at the beginning of the study. Determining the residential factors of research participants, such as their distance from suburban developments or farms, could give better insights into the connection between eco-grief and rural living.

Limitations

The study exhibits several limitations that should be considered when interpreting the results. First, participants were gathered through snowball and convenience sampling which may have biased the selection procedure since these methods are non-random (Berger et al., 2021). Participants were collected through social media, friends and family emphasising some viewpoints over others. Random sampling methods, such as stratified or cluster sampling, would guarantee a more diverse and representative sample. In addition, efforts could be made to reduce selection biases by contacting organisations and community centres which prevents the overuse of social networks.

Next, the study's sample size is fulfilling and exceeds the number of participants (n=242) that was before calculated with the G*power (n=210) (Appendix C). Nevertheless, the number of participants is still small compared to the study conducted by Ágoston et al., (2022) (n= 4608). Generally, a sample size of 300 is seen as good, whereas a sample size of 500 – 1000 is seen as excellent (Kyriazos, 2018). These requirements are not met by the current study, making it difficult to compare with previous studies.

Furthermore, the study encountered difficulties regarding the inequality of the sample size since the sample consisted of only 63 participants from rural areas compared to 179 participants from urban areas. In research conducted by Rusticus and Lovato (2014), it was confirmed that equal sample sizes are more scientifically powerful compared to unequal

sample sizes. Therefore, the small number of rural participants does not represent the rural population appropriately and limits its generalisability.

In addition, the study did not consider the complexity of rural or urban populations, including differences in population density, land use patterns, and availability of natural resources. Although participants were classified according to their location in urban or rural areas these are comprehensive terms that do not identify the contact people have with nature or previous experiences with climate catastrophes. In a study by Batterham et al. (2022), different definitions for rurality that explain non-rurality such as remote areas, rural areas, or regional/semi-urban centres within rural areas, have been provided. A distinction between rural, urban, and suburban populations has been conducted in research by Bonny et al. (2020) where participants have been divided into urban/suburban or rural. Therefore, possible distinctions between eco-grief and eco-anxiety may have been unexplored because of this lack of specification.

Strengths

After describing the study's limitations, the study's strengths will now be considered. Besides, the study's diverse sample representation involves participants with different educational backgrounds, various age groups ranging from 18 to 75 years and diverse living. This diversity allows for a complete examination of the psychological impacts of climate change. By considering different geographic and cultural contexts, the generalizability and applicability of the results is enhanced.

Likewise, emotions regarding climate change have been examined among different populations already. In a recent study by Zeier and Wessa (2024), eco-anxiety and eco-grief have been investigated among the German population. However, this study focuses on German and Dutch populations and adheres to a comparison among these populations. The consideration of their urban and rural living fills a valuable gap in the literature on eco-grief and eco-anxiety. Consequently, the study provides significant insights into how climate

change influences mental health affectations in different geographic regions, by examining the experiences of individuals in these specific cultural and environmental settings.

Next, using the translated questionnaires from Doyle (2024) and Gökoglan (2024) multiple dimensions of psychological distress related to climate change were included. The study ensures the complexity of individuals' emotional responses to climate change, contributing to the understanding of the phenomenon. This rises in urgency, given the increase in climate change-related consequences. By building on established measurement tools, it is assured for consistency and comparability of data across diverse cultural contexts. Thereby, meaningful comparisons and interpretations of findings are supported.

Implications for Future Research

After gaining insights into the advantages and disadvantages of this study, possible implications for future research will be explained. According to the study's findings, a more comprehensive understanding of participants' experiences and perspectives regarding eco-grief and eco-anxiety could be gained when using a mixed-methods approach that combines quantitative surveys with qualitative interviews or observational measures.

In addition, applying experience-sampling methods instead of a cross-sectional study design would ensure a better insight into the causes and reasons behind the participants' emotions. By conducting experience-sampling methods an individual's feelings, thoughts, actions, context, and activities are measured daily (Zirkel et al., 2015). Hence, the aspects of participants' experiences can be examined and the context that shapes these experiences (Zirkel et al., 2015).

Moreover, future studies should achieve an equal sample size across urban and rural populations to ensure comparability and statistical power in the analysis. This would allow for increased reliability and generalizability of the findings and a better understanding of the relationship between living and mental health affectations related to climate change would be provided. Accordingly, considering cultural, and regional differences among individuals could

help to create coping strategies, promote community care, and support individuals in dealing with the psychological impacts of climate change.

Conclusion

This research was implemented to investigate potential differences between living in rural or urban areas and experiencing eco-anxiety and eco-grief among German and Dutch populations. The findings indicated no significant impact of living in rural or urban areas on eco-anxiety or eco-grief. However, there was a relationship between eco-anxiety and eco-grief without a moderating effect of rural living. The study includes a large and diverse sample, a unique focus on German and Dutch populations and a better understanding of mental health affectations caused by climate change. Therefore, this study supports acquiring deeper insights into this topic across various cultural and geographic backgrounds and contributes to an overall picture of climate change emotions. This rises in importance given the increased fear of climate change catastrophes.

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Appendices

Appendix A

STROBE Checklist

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

Appendix B

Online Advertisements

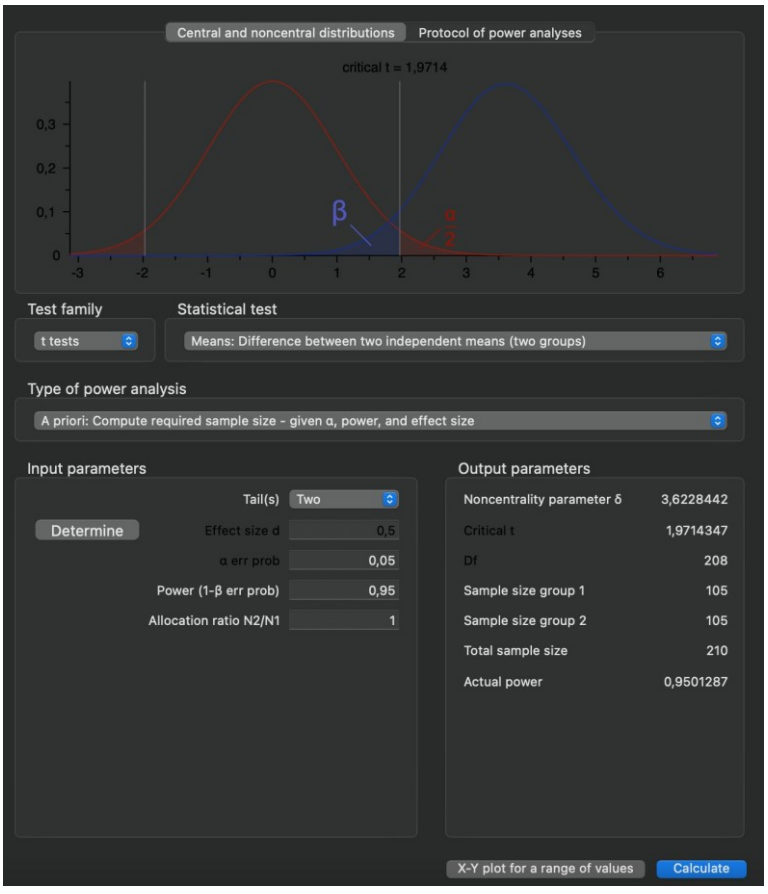

Wat zijn de psychologische gevolgen van klimaatverandering?
Nieuwsgierig? Help ons dit te onderzoeken!
Deelname duurt ongeveer 15 minuten. Voorwaarden:
U bent 18+, woont in Nederland of Duitsland, en verstaat Nederlands of Duits


Psychologische gevolgen van klimaatverandering
Nieuwsgierig?
Help ons dan en neem deel aan ons onderzoek waarin we precies dat willen uitzoeken.
Voorwaarden voor deelname:
Leeftijd: Ten minste 18 jaar oud
Nationaliteit: Duits of Nederlands


Psychische Auswirkungen des Klimawandels
Neugierig?
Dann hilf uns und werde Teil unserer Studie, bei der wir genau dass herausfinden wollen.
Teilnahmebedienungen:
Alter: Mind. 18 Jahre alt
Sprache: Deutsch oder Niederländisch

Appendix C

G-Power



Appendix D

Opening Statements of Survey in Qualtrics

German Version

Willkommen
Das Ziel dieser Studie ist es, den Zusammenhang zwischen Klimawandel, psychischen Störungen und umweltfreundlichem Verhalten in der deutschen und niederländischen Bevölkerung zu untersuchen. Die Studie wird von drei Bachelor- und einer Masterstudierenden der Psychologie an der Universität Twente durchgeführt und die gesammelten Daten werden für ihre Bachelor- und Masterarbeit analysiert.

Teilnahme
Um an dieser Studie teilnehmen zu können, müssen Sie mindestens 18 Jahre alt sein und entweder in Deutschland oder den Niederlanden leben. Ausserdem müssen Sie entweder deutsch oder niederländisch sprechen. Personen, die derzeit in Behandlung einer psychischen Krankheit sind oder in den letzten zwei Jahren suizidale Gedanken hatten, können nicht an dieser Studie teilnehmen, um sie vor möglichen Schäden durch die Teilnahme zu schützen. Ihre Teilnahme an dieser Studie ist vollkommen freiwillig, und Sie haben das Recht, jederzeit ohne Angabe von Gründen oder ohne Konsequenzen zurückzutreten. Alle bis dahin von Ihnen bereitgestellten Daten werden von weiteren Analysen ausgeschlossen. Nach Abschluss des Fragebogens werden jedoch alle Daten anonymisiert und sind daher nicht identifizierbar, was eine Löschung der Daten unmöglich macht. Die Verwendung Ihrer Daten erfolgt ausschliesslich unter vertraulichen Umständen. Nach der Zustimmung zur Teilnahme werden demografische Fragen gestellt. Um Anonymität zu gewährleisten, werden keine identifizierbaren Informationen gesammelt. Der Fragebogen dauert etwa 15-20 Minuten. Ihre Teilnahme an dieser Studie wird sehr geschätzt und wird dazu beitragen, unser Verständnis der psychologischen Auswirkungen des Klimawandels zu vertiefen.

Kontaktdaten
Diese Studie wurde von der Ethikkommission der Universität Twente geprüft und genehmigt. Für zusätzliche Informationen oder bei Fragen wenden Sie sich bitte an die Forscher:

Michele Petkovski (c.m.petkovski@student.utwente.nl)
Anna Rupp (a.b.rupp@student.utwente.nl)
Charli Mania (c.r.mania@student.utwente.nl)
Jasper Wrana (j.r.wrana@student.utwente.nl)

Alternativ können Sie sich an den Mentor Dr. Alejandro Dominguez Rodriguez (a.dominguezrodriguez@utwente.nl), wenden.

Dutch Version

Welkom
Het doel van dit onderzoek is om de relatie tussen klimaatverandering, psychische stoornissen en milieuvriendelijk gedrag in de Duitse en Nederlandse bevolking te onderzoeken. Het onderzoek zal worden uitgevoerd door drie bachelor- en één masterstudenten Psychologie aan de Universiteit Twente en de verzamelde gegevens zullen worden geanalyseerd voor hun bachelor- en

masterscripties.

Deelname
Om deel te nemen aan dit onderzoek moet u 18 jaar of ouder zijn en in Duitsland of Nederland wonen. U moet ook Duits of Nederlands spreken. Mensen die momenteel onder behandeling zijn voor een psychische aandoening of die de afgelopen twee jaar suïcidale gedachten hebben gehad, kunnen niet deelnemen aan dit onderzoek om hen te beschermen tegen mogelijke schade door deelname. Uw deelname aan dit onderzoek is geheel vrijwillig en u heeft het recht om u op elk moment terug te trekken zonder opgaaf van reden of consequenties. Alle gegevens die u tot op dat moment hebt verstrekt, worden uitgesloten van verdere analyses. Zodra de vragenlijst is ingevuld, worden alle gegevens echter geanonimiseerd en kunnen ze dus niet meer worden geïdentificeerd, waardoor het onmogelijk is om uw gegevens te verwijderen. Uw gegevens worden uitsluitend onder vertrouwelijke omstandigheden gebruikt. Demografische vragen worden gesteld zodra u hebt ingestemd met deelname. Om anonimiteit te garanderen, wordt er geen identificeerbare informatie verzameld. Het invullen van de vragenlijst duurt ongeveer 15-20 minuten. Uw deelname aan dit onderzoek wordt zeer op prijs gesteld en zal bijdragen aan een beter begrip van de psychologische gevolgen van klimaatverandering.

Contactgegevens
Dit onderzoek is beoordeeld en goedgekeurd door de Ethische Commissie van de Universiteit Twente. Voor aanvullende informatie of vragen kunt u contact opnemen met de onderzoekers:

Michele Petkovski (c.m.petkovski@student.utwente.nl)
Anna Rupp (a.b.rupp@student.utwente.nl)
Charli Mania (c.r.mania@student.utwente.nl)
Jasper Wrana (j.r.wrana@student.utwente.nl)

U kunt ook contact opnemen met de begeleider Dr. Alejandro Dominguez Rodriguez (a.dominguezrodriguez@utwente.nl).

Appendix E

Informed Consent in Qualtrics

German Version

Indem ich unten auf JA klicke, bestätige ich das Folgende:

Ich habe alle Informationen gelesen und erfülle alle Teilnahmebedingungen. Ich bestätige, dass meine Teilnahme völlig freiwillig ist. Ich erkenne auch mein Recht an, meine Einwilligung jederzeit ohne Angabe von Gründen zu widerrufen, insbesondere wenn ich Unbehagen oder Stress jeglicher Form empfinde. Solch Widerruf wird keine Konsequenzen nach sich ziehen.

Darüber hinaus verstehe ich Folgendes:

- Alle vom Forscher erhobenen Daten bleiben völlig anonym und können nicht auf meine Identität zurückgeführt werden. Ein Rücktritt ist daher nach Beendigung der Umfrage nicht mehr möglich.

- Mir ist bekannt, dass die von mir zur Verfügung gestellten Informationen in Forschungsberichten verwendet werden, deren Ziel es ist, die Auswirkungen des Klimawandels auf die psychische Gesundheit darzustellen.

- Ich befinde mich derzeit in KEINER medizinischen oder therapeutischen Behandlung aufgrund einer psychischen Störung.

- Ich habe in den letzten zwei Jahren KEINE Selbstmordgedanken erfahren.

- Mir ist bewusst, dass die Teilnahme an der Studie aufgrund der Diskussion der sensiblen Thematik des Klimawandels zu psychischem Unbehagen führen kann.

- Ich erkläre mich damit einverstanden, keine Informationen über den Ablauf und die Einzelheiten der Studie zu teilen, da dies die Ergebnisse der Studie beeinträchtigen könnte.

- Ich erkläre mich damit einverstanden, dass meine Antworten in der Umfragedatenbank für mögliche zukünftige Forschungs- und Ausbildungszwecke genutzt werden.

Dutch Version

Door hieronder op JA te klikken, bevestig ik het volgende:

Ik heb alle informatie gelezen en voldoe aan alle deelnamevoorwaarden. Ik bevestig dat mijn deelname volledig vrijwillig is. Ik erken ook mijn recht om mijn medewerking aan dit onderzoek op elk moment in te trekken zonder opgave van reden, vooral als ik ongemak of stress van welke vorm dan ook ervaar. Een dergelijke intrekking heeft geen gevolgen.

Daarnaast begrijp ik het volgende:

- Alle door de onderzoekers verzamelde gegevens blijven volledig anoniem en zijn niet te herleiden tot mijn identiteit. Na afloop van de enquête is terugtrekking dus niet meer mogelijk.

- Ik begrijp dat de informatie die ik verstrek zal worden gebruikt in onderzoeksrapporten die tot doel hebben de impact van klimaatverandering op de psychische gezondheid aan te tonen.

- Ik onderga momenteel GEEN medische of therapeutische behandeling voor een psychische stoornis.

- Ik heb de afgelopen twee jaar GEEN zelfmoordgedachten gehad.

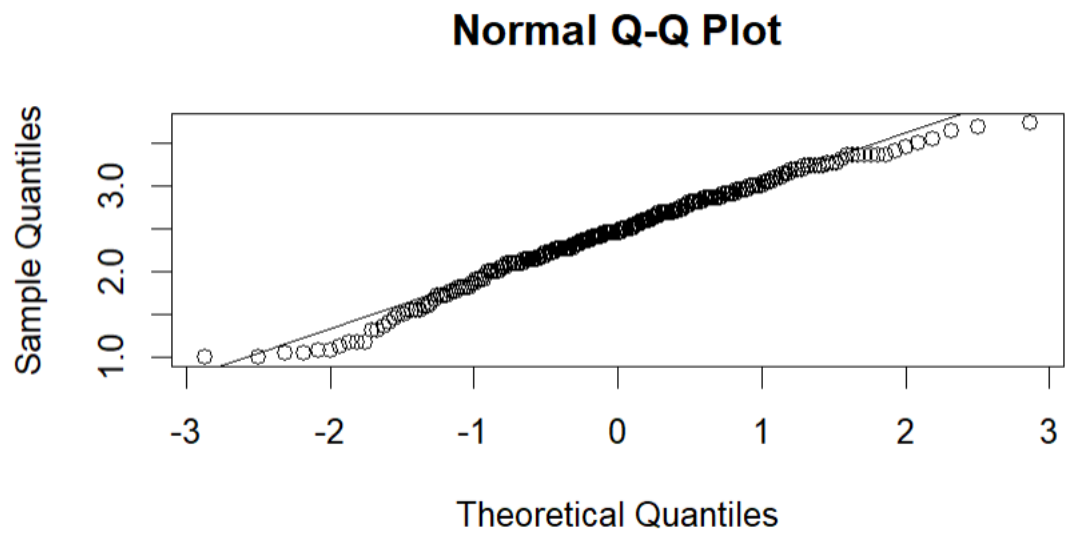
- Ik ben mij ervan bewust dat deelname aan het onderzoek psychologisch ongemak kan veroorzaken als gevolg van de discussie over de gevoelige kwestie van klimaatverandering.

- Ik ga ermee akkoord geen informatie te delen over het proces en de details van het onderzoek, aangezien dit de resultaten van het onderzoek zou kunnen beïnvloeden.

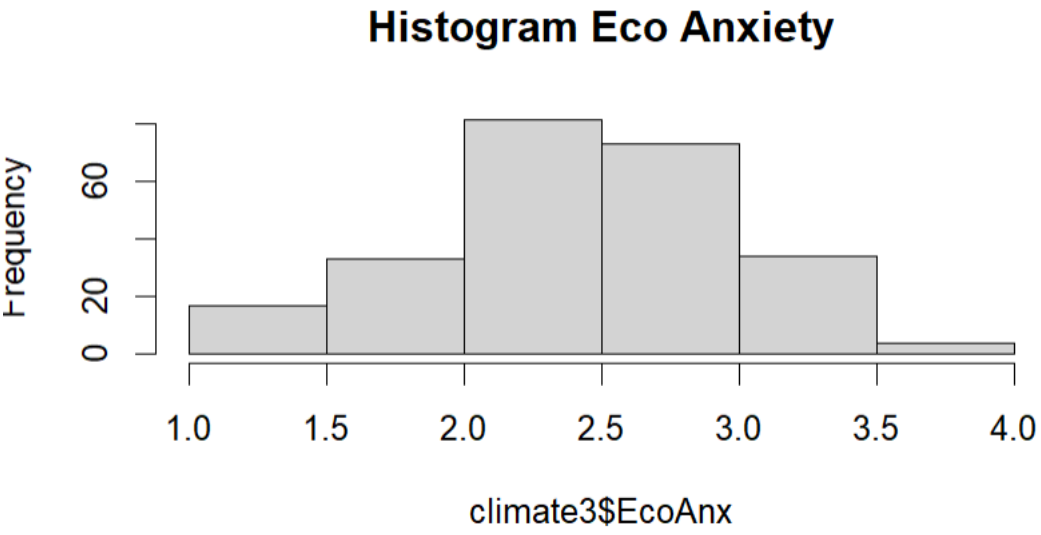
- Ik ga ermee akkoord dat mijn antwoorden worden gebruikt in de enquêtedatabase voor mogelijk toekomstig onderzoeks- en trainingsdoeleinden.

Appendix F

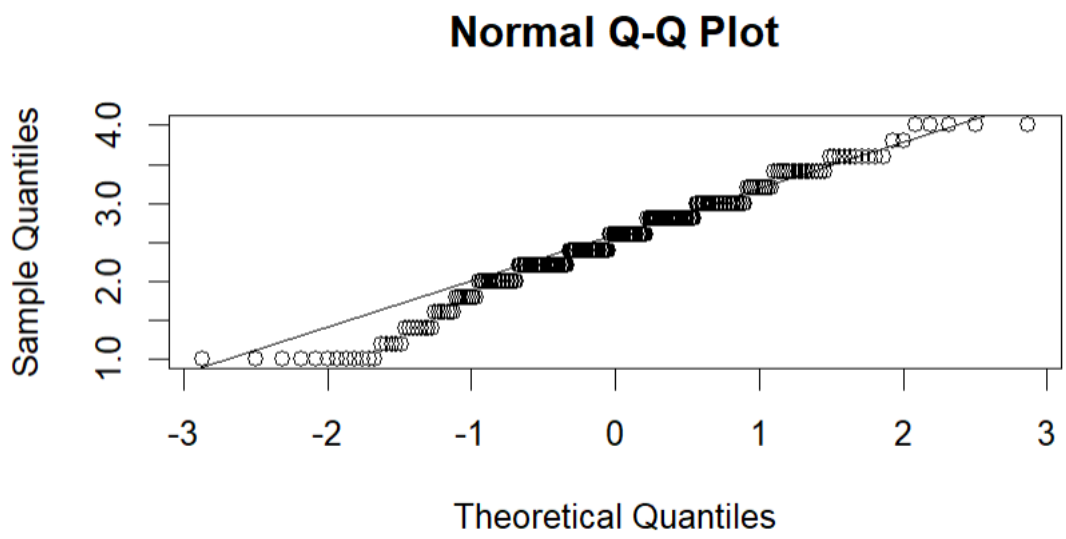
Q-Q Plot EAQ-22



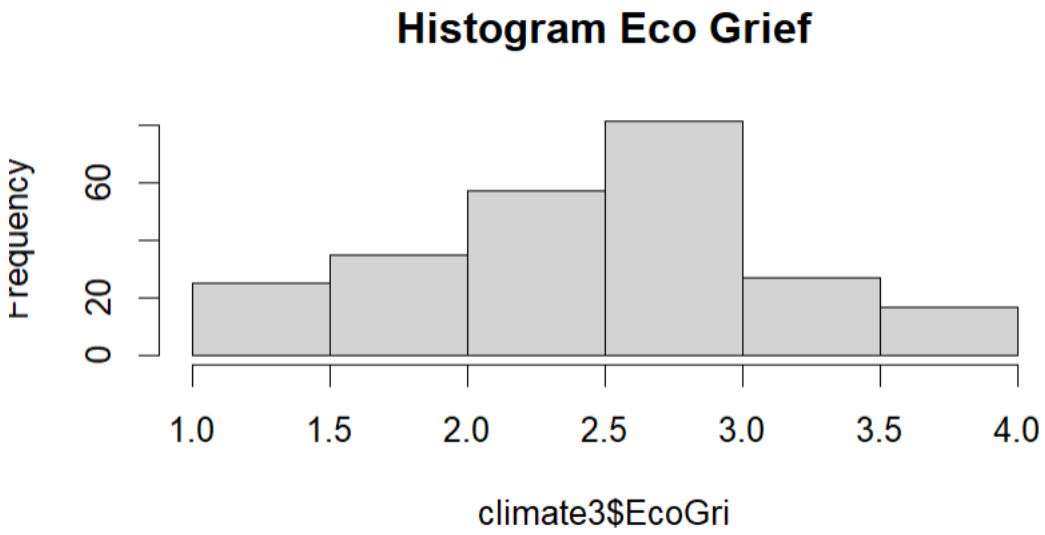
Histogram Eco-Anxiety



Q-Q Plot EGri-6

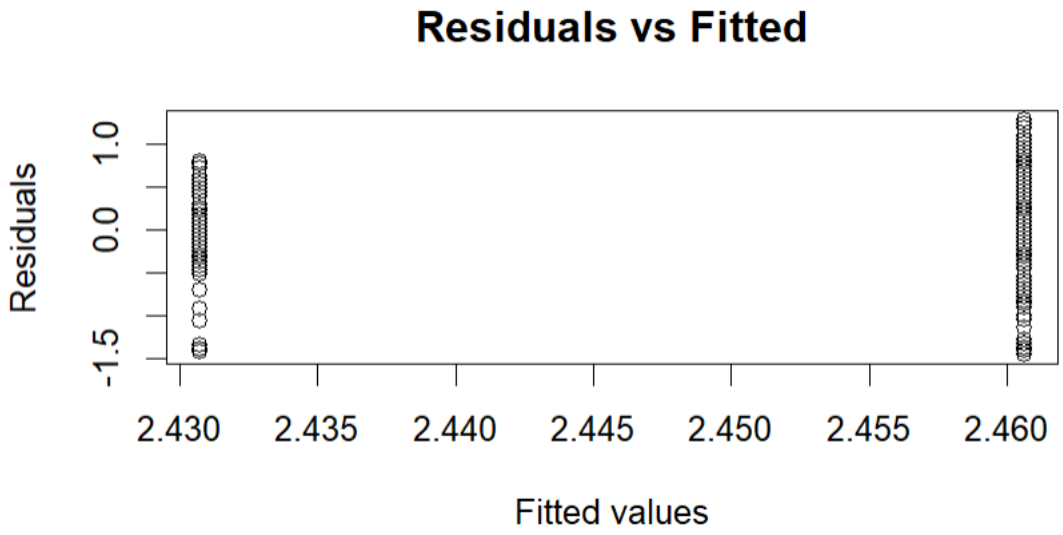


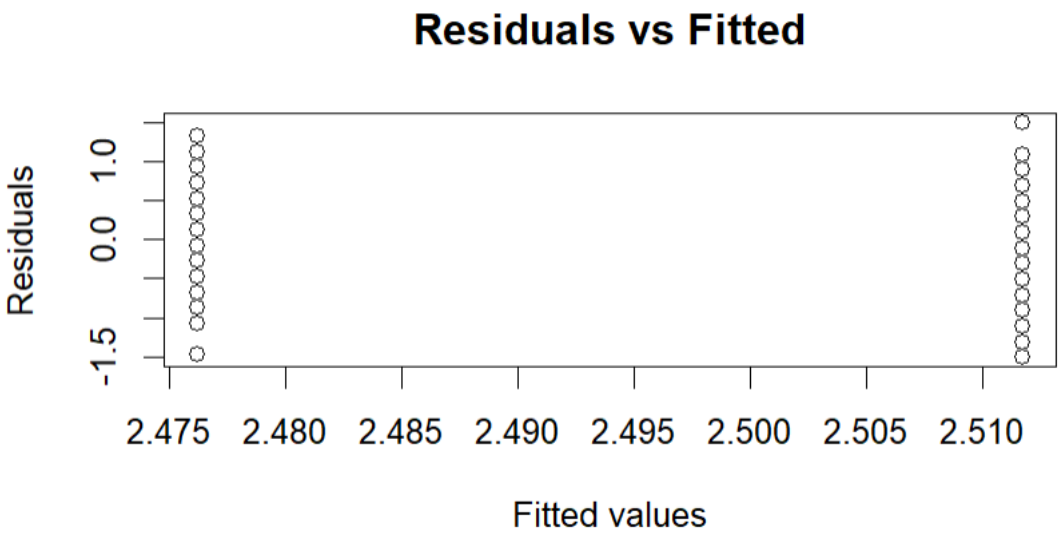
Histogram Eco-Grief



Appendix G

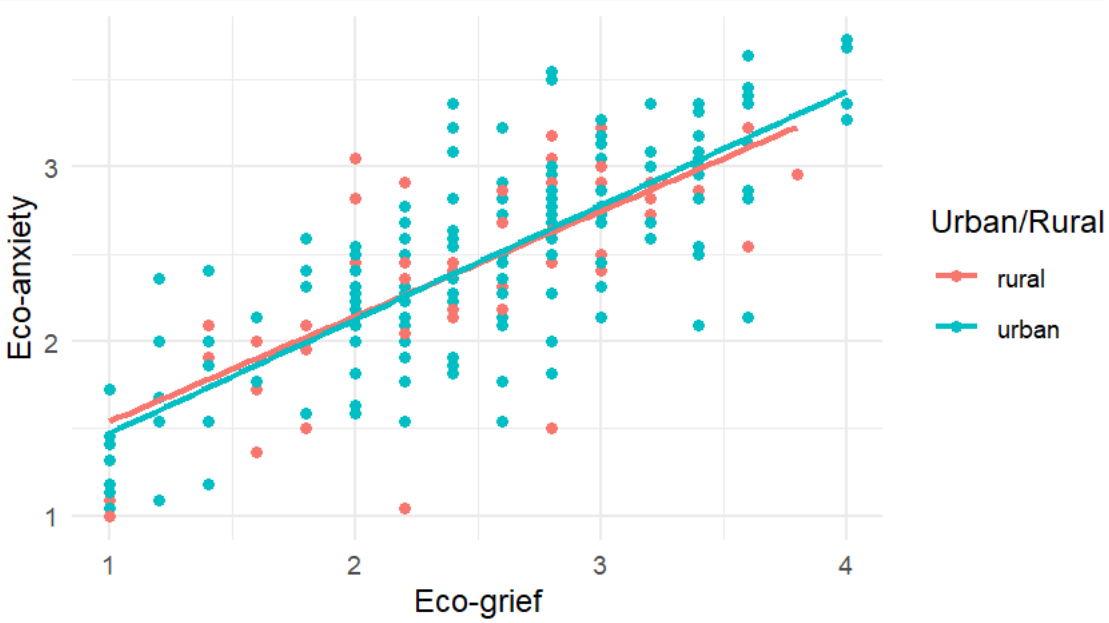
Fitted values vs. residuals





Appendix H

Scatterplot moderated multiple regression




```
> ggplot(climate, aes(x = EcoGri, y = EcoAnx, color = urbanrural_dummy)) +
+   geom_point() +
+   geom_smooth(method = "lm", se = FALSE) +
+   labs(x = "Eco-grief", y = "Eco-anxiety", color = "Urban/Rural") +
+   theme_minimal()
`geom_smooth()` using formula = 'y ~ x'
```

Appendix I

R-Script

#load packages

library(tidyverse)

library(ggplot2)

library(dplyr)

library(lmtest)

library(interactions)

library(readr)

#import data set

climate3 <- read.csv("Eco-anxiety, Eco-guilt, Eco-grief German Version_8 May 2024_01.35.csv")

#clean data - get rid of rows and columns

View(climate3)

names(climate3)

```
#delete all other questionnaires
climate3 <- climate3[,-c(42:68, 75:100)]
climate3 <- climate3[,-c(48:55)]
climate3 <- climate3[,-c(49:49)]
climate3 <- climate3[,-c(49:51)]

climate3 <- climate3[,-c(1:3)]
climate3 <- climate3[,-c(2,4,5,6,7)]
View(climate3)
as.character(as.matrix(climate3[1,]))
names(climate3)<-as.character(as.matrix(climate3[1,]))
names(climate3)
climate3 <- climate3 [-c(1:2),]

#rename variables

names(climate3)[4]<- "gender"
names(climate3)[5]<- "age"
names(climate3)[6]<- "degree"
names(climate3)[7]<- "degree2"
names(climate3)[8]<- "nationality"
names(climate3)[9]<- "closewater"
names(climate3)[10]<- "sealevel"
names(climate3)[11]<- "floodvictim"
names(climate3)[12]<- "ruralurban"

#making age numeric#
climate3$age<-as.numeric(as.character(climate3$age))
class(climate3$age)
#making gender variable ready#
levels(climate3$gender)<- c(NA, "Weiblich", "Männlich", "Non-Binär/anderes") #need to
find way to get it ready for use#
```

```
summary(climate3$gender)
#removing participants#
num_participants <- nrow(climate3)

print(num_participants)
#currently: 370
climate3 <- climate3[climate3$Finished == "True", ]
num_participants <- nrow(climate3)
print(num_participants)

#after removing non-completers: 270 (100 non-completers)
#removing other nationalities
climate3 <- climate3[climate3$nationality != "Sonstige", ]
num_participants <- nrow(climate3)
print(num_participants)

#after removing other nationalities: 248
#need ro remove people who did not conform with second informed consent
names(climate3)[40]<-"consent2"
climate3 <- climate3[climate3$consent2 != "Nein", ]
num_participants <- nrow(climate3)
print(num_participants)

names(climate3)[3]<-"consent1"
climate3 <- climate3[climate3$consent1 != "NEIN (Sie werden zum Ende der Studie
weitergeleitet)", ]
num_participants <- nrow(climate3)
print(num_participants)

#after removing people who did not consent at the end: 245 (-3)

#check demographics#
#gender#
```

```
gender_freq <- table(climate3$gender)
print(gender_freq)
gender_prop <- prop.table(gender_freq)
print(gender_prop)
#age#
age_mean <- mean(climate3$age)
age_median <- median(climate3$age)
age_sd <- sd(climate3$age)
age_range <-range(climate3$age)
print(age_mean)
print(age_median)
print(age_sd)
print(age_range)
#nationality#
table(climate3$nationality)
#degree#
degree_freq <- table(climate3$degree)
print(degree_freq)
degree2_freq <- table(climate3$degree2)
print(degree2_freq)
#location#
closewater_freq <- table(climate3$closewater)
print(closewater_freq)
sealevel_freq <- table(climate3$sealevel)
print(sealevel_freq)
floodvictim_freq <- table(climate3$floodvictim)
print(floodvictim_freq)
ruralurban_freq <- table(climate3$ruralurban)
print(ruralurban_freq)

#German answers to english
climate3$ruralurban <- recode(climate3$ruralurban,
                              "städtisch" = "urban",
```

```
                    "ländlich" = "rural")


## Making Answers of the Questionnaires Numeric ##
#For Eco-Anxiety Scale
columns_to_recode <- 13:34
climate3 <- climate3 %>%
  mutate(across(columns_to_recode, ~ case_when( . == "stimme nicht zu" ~ 1,
                                    . == "stimme eher nicht zu" ~ 2,
                                    . == "stimme eher zu" ~ 3,
                                    . == "stimme zu" ~ 4,
                                    TRUE ~ NA_real_ )))
climate3 <- climate3 %>%
  mutate(EcoAnx = rowMeans(select(., columns_to_recode), na.rm = TRUE))

#For Eco-Grief Scale
columns_to_recode <- 35:39
climate3 <- climate3 %>%
  mutate(across(columns_to_recode, ~ case_when( . == "stimme nicht zu" ~ 1,
                                    . == "stimme eher nicht zu" ~ 2,
                                    . == "stimme eher zu" ~ 3,
                                    . == "stimme zu" ~ 4,
                                    TRUE ~ NA_real_ )))
climate3 <- climate3 %>%
  mutate(EcoGri = rowMeans(select(., columns_to_recode), na.rm = TRUE))

## Computing means, SDs and ranges of EAQ-22 & Ecogrief ##
##descriptive statistics
summary(climate3)
mean(climate3$EcoAnx)
sd(climate3$EcoAnx)
mean(climate3$EcoGri)
sd(climate3$EcoGri)
```

```
class(climate3$EcoAnx)

class(climate3$EcoGri)



##Assumptions##

##Check for normality

#Eco-Anxiety

qqnorm(climate3$EcoAnx); qqline(climate3$EcoAnx)

hist(climate3$EcoAnx, main = "Histogram Eco Anxiety")

#Shapiro-Wilk Test#

shapiro.test(climate3$EcoAnx)

#Kolmogorov-Smirnov Test#

ks.test(climate3$EcoAnx, "pnorm", mean = mean(climate3$EcoAnx), sd =
sd(climate3$EcoAnx))


#EcoGrief

qqnorm(climate3$EcoGri); qqline(climate3$EcoGri)

hist(climate3$EcoGri, main = "Histogram Eco Grief")

#Shapiro-Wilk Test#

shapiro.test(climate3$EcoGri)


#Kolmogorov-Smirnov Test#

ks.test(climate3$EcoGri, "pnorm", mean = mean(climate3$EcoGri), sd =
sd(climate3$EcoGri))



##Creating dummy variables##


climate3$urbanrural_dummy <- as.integer(factor(climate3$ruralurban == "städtisch", levels =
c(FALSE, TRUE)))

View(climate3)

## Check for homoscedasticity

#ruralurban Ecoanxiety

model1 <- lm(EcoAnx ~ urbanrural_dummy, data = climate3)
```

```
plot(fitted(model1), residuals(model1), main = "Residuals vs Fitted", xlab = "Fitted values",
ylab = "Residuals")


#scatterplot


# above 0.05 -> homoscedascity

bptest(model1)

##rural urban Ecogrief

model2 <- lm(EcoGri ~ urbanrural_dummy, data = climate3)

plot(fitted(model2), residuals(model2), main = "Residuals vs Fitted", xlab = "Fitted values",
ylab = "Residuals")


bptest(model2)

# above 0.05 -> homoscedascity


##Hypotheses##


#hypothesis1


model_urban <- lm(EcoAnx ~ climate3$urbanrural_dummy, data = climate3)

summary(model_urban)



# Create the bar chart


custom_colors <- c("white", "grey")


ggplot(climate3, aes(x = ruralurban, y = EcoAnx, fill = ruralurban)) +
  geom_bar(stat = "summary", fun = "mean", position = "dodge", color = "black") +
  labs(title = "EcoAnxiety mean of each population",
       x = "location",
       y = "Mean level of Eco Anxiety") +  scale_fill_manual(values = custom_colors) +
  scale_y_continuous(breaks = seq(0, 2.5, by = 0.5))
```

```
boxplot( EcoAnx ~ urbanrural_dummy, data = climate3,
names = c("Urban", "Rural"))


#hypothesis2

model_rural <- lm(EcoGri ~ urbanrural_dummy, data = climate3)
summary(model_rural)


boxplot( EcoGri ~ urbanrural_dummy, data = climate3,
        names = c("Urban", "Rural"))

ggplot(climate3, aes(x = ruralurban, y = EcoGri, fill = ruralurban)) +
  geom_bar(stat = "summary", fun = "mean", position = "dodge", color = "black") +
  labs(title = "EcoGrief mean of each population",
       x = "location",
       y = "Mean level of Eco Grief") +  scale_fill_manual(values = custom_colors) +
  scale_y_continuous(breaks = seq(0, 2.5, by = 0.5))


#hypothesis 3

model_moderation <- lm(EcoAnx ~ EcoGri*urbanrural_dummy, data = climate3)
summary(model_moderation)

ggplot(climate3, aes(x = EcoGri, y = EcoAnx, color = ruralurban)) +
  geom_point() +
  geom_smooth(method = "lm", se = FALSE) +
  labs(x = "Eco-grief", y = "Eco-anxiety", color = "Urban/Rural") +
  theme_minimal()
```