

Article

Climate Emotions and Readiness to Change: Evidences from Generalized Additive Models

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Abstract

The growing negative consequences of climate change support the need to deepen and investigate factors that may sustain the engagement of pro-environmental behaviors. In this scenario, eco-emotions represent a key factor that can potentially shape sustainable behaviors. In keeping with this, the present study aimed at observing the potential relationships between eco-emotions and readiness to change (RTC), namely a psychological construct closely related to pro-environmental behaviors. Specifically the RTC dimensions were the following: perceived importance of the problem, motivation, self-efficacy, effectiveness of the proposed solution, social support, action, and perceived readiness. In detail, Generalized Additive Models (GAMs) were performed in order to detect both linear and non-linear associations between eco-emotions and the dimensions of RTC by assuming a complex perspective. The final sample was composed of 252 participants (mean age = 32.99, SD = 14.640). The results pointed out several significant associations (both linear and non-linear) between eco-emotions and the RTC dimensions. In detail, the perceived importance of the problem was linearly associated with anger and anxiety, while sorrow and enthusiasm showed non-linear effects. Furthermore, motivation was linearly linked to anger and guilt and non-linearly to contempt, enthusiasm, and sorrow. In terms of self-efficacy, anger, enthusiasm, and sorrow showed linear relationships, whereas isolation showed a non-linear association. Perceived effectiveness of the proposed solution was linearly related to enthusiasm and sorrow and non-linearly to anger, powerlessness, isolation, and anxiety. Similarly, social support was linearly connected with enthusiasm, isolation, and sorrow, and non-linearly with powerlessness and anxiety. Moreover, action was primarily driven by anger in a linear relationship, while enthusiasm, powerlessness, guilt, and anxiety showed non-linear associations. Finally, perceived readiness was linearly related to anxiety and non-linearly to anger, contempt, enthusiasm, powerlessness, guilt, and sorrow. These findings should be interpreted in light of the study's limitations, including its cross-sectional nature, reliance on self-reported measures, use of snowball sampling, and sample demographic characteristics, all of which may affect the generalizability of the results. Nevertheless, the results pointed out the presence of several significant linear (e.g., anxiety and the perceived importance of the problem) and non-linear (e.g., contempt and motivation) associations between various eco-emotions and RTC factors. The findings underscore the need for a complex approach to this field of research, suggesting that further studies, policies, and environmental awareness programs should consider the multifaceted nature of these phenomena in order to develop effective and valuable interventions.



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1. Introduction

In recent years, we have witnessed an alarming and increasing climate change crisis, as reported by the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28). Notably, the negative effects of climate change consequences, including rising global temperatures and sea levels, as well as extreme weather events and glacier melting, have been observed [1–4]. These negative outcomes tend to affect both the planet's health (e.g., lack of biodiversity and natural environment disruption) and physical and mental human health [5–10]. In fact, the literature has reported links between the consequences of the climate crisis and negative conditions affecting human well-being at the physical (e.g., asthma) and mental (e.g., anxiety) levels [7,9,11–13]. Moreover, in addressing the psychological aspects associated with environmental changes, several scholars have identified a range of emerging emotions strictly connected with climate change, such as, for example, anxiety, fear, grief, powerlessness, hopelessness, and isolation [14–18]. Taking the framing perspective into consideration, such emotional responses may putatively be exacerbated by a cognitive evaluation, which is associated with a frame of reference, such as available information and values [19–21]. Therefore, emotions can be influenced by the above framework and can also play a crucial role in shaping behavior, including pro-environmental behavior [19–25]. From our perspective, a deeper investigation of the role of eco-emotions in influencing pro-environmental behaviors is fundamental, especially considering the importance of emotional processes in climate crisis communication [26–29]. However, considering that emotions can be defined as transient and mental states [30–32], such an investigation from our point of view should take a complex perspective [33,34]. In detail, in recent years, we have witnessed a growing interest in the study of behavior by assuming a complex perspective that includes, among the various factors, the presence of non-linearity between the variables investigated [33–36]. Based on this assumption, it seems necessary to investigate phenomena, including human behavior and eco-emotions, considering the possible presence of non-linear relationships between the phenomena under study [34,37–40]. In line with this, a useful methodology to observe potential non-linear relationships is the application of Generalized Additive Models (GAMs) [41–45]. GAMs allow flexible modeling and visualization of complex relationships without imposing restrictive parametric assumptions. This flexibility is achieved through the use of nonparametric smoothing splines [45], which enable the model to capture data-driven relationships rather than relying on a priori imposed ones. As a result, GAMs can uncover distinct non-linear effects for each predictor, patterns that might otherwise remain hidden under linear estimation approaches or more constrained modeling frameworks. In keeping with this, to the best of our knowledge, this is the first study to investigate the role of eco-emotions from a complex perspective.

1.1. Emotions and Sustainability

Emotions can be defined as complex phenomena that have been deeply investigated by several scholars over the years [30,46]. However, there are still inconsistencies about what an emotion is [46]. In general, emotions can be conceptualized as transient and mental states that respond to internal or environmental stimuli [30–32,47]. Moreover, the importance of emotions has also been emphasized in the context of sustainability [31]. As previously mentioned, several scholars observed the existence of different emotions when dealing with climate change (e.g., grief, anxiety, guilt, isolation, fear, and sadness) [14–18]. In keeping

with this, Marczak and colleagues [16] also developed an inventory of climate emotions (ICE) to quantitatively measure eco-emotions and provide a useful tool for developing comprehensive models of the psychology of the climate crisis.

In light of all the above, the relevance of emotions in the context of sustainability has emerged, including their role in shaping pro-environmental behaviors [19–22,24,25]. Moreover, several scholars also pointed out how these kinds of feelings (e.g., eco-guilt) may be able to support the engagement in sustainable actions also in terms of climate policy support [48]. Indeed, it has been observed how emotional processes may play a key role in the engagement of sustainable behaviors as well as in promoting readiness to change (RTC) [23,31,49,50]. In light of all the above, deeply investigating the putative links between eco-emotions and sustainable attitudes and behaviors has great relevance. In particular, considering how eco-emotions can be closely associated with culture [51,52], it is essential to investigate the above-mentioned phenomenon within different cultural contexts (e.g., individualistic or collectivistic countries) [53,54] in order to observe potential differences also in engagement in sustainable attitudes and behaviors.

1.2. Readiness to Change and Sustainability

Based on traditional psychological frameworks, behavioral models can be classified into two different categories: continuum or stage models [55–59]. While continuum models (e.g., the Theory of Planned Behavior and the Protection Motivation Theory) consider intentionality to be the key and predictive factor of behavior, stage models (e.g., the Trans-theoretical Model) assume the existence of different stages in the behavioral process [55–59]. However, both the continuum and stage approaches seem to have limitations in terms of, for example, the use of linear assumptions or low capability to predict phenomena [60–64]. In this scenario, the Readiness to Change (RTC) concept may overcome the limitations above because it integrates several dimensions such as affective, behavioral, and cognitive factors, as well as the HAPA and SOCRATES models [61,65–69]. In detail, the RTC conceptually includes both the static and dynamic nature of the phenomenon [66,70,71]. In line with this, Duradoni et al. [72] developed a new model able to capture the multidimensional nature of the RTC model. Notably, this RTC model is composed of seven different dimensions: (1) perceived importance of the problem, (2) motivation, (3) self-efficacy, (4) effectiveness of the proposed solution, (5) social support, (6) action, and (7) perceived readiness. Since then, the literature findings have pointed out the applicability of RTC in the field of sustainability, as postulated by Duradoni and colleagues [72–74]. Consistently, positive associations have been found between RTC dimensions and environmental internal and communitarian locus of control with regard to responsibility allocation and the ability to support sustainable behaviors from a collective point of view [75]. Furthermore, significant links have been observed between RTC and pro-environmental behaviors, including using sustainable transportation and consuming novel foods [49,50,72–74]. Moreover, a study of Baroni and colleagues [50] on eco-emotions highlighted a connection between RTC dimensions and eco-anxiety, suggesting that RTC factors may play a supporting role in pro-environmental behavior engagement. However, there is still a gap in the literature concerning the potential relationship between RTC dimensions and eco-emotions beyond anxiety. Therefore, more studies are needed to deepen the investigation of these phenomena and add new findings to this field of research.

1.3. Aim of the Study

As previously mentioned, emotions represent a key factor in the engagement of pro-environmental behaviors and sustainability [19–21,24,25]. More broadly, negative emotions can also drive pro-environmental engagement [76,77]. Therefore, anger is an

expected emotional response that motivates people to confront violations of social norms and unacceptable situations [78]. It has previously been linked to greater engagement in climate activism [77]. Therefore, anger is expected to show a positive association with RTC. Contempt is most often expressed by individuals who have not been directly harmed by the norm violation. Rather than promoting self-improvement, it functions to ostracize norm violators, addressing norm compliance from a third-party perspective [79]. Thus, contempt is expected to be associated with perceived importance and motivation. Furthermore, previous studies have associated contempt with negative pro-climate perceptions and policy support [15]. Enthusiasm is a future-oriented emotion that propels people towards action and fosters belief in the attainability of goals [80]. Consequently, it is hypothesized to have a positive association with RTC. Powerlessness reflects a lack of agency and perceived ability to effect change. Past studies have associated powerlessness with reduced pro-climate engagement [15]. Therefore, a negative association with RTC is expected. Guilt has been linked to personal sacrifice for the benefit of the environment, as well as to higher levels of pro-climate engagement [15]. Accordingly, a positive association with the RTC dimensions is anticipated. Climate isolation captures the feeling of being emotionally disconnected from others regarding climate concerns. While some studies suggest that this sense of isolation can motivate individual climate action, others indicate that higher levels of isolation are found among the less engaged [15], suggesting a complex relationship. Consequently, a negative association with the RTC dimensions is anticipated. Anxiety about climate change has been associated with increased participation in climate activism [81]. Therefore, a positive correlation is expected. Climate sorrow, which is defined as a deep emotional response to environmental loss, can strengthen commitment to environmental protection [78]. It has previously been linked to greater pro-environmental engagement [14]. Accordingly, a positive association with RTC is expected. However, there is still the need to further investigate their link, considering also the association between emotional processes and RTC [31]. In fact, although literature has identified associations between RTC and eco-anxiety, we argue that studies should expand this research to include a broader spectrum of climate-related emotions potentially associated with RTC dimensions. This assumption is based on the importance of RTC as a psychological antecedent of behavioral change [72]. Moreover, considering the fluctuating and transient characteristics of emotions, it is important to investigate the link between this kind of process and RTC without postulating a linear association a priori. Notably, by taking into consideration a complexity perspective of human beings [33–36], examining phenomena assuming putative non-linear associations may result in valuable new findings that could add new information about the properties of the association between climate-related emotions and RTC. Considering all the above and taking an exploratory point of view, the present study aimed to observe the potential links between climate emotions and RTC dimensions using GAMS (GAM) [41].

2. Materials and Methods

2.1. Study Design

An online, self-report data collection using Google Forms was launched through the most popular social platforms via a snowball sampling method. According to the Italian privacy legislation (Law Decree DL-101/2018) and EU Regulation (2016/679), data were anonymously and voluntarily collected. The following participation inclusion criteria were used: (i) age equal to or more than 14 and (ii) knowledge of the Italian language. By considering the importance of being inclusive in the collection of socio-demographic data in the field of research [82], the final sample consisted of 252 participants (39.3% cisgender men; 59.9% cisgender women; 0.8% people belonging to the LGBTQIA+ community; mean age = 32.99, SD = 14.640).

2.2. Instruments

In the survey, the following instruments were administered: The Readiness to Change Scale (RTC; [72]): The scale measures the subjective RTC and it is composed of 29 items scored on a 5-point Likert scale (1: “strongly disagree”; 5: “strongly agree”). Specifically, the instrument assesses seven different factors, namely perceived importance of the problem (Items 1–4; e.g., “This change is very important for me”), motivation to change (Items 5–8; e.g., “I am determined to change my habits”), self-efficacy (Items 9–13; e.g., “I am confident in my ability to change habits”), effectiveness of the proposed solution (Items 14–17; e.g., “I think there are effective ways of dealing with this change”), social support (Items 18–21; e.g., “I feel supported by the people close to me in this change”), action (Items 22–25; e.g., “I am already doing something to solve my problem”), and perceived readiness (Items 26–29; e.g., “I am ready to change”) [72]. From a psychometric point of view, the instrument is characterized by a good internal reliability (Table 1) [72]. The total score of each subscale is calculated by summing the raw score of each item (score range: 4–20). Finally, for the data collection, the Italian standardized version of the instrument was used [72].

Table 1. Internal reliability values of the RTC subscale [72].

RTC Subscales	McDonald’s ω
Perceived importance of the problem	0.78
Motivation to change	0.83
Self-efficacy	0.87
Effectiveness of the proposed solution	0.81
Social support	0.74
Action	0.83
Perceived readiness	0.82

Notes: RTC, Readiness to Change.

Inventory of Climate Emotions (ICE; [16]): a 60-item questionnaire scored on a 5-point Likert scale that assesses 8 different climate emotions in terms of: climate anger (Items 1–4; e.g., “I feel angry that the political and economic system that we live in harms the climate”), climate contempt (Items 5–8; e.g., “I am tired of the topic of climate change”), climate enthusiasm (Items 9–12; e.g., “The increasing public engagement with climate change gives me hope”), climate powerlessness (Items 13–16; e.g., “I feel confused about what I can do to reduce climate change”), climate guilt (Items 17–20; e.g., “I have a guilty conscience about not doing enough to mitigate climate change”), climate isolation (Items 21–24; e.g., “I feel like one of the few people who actually understand what climate change entails”), climate anxiety (Items 25–28; e.g., “Climate change makes me feel like I have been diagnosed with a terminal illness”), and climate sorrow (Items 29–32; e.g., “I feel sorry about the possibilities we are losing forever because of climate change”). Raw sum scores for each emotion subscale were used, ranging from 4 to 20. The scale has a good internal reliability. However, given that there is no validated version of the instrument used, the original scale items were translated into Italian for this study. However, based on this, we calculated Cronbach’s alpha values for each subscale in relation to the analyzed sample (Table 2).

2.3. Statistical Analysis

In line with the aim of the study, a Generalized Additive Model (GAM) was carried out to investigate both linear and non-linear associations between climate emotions and dimensions of RTC through the use of smoothing functions [41–44]. In detail, non-linearity was investigated by observing the effective degrees of freedom (EDF) values (i.e., values close to 1 are equal to the presence of linear links) [41,42]. Considering the study’s sample size ($n = 257$) and the number of covariates included ($n = 8$), the ratio between these two

factors (257/8) is lower than the threshold of 40, indicated in the literature as a benchmark for the stability of GAMs [83]. For this reason, the models were estimated using the REML method, ensuring a more stable selection of the penalty [44]. Furthermore, a Likelihood Ratio Test was conducted to compare the GAM with a linear model, and the concurvity index was calculated to assess the potential presence of non-linear multicollinearity among the predictors. In detail, RTC dimensions were used as dependent variables, while the set of climate emotions was used as independent values. The R^2 (adjusted coefficient of determination) and the explained variance were used as model fit indexes. The R software (version 4.3.1.) and *mgcv* package were used to conduct statistical analysis [42,44,84].

Table 2. Internal reliability values of the ICE subscale.

ICE Subscales	Cronbach's Alpha	
	Marczak et al. [16]	Present Study
Anger	0.95	0.951
Contempt	0.92	0.826
Enthusiasm	0.91	0.860
Powerlessness	0.81	0.729
Guilt	0.93	0.819
Isolation	0.92	0.869
Anxiety	0.94	0.912
Sorrow	0.91	0.924

Notes: ICE, Inventory of Climate Emotions.

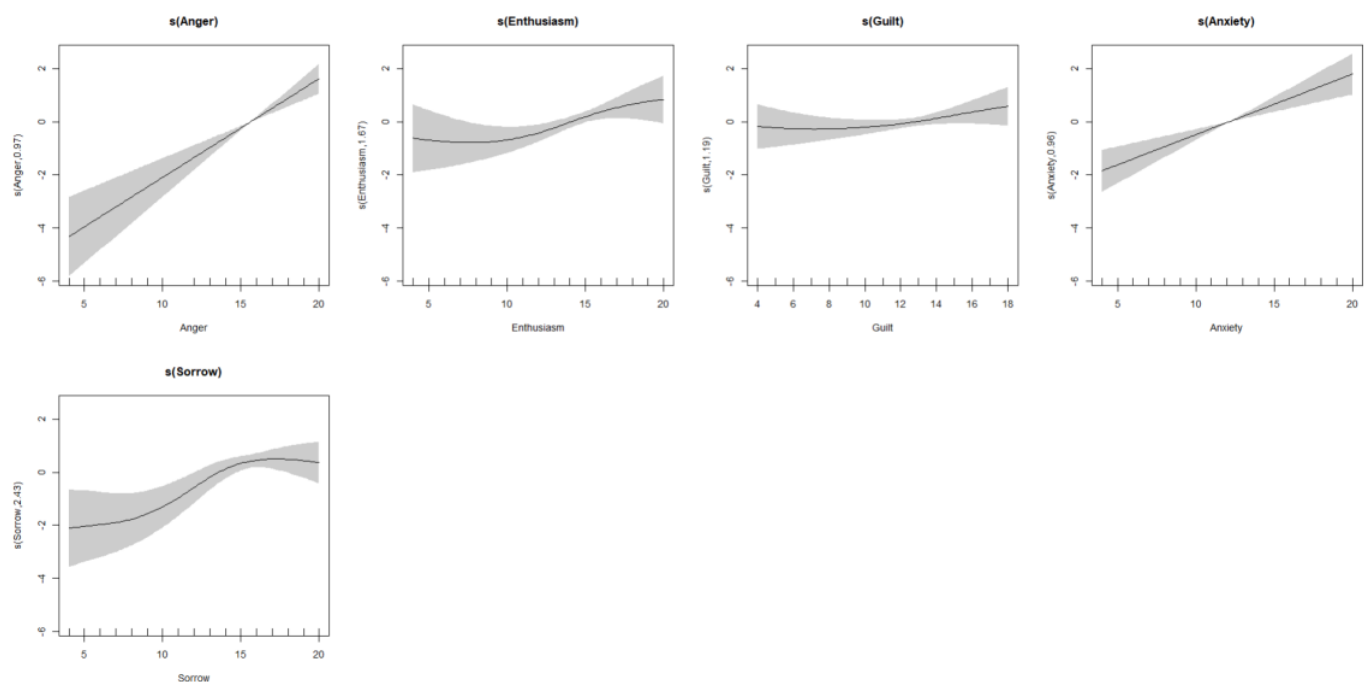
3. Results

In general, the concurvity analysis returned mean and maximum values of 0.149 and 0.546, respectively. In keeping with this, the results suggested the presence of moderate non-linear redundancy among some of the predictors considered that needs to be taken into consideration (concurvity values: 0 = no problem; 1 = total lack of identifiability) [44,85].

Concerning the link between climate emotions and the perceived importance of the problem (RTC), the GAM pointed out both linear and non-linear significant associations (Table 3 and Figure 1). Specifically, a linear association was found between anger ($\text{Edf} = 0.971$; $p < 0.001$), anxiety ($\text{Edf} = 0.956$; $p < 0.001$), and the perceived importance of the problem. In this scenario, based on its overall effect size (effect range: 5.964; 95% CI: from -5.797 to 2.189), the anger variable would appear to represent the factor capable of greatly influencing the RTC dimension considered. Conversely, non-linear relationships have been observed between this RTC dimension and both enthusiasm ($\text{Edf} = 1.665$; $p = 0.00310$) and sorrow ($\text{Edf} = 2.434$; $p < 0.001$) (Table 3 and Figure 1). Among them, the eco-emotion sorrow would appear to have a greater influence on the RTC dimension considered (effect range: 2.612; 95% CI: from -3.530 to 1.146) compared to the enthusiasm factor. Finally, the results did not show significant associations between the perceived importance of the problem (RTC) and emotions of contempt, powerlessness, and isolation. The portion of the model variance was 65.5% (adjusted R^2). Furthermore, the likelihood ratio test revealed a difference in deviance of 60.86 ($p = 0.009998$), indicating that the GAM provides a more accurate representation of the relationships between the variables than the linear model.

Table 3. Eco-emotions and perceived importance of the problem (RTC) results.

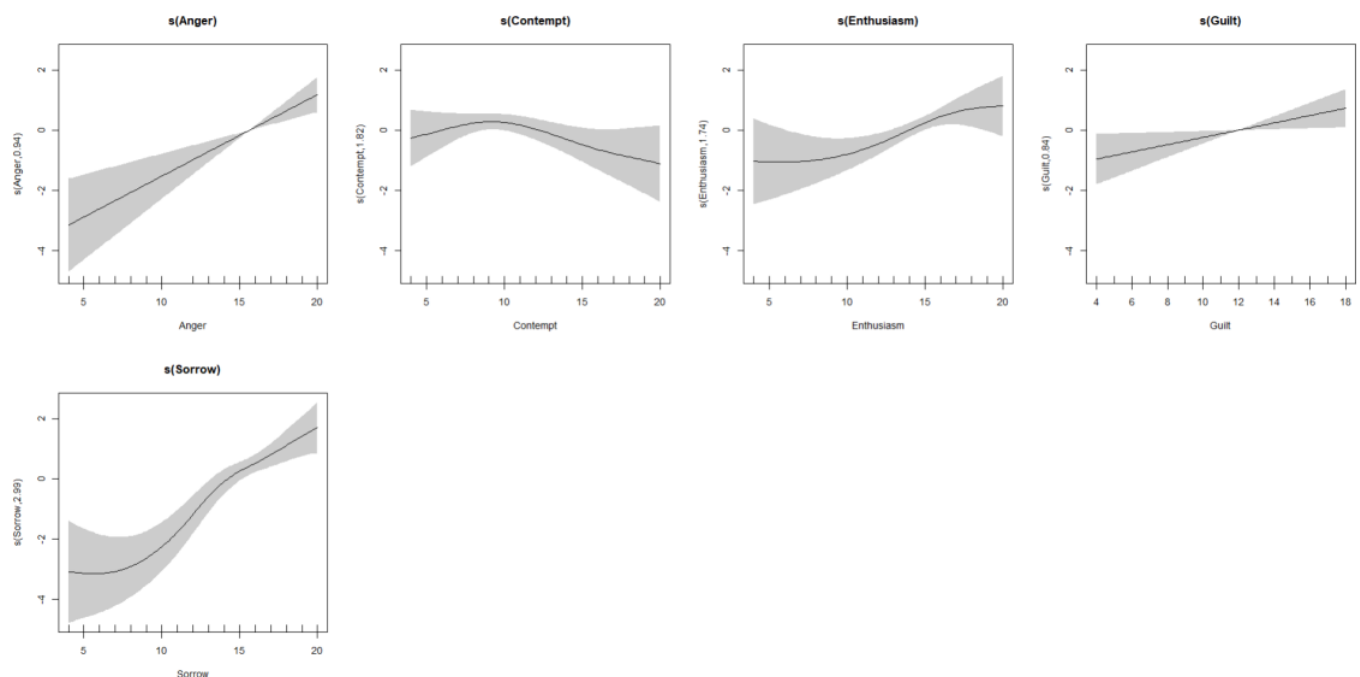
	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj-R ² (%)	DE (%)
Anger	0.971	9	3.714	<0.001	5.964	−5.797	2.189	65.5	65.5
Contempt	0.000	9	0.000	0.528	0.000	−0.011	0.011		
Enthusiasm	1.665	9	0.958	0.00310	1.624	−1.870	1.729		
Powerlessness	0.000	9	0.000	0.580	0.000	−0.009	0.009		
Guilt	1.194	9	0.320	0.0817	0.849	−1.007	1.302		
Isolation	0.227	9	0.033	0.248	0.209	−0.638	0.362		
Anxiety	0.956	9	2.434	<0.001	3.650	−2.622	2.557		
Sorrow	2.434	9	1.759	0.000215	2.612	−3.530	1.146		

**Figure 1.** GAM Results about the link between RTC—Perceived importance of the problem and climate emotions. Notes: The *y*-axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

For what concerns the association between climate emotions and motivation (RTC), results showed linear and significant associations with anger (Edf = 0.943; $p < 0.001$) and guilt (Edf = 0.843; $p = 0.0114$) (Table 4 and Figure 2). Among them, anger would appear to have a greater influence on the RTC dimension considered (effect range: 4.356; 95% CI: from −4.684 to 1.768) compared to the guilt factor. On the other hand, non-linear and significant associations emerged between motivation (RTC) and contempt (Edf = 1.815; $p = 0.0346$), enthusiasm (Edf = 1.735; $p = 0.00114$), and sorrow (Edf = 2.991; $p < 0.001$) (Table 4 and Figure 2). Sorrow seems to be the variable with a higher influence on the motivation (effect range: 4.866; 95% CI: from −4.772 to 2.562). No significant linear or non-linear associations have also been observed between powerlessness, isolation, anxiety, and motivation (RTC). The model has a portion of variance equal to 61.5% (adjusted R^2). Moreover, the likelihood ratio test pointed out a difference in deviance of 82.2 ($p = 0.02637$), supporting the use of GAM.

Table 4. Eco-emotions and motivation (RTC) results.

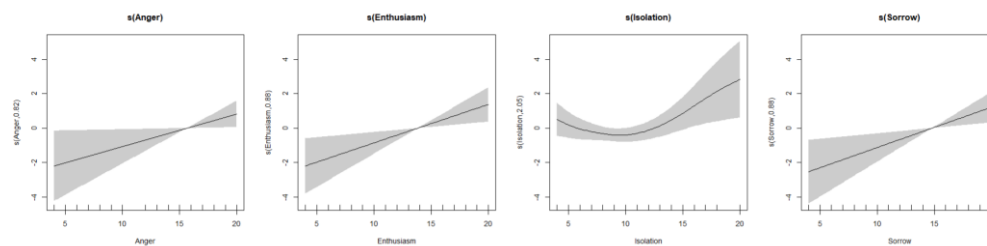
	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj-R ² (%)	DE (%)
Anger	0.943	9	1.844	0.000021	4.356	−4.684	1.768	61.5	62.9
Contempt	1.815	9	0.577	0.0346	1.405	−2.369	0.673		
Enthusiasm	1.735	9	1.153	0.00114	1.871	−2.434	1.796		
Powerlessness	0.924	9	0.211	0.1135	0.645	−0.876	1.220		
Guilt	0.843	9	0.588	0.0114	1.696	−1.781	1.361		
Isolation	0.000	9	0.000	0.6423	0.000	−0.008	0.008		
Anxiety	0.000	9	0.000	0.3497	0.000	−0.015	0.014		
Sorrow	2.991	9	4.294	<0.000001	4.866	−4.772	2.562		

**Figure 2.** GAM Results about the link between RTC—Motivation and climate emotions. Notes: The *y*-axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

Regarding the putative associations between climate emotions and self-efficacy (RTC), the GAM showed the presence of linear associations with anger (Edf = 0.821; $p = 0.01354$), enthusiasm (Edf = 0.833; $p = 0.00288$), and sorrow (Edf = 0.883; $p = 0.00205$) (Table 5 and Figure 3). Among them, sorrow seems to be the variable with a higher influence on self-efficacy (effect range: 3.752; 95% CI: from −4.340 to 2.089). Conversely, only one significant, non-linear association has emerged between isolation and self-efficacy (RTC) (Edf = 2.047; $p = 0.01257$; effect range: 3.238; 95% CI: from −0.787 to 5.012 (Table 5 and Figure 3). No other significant link has been detected. The portion of the model variance was 25.2% (adjusted R^2). Moreover, the likelihood ratio test pointed out a difference in deviance of 83.75 ($p = 0.04949$), supporting the use of GAM compared to the linear model.

Table 5. Eco-emotions and self-efficacy (RTC) results.

	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj-R ² (%)	DE (%)
Anger	0.821	9	0.511	0.01354	3.013	−4.186	1.58	25.2	27.3
Contempt	0.188	9	0.026	0.25312	0.258	−0.926	0.951		
Enthusiasm	0.883	9	0.836	0.00288	3.574	−0.537	0.771		
Powerlessness	1.131	9	0.261	0.10976	1.063	−3.761	2.366		
Guilt	0.704	9	0.264	0.06309	1.480	−1.455	1.906		
Isolation	2.047	9	0.832	0.01257	3.238	−0.787	5.012		
Anxiety	0.325	9	0.053	0.20988	0.489	−1.179	2.004		
Sorrow	0.883	9	0.839	0.00205	3.752	−4.340	2.089		

**Figure 3.** GAM Results about the link between RTC—Self-efficacy and climate emotions. Notes: The *y*-axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

Regarding the effectiveness of the proposed solution (RTC), the results revealed a significant, linear association between these RTC dimensions and climate emotions, particularly enthusiasm (Edf = 0.978; $p < 0.001$) and sorrow (Edf = 0.956; $p < 0.001$) (Table 6 and Figure 4). Enthusiasm seems to be the variable with a higher influence on the effectiveness of the proposed solution (effect range: 5.443; 95% CI: from −0.010 to 0.011). For what concerns non-linearity, an association has been found between effectiveness of the proposed solution results (RTC) and anger (Edf = 2.744; $p < 0.001$), powerlessness (Edf = 1.618; $p = 0.0043$), isolation (Edf = 3.275; $p = 0.0099$), and anxiety (Edf = 1.536; $p = 0.0123$) (Figure 4). In this scenario, anger seems to be the variable with a higher influence on the effectiveness of the proposed solution (effect range: 3.791; 95% CI: from −4.898 to 1.014). No significant associations have been observed with contempt and guilt. The model has a portion of variance equal to 60.6% (adjusted R^2). Moreover, the likelihood ratio test revealed a difference in deviance of 155.06 ($p < 0.001$).

Table 6. Eco-emotions and effectiveness of the proposed solution (RTC) results.

	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj-R ² (%)	DE (%)
Anger	2.744	9	2.532	<0.001	3.791	−4.898	1.014	60.6	62.3
Contempt	0.0001	9	0.000	0.767	0.000	−1.454	1.368		
Enthusiasm	0.978	9	4.021	<0.001	5.443	−0.010	0.011		
Powerlessness	1.618	9	0.921	0.0043	1.384	−4.435	2.788		
Guilt	0.0011	9	0.000	0.314	0.001	−0.026	0.027		
Isolation	3.275	9	1.171	0.0099	3.764	−0.794	5.938		
Anxiety	1.536	9	0.683	0.0123	1.281	−1.357	1.92		
Sorrow	0.956	9	2.369	<0.001	4.473	−4.302	2.07		

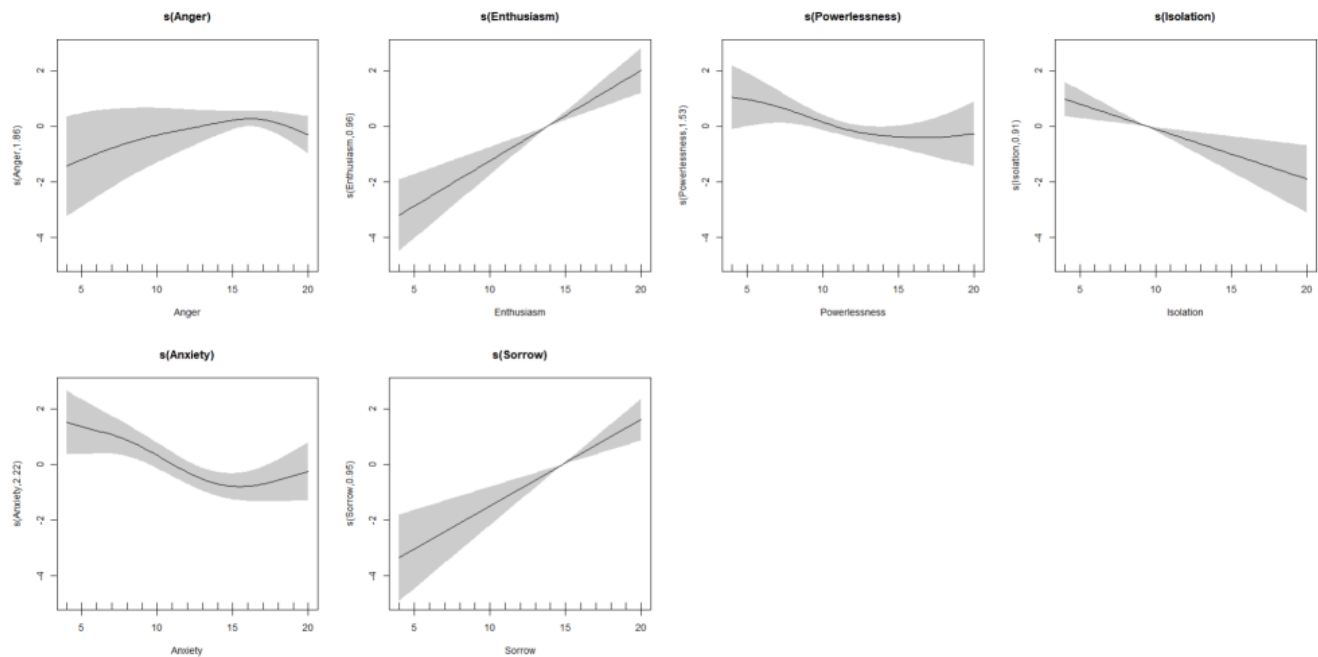


Figure 4. GAM Results about the link between RTC—Effectiveness of the proposed solution and climate emotions. Notes: The y -axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

Regarding results related to social support (RTC), three linear and significant associations were observed between this RTC dimension and enthusiasm ($\text{Edf} = 0.961$; $p < 0.001$), isolation ($\text{Edf} = 0.908$; $p < 0.001$), and sorrow ($\text{Edf} = 0.949$; $p < 0.001$) (Table 7 and Figure 5). Enthusiasm seems to be the variable with a higher influence on social support (effect range: 5.202; 95% CI: from -0.005 to 0.005). On the other hand non-linear and significant associations have been found with powerlessness ($\text{Edf} = 1.528$; $p = 0.0156$) and anxiety ($\text{Edf} = 2.216$; $p < 0.001$). (Figure 5). This last seems to be the variable with a higher influence on social support (effect range: 2.308; 95% CI: from -1.394 to 2.169) compared to powerlessness. No significant link has been found between social support (RTC) and anger, contempt, or guilt. The portion of the model variance was 40.5% (adjusted R^2). Finally, the likelihood ratio test revealed a difference in deviance of 95.919 ($p = 0.01287$).

Table 7. Eco-emotions and social support (RTC) results.

	Edf	Ref.df	T	p	Effect Range	95% CI Lower	95% CI Upper	Adj- R^2 (%)	DE (%)
Anger	1.864	9	0.518	0.0552	1.706	-3.196	0.64	40.5	42.6
Contempt	0.000	9	0.000	0.6504	0.000	-1.319	2.639		
Enthusiasm	0.961	9	2.761	<0.001	5.202	-0.005	0.005		
Powerlessness	1.528	9	0.663	0.0156	1.449	-4.448	2.799		
Guilt	0.340	9	0.048	0.259	0.210	-0.649	0.431		
Isolation	0.908	9	1.100	<0.001	2.867	-3.071	1.583		
Anxiety	2.216	9	1.457	<0.001	2.308	-1.394	2.169		
Sorrow	0.949	9	2.069	<0.001	4.963	-4.873	2.345		

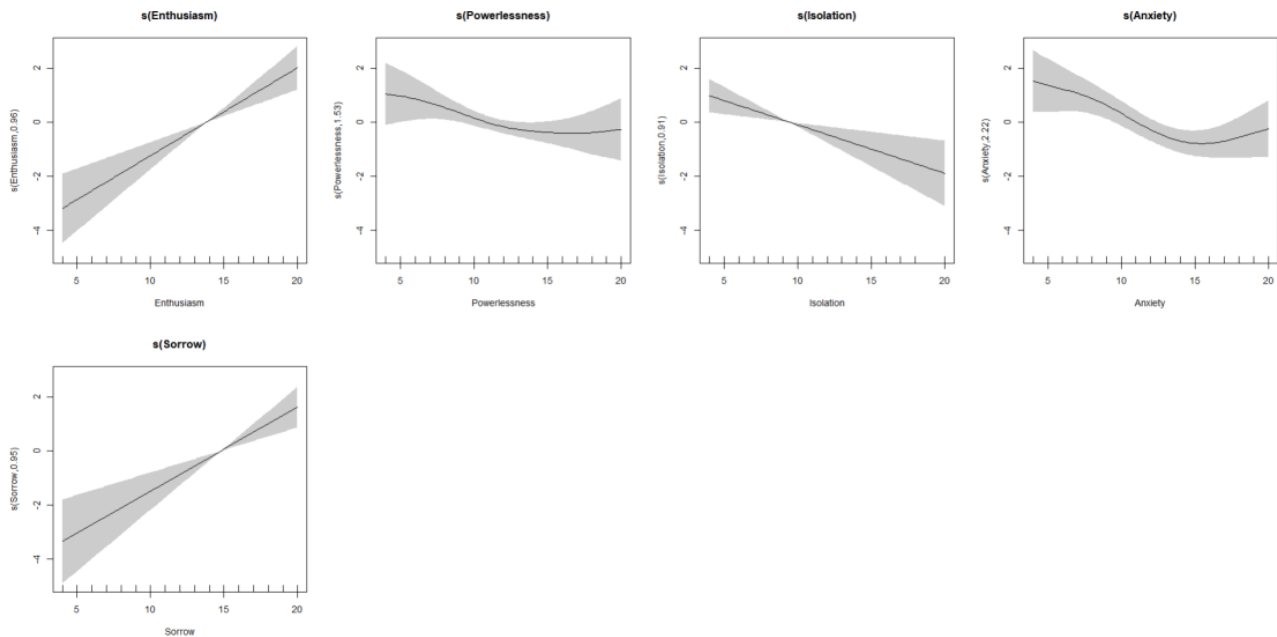


Figure 5. GAM Results about the link between RTC—Social support and climate emotions. Notes: The y-axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

With respect to the putative associations between action (RTC) and climate emotions, the GAM showed the presence of both linear and non-linear links. Notably, linear associations were observed with anger (Edf = 1.271; $p < 0.001$; effect range: 4.670; 95% CI: from -5.467 to 1.950) (Table 8 and Figure 6). Conversely, non-linear associations were found between action (RTC) and enthusiasm (Edf = 1.605; $p < 0.001$), powerlessness (Edf = 1.925; $p < 0.001$), guilt (Edf = 1.856; $p = 0.0110189$), and anxiety (Edf = 2.565; $p < 0.001$) (Table 8 and Figure 6z). Enthusiasm seems to be the variable with a higher influence on action (effect range: 2.112; 95% CI: from -2.577 to 2.220). No significant associations were detected for what concern contempt and isolation. The model has a portion of variance equal to 49.5% (adjusted R^2). Finally, the likelihood ratio test revealed a difference in deviance of 254.01 ($p = 0.00303$).

Table 8. Eco-emotions and action (RTC) results.

	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj- R^2 (%)	DE (%)
Anger	1.121	9	1.404	0.000110	4.670	-5.467	1.950	49.5	51.9
Contempt	0.415	9	0.064	0.216074	0.339	-0.929	0.680		
Enthusiasm	1.605	9	0.830	0.004720	2.112	-2.577	2.220		
Powerlessness	1.925	9	1.385	0.000506	3.224	-2.452	4.119		
Guilt	1.856	9	0.826	0.010189	2.096	-0.761	3.097		
Isolation	1.619	9	0.434	0.068845	1.664	-0.633	3.106		
Anxiety	2.565	9	2.972	<0.001	4.148	-4.302	2.026		
Sorrow	1.071	9	0.234	0.112313	1.058	-1.917	1.165		

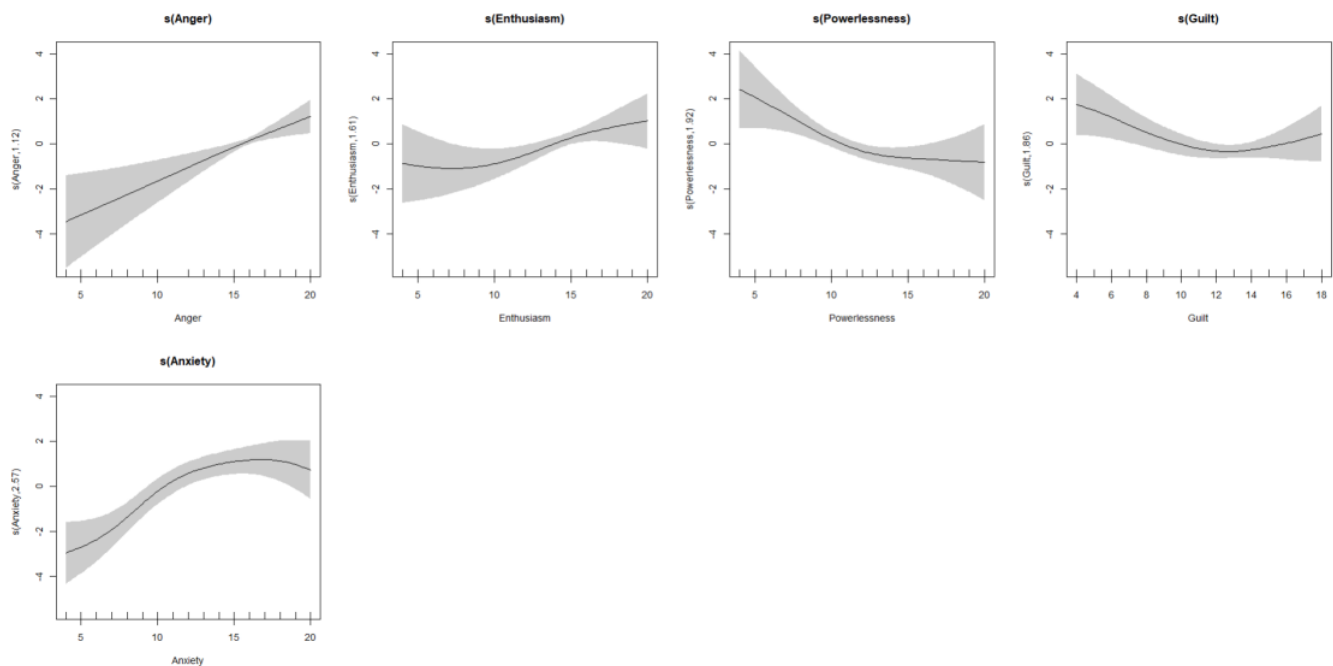


Figure 6. GAM Results about the link between RTC—Action and climate emotions. Notes: The y-axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

Finally, the results pointed out only one linear association between perceived readiness (RTC) and anxiety (Edf = 0.817; $p = 0.01746$; effect range: 1.642; 95% CI: from -0.982 to 2.397) (Table 9 and Figure 7). Conversely, the GAM pointed out significant and non-linear associations between this RTC dimension and anger (Edf = 2.993; $p < 0.001$), contempt (Edf = 1.621; $p = 0.01730$), enthusiasm (Edf = 1.590; $p = 0.00374$), powerlessness (Edf = 1.648; $p = 0.01566$), guilt (Edf = 2.057; $p = 0.00146$), and sorrow (Edf = 2.795; $p = 0.00478$) (Table 9 and Figure 7). Anger seems to be the variable with a higher influence on the effectiveness of the perceived readiness (effect range: 6.943; 95% CI: from -8.309 to 1.711). No significant associations have been found between perceived readiness (RTC) and isolation. The portion of the model variance was 58.8% (adjusted R^2). Finally, the likelihood ratio test pointed out a difference in deviance of 245.05 ($p < 0.001$).

Table 9. Eco-emotions and perceived readiness (RTC) results.

	Edf	Ref.df	T	<i>p</i>	Effect Range	95% CI Lower	95% CI Upper	Adj- R^2 (%)	DE (%)
Anger	2.993	9	3.854	<0.001	6.943	−8.309	1.711	58.8	61
Contempt	1.621	9	0.645	0.01730	1.391	−1.604	1.563		
Enthusiasm	1.590	9	0.886	0.00374	1.802	−2.239	1.241		
Powerlessness	1.648	9	0.676	0.01566	1.590	−2.66	1.633		
Guilt	2.057	9	1.264	0.00146	2.225	−0.754	3.046		
Isolation	0.001	9	0.000	0.39354	0.000	−0.032	0.033		
Anxiety	0.817	9	0.495	0.01746	1.642	−0.982	2.397		
Sorrow	2.795	9	1.195	0.00478	2.522	−2.516	2.009		

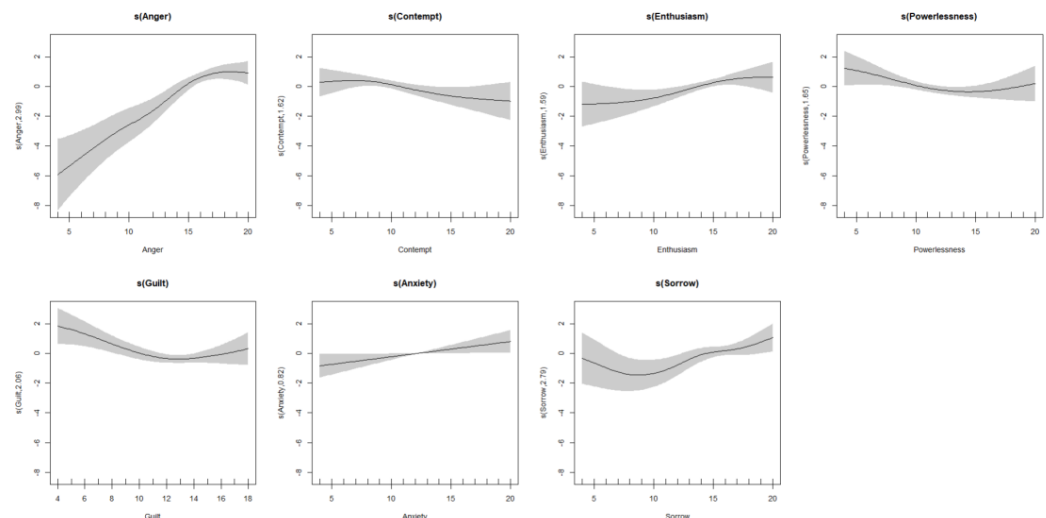


Figure 7. GAM Results about the link between RTC—Perceived readiness and climate emotions. Notes: The y -axis represents the smoothed effect of the emotion on the RTC dimension, where values above or below zero indicate a positive or negative influence, respectively.

4. Discussion

Climate emotions can have a pivotal role in shaping pro-environmental behaviors [26–29]. However, scientific evidence highlights the need to further investigate their relationship [31]. In keeping with this, the present study aimed to explore the potential associations between climate emotions and readiness to change, namely a “*fundamental psychological construct reflecting the propensity for behavioral change*” ([73], p. 4). In particular, Generalized Additive Models were carried out to examine the presence of linear or non-linear associations between the investigated phenomena, taking into account the complexity and non-linearity characteristics of systems.

In general, the results highlighted significant linear and non-linear associations between climate emotions and dimensions of readiness to change.

Notably, the results indicated that climate emotions, especially anger, enthusiasm, and sorrow, are significantly associated with most of the dimensions of readiness to change investigated, regardless of linearity or non-linearity. In particular, both anger and sorrow, in most cases, would appear to be the factors largely able to have a higher influence on the readiness to change dimensions.

In this scenario, anger represents a moral emotion that is potentially associated with frustration over the inability of policymakers or the community to hinder climate change [15,16,18,86,87]. Previous scholars have highlighted that, in the context of the climate crisis, anger can be considered an adaptive and predictive factor of engagement in sustainable behaviors, environmental activism, and pro-climate perceptions [77,86]. Based on this, the results of the present study confirmed the proactive role of anger in readiness to change, potentially including the sustainable framework. On the other hand, sorrow represents feelings of loss and melancholy in the face of the perceived irreparability of the climate crisis [15,16]. Specifically, a study by Marczak and colleagues [16] found positive correlations between sorrow and individual pro-climate behavior, supporting the results that emerged in the present work.

Moreover, contempt refers to feelings of underestimating the climate crisis [15]. In this regard, the results revealed significant associations between contempt and only two RTC dimensions, specifically motivations and perceived readiness. Moreover, the results did not confirm the hypothesized link between contempt and perceived importance. In general, interpreting the findings is quite challenging. Previous scholars have highlighted a

negative association between climate contempt and sustainable factors [15]. These findings seem to suggest that even negative emotions could have a proactive function. In particular, contempt might reflect a sign of critical awareness of the problem. However, it still remains to be explored whether and under what conditions contempt may act as a positive driver of behavior, particularly in the context of sustainability. In keeping with this, future studies are needed to better understand the role of climate contempt in supporting readiness to change.

Furthermore, the results showed significant associations between climate enthusiasm and all the RTC dimensions considered. Specifically, climate enthusiasm may refer to feeling confident in the community to cope with the climate crisis [15]. Based on this, the above links are supported by the results in the literature considering that climate enthusiasm has been observed to be associated with facts such as pro-climate perceptions, perception of climate change, participatory action, self-efficacy of climate action, collective efficacy of climate action, individual pro-environmental behavior, and support for pro-climate policies—dimensions potentially associated with all the readiness to change factors that emerged [15,16,72].

In addition, the results also showed negative associations between climate powerlessness and readiness to change dimensions, including effectiveness of the proposed solution, social support, action, and perceived readiness. Climate powerlessness would represent the perception of personal inability to cope with the climate crisis. Previous studies have highlighted the negative association between this type of emotion and the implementation of pro-environmental behaviors, supporting the results of the present study [15,16,88].

Moreover, associations have been reported between climate guilt and various dimensions of readiness to change, specifically motivation, action, and perceived readiness. As proposed by Marczak and colleagues [15,16], climate guilt refers to feeling guilty about engaging in behaviors that can negatively impact the climate. Interestingly, we observed different directions, both positive and negative, regarding the links between climate guilt and the aforementioned dimensions of readiness to change. While guilt and the perceived importance of the problem are generally associated with a positive trend, the other links have an opposite direction. In line with the study of Marczak et al. [15,16], people who feel guilty would still seem to have a perception of the ongoing climate crisis. However, as emerges from the present work, this emotional process would seem to play a different role in the other dimensions of readiness to change. Therefore, future investigations are needed to better understand the role and implications of climate guilt in terms of behavioral engagement.

Regarding climate isolation, the results of the present study revealed associations with dimensions of readiness to change, including self-efficacy, the effectiveness of the proposed solution, social support, and action. Climate isolation refers to the perception that the community is not sufficiently involved in the climate crisis and consequently feeling alone [15,16]. The emerging associations between isolation and the above dimensions of readiness to change showed a positive trend, regardless of linearity or non-linearity, except for the link with the social support dimension of readiness to change. From our perspective, the results align with previous findings that have observed links between climate isolation and perceptions of climate change [15,16]. On the other hand, previous scholars have also highlighted negative links between isolation and social support as a consequence of experiencing a climate disaster [89], which partially supports the findings of the present study.

Finally, the results showed significant associations between several dimensions of readiness to change and anxiety, reflecting a feeling of helplessness in the face of climate change consequences [15,16]. Notably, links emerged with the perceived importance of

the problem, social support, action, and perceived readiness. The present findings are well supported by existing literature, as the study by Baroni and colleagues [50] pointed out the presence of connections between eco-anxiety and readiness to change factors. Moreover, Hogg and colleagues [7] also found associations between affective eco-anxiety and pro-environmental behaviors, specifically in terms of adopting a low-carbon lifestyle.

In general, the results have highlighted several links between climate emotions and the dimensions of readiness to change. Furthermore, the results highlight significant differences in the explained variance among RTC dimensions. In this regard, the results showed higher values of explained variance for the RTC dimensions: perceived importance of the problem (65.5%), motivation (61.5%), effectiveness of the proposed solution (60.6%), and perceived preparedness (58.8%). Conversely, dimensions such as agency, social support, and self-efficacy are characterized by lower values. In this regard, it is possible that the perceived importance of the problem has the highest explained variance value based on its close link with the perception of risk, which, in turn, appears to be a stressor associated with emotional processes [72,90]. In this regard, for example, it has been observed that climate anxiety is associated with risk perception [50,91,92]. This link could also extend to other eco-emotions based on the traditional theoretical approach regarding the close relationship between emotions and adaptive risk perception [90].

In summary, the above data could explain why the perceived importance of the problem is the dimension characterized by the highest explained variance. Conversely, focusing on the dimension with the lowest explained variance, i.e., self-efficacy (25.2%), despite the existing link between emotions and self-efficacy [93], this could depend on the fact that the analyses of the present study did not take into account cross-gender invariance [93]. Indeed, Gunzenhauser et al. [93] highlighted the potential difference in emotional processes between genders. In line with this, future studies are needed to investigate possible differences in the link between eco-emotions and controlling self-efficacy by gender.

Summing up, the findings above have been interpreted in a general way so far. The following paragraphs will discuss them in light of the presence or absence of linear or non-linear associations.

Climate Emotions and Readiness to Change: Through a Complex Perspective

Emotions are not fixed traits but dynamic and context-dependent psychological phenomena [30,47]. They vary in intensity and expression over time due to the influence of situational, cognitive, and social factors. Because of their changing nature, frameworks that can handle complexity are needed to identify non-linear and multi-dimensional emotional trajectories that deviate from linear assumptions. This layered structure is particularly relevant in RTC where, as in other domains, emotions play a key role in fostering change [23]. However, triggering an emotion is not always enough to spark positive changes. According to the results of this study, some emotions show more convoluted and non-linear patterns. Indeed, excessive activation of these emotions can have inhibitory or counterproductive effects on change processes. Previous research has already shown similar patterns. Therefore, building on previous complex approaches (e.g., [34]), this study goes a step further, employing GAM to investigate linear and non-linear associations between eco-emotions and components of RTC. Thus, an emotion can have a linear or non-linear association, significant or not, depending on the specific domain of change (i.e., perceived importance of the problem, motivation, self-efficacy, effectiveness of the proposed solution, social support, action, and perceived readiness).

Regarding anger, linear associations have been found between this kind of emotion and RTC dimensions in terms of perceived importance of the problem, self-efficacy, and

willingness to act, as also reported in previous studies [77]. The above findings could be because anger can be interpreted as a response to address environmental injustice [86,94]. Based on this, the above relationship may also depend on a strong awareness of the perceived risk due to the climate crisis. Furthermore, as argued by Van Zomeren et al. [95], in this scenario, self-efficacy would seem to play a role in motivating and sustaining anger [86,95]. This assumption could therefore also explain the link that emerged between anger and self-efficacy.

Moreover, to the best of our knowledge, the potential non-linear relationships between climate anger and factors such as the perceived effectiveness of proposed solutions, motivation, and perceived readiness to change found in this study have not yet been explored, even in other related fields. In keeping with this, considering the U-shapes that emerged in the results, it is possible to speculate that certain levels of anger, in terms of arousal, may exacerbate burnout symptoms by contrasting the expression of the RTC dimensions above [96,97].

Moreover, the results pointed out significant and non-linear associations between contempt and motivation and perceived readiness. These results may be due to the intrinsic characteristics of contempt. Specifically, this type of emotion is characterized by the presence of both moral and non-moral facets [98]. In line with this, this duality could explain why non-linear relationships with the aforementioned RTC dimensions emerged. Moreover, the non-linear link between contempt and motivation also aligns with previous research. Indeed, Van Doorn et al. [99] found that consumers with very high levels of environmental concern were more likely to regularly purchase organic products. Conversely, those with low to moderate concern showed little to no behavioral impact. One possible explanation is that people experiencing high levels of climate contempt may be aware of environmental issues, but this awareness can lead to emotional fatigue and contempt rather than an increased readiness to change.

Furthermore, findings showed linear associations between enthusiasm and self-efficacy and social support, while non-linear links with the perceived importance of climate change, motivation, effectiveness of proposed solutions, action, and perceived readiness. Greater enthusiasm, understood as an emotional response that is hopeful and future-oriented, has been linked to the recognition of climate change as an important issue [15], as well as with higher levels of self-efficacy and belief in the effectiveness of potential solutions [16,18,100–102]. However, when it comes to social support, the relationship is not direct: studies suggest that social support does not independently lead to climate action. Instead, hope acts as a mediator, directing the emotional or instrumental support received into action-oriented motivation [101].

Concerning powerlessness, the results pointed out the presence of a linear link between it and the effectiveness of the proposed solution. Conversely, non-linear associations have been found with respect to social support, action, and perceived readiness. In this regard, findings in the literature support both types of findings. Specifically, although it has been observed that helplessness can be a factor capable of promoting engagement in sustainable actions [103,104], it is also true that this specific type of emotion can be associated with feelings of uncertainty regarding the actions to be undertaken as well as a lack of control over the actions themselves [103–107]. Consequently, although further investigation of the emerging findings is needed, the data in the literature support the presence of a complex scenario relating to helplessness in this context.

Moreover, concerning guilt, a linear association was found between it and the perceived importance of the problem, aligning with previous findings where eco-guilt was found to motivate eco-friendly behaviors [108]. The linear association between eco-guilt and motivation has also been found. In particular, Moore and Yang [109] found that

eco-guilt was significantly associated with the pro-environment intention. Similarly, Rees et al. [110] showed that being exposed to environmental damage done by humans predicted the intention to act in a sustainable way (e.g., sign a pro-environment petition). However, guilt has also been reported to have a non-linear relationship with action, and perceived readiness has been largely consistent with this multi-faceted relationship in various contexts, suggesting a threshold at which eco-guilt and shame can transition from promoting positive change to engendering backlash behaviors [111].

Moreover, regarding climate isolation, a linear link was found between it and social support with a negative trend. On the other hand, non-linear associations have been observed between isolation and self-efficacy and effectiveness of the proposed solution. Concerning the link between isolation and social support, the result is corroborated by literature findings considering that a person can feel isolated if not supported by his community in the context of pro-environmental behavior engagement [76,112]. However, previous scholars have also observed a close link between climate isolation and climate actions [16]. In keeping with this, it is possible to speculate that the counterbalance between feeling isolated and being engaged in sustainable behaviors results in non-linear associations with some of the investigated RTC dimensions. However, future studies should explore this further.

Furthermore, linear associations between anxiety and both the perceived importance and perceived readiness emerged. These results have already been documented [15,50,113]. By giving an example, previous research with children and young people found a linear association between anxiety and the perceived effectiveness of governmental responses, where higher anxiety correlated with perceptions of inadequate action [114].

In contrast, the relationship between climate anxiety and social support appears to be non-linear. This aligns with previous literature suggesting a complex dynamic between the two variables. Social support has been shown to play a mediating role between eco-anxiety and pro-environmental behavior. For example, eco-anxiety can predict increased seeking of social support, which in turn predicts greater engagement in pro-environmental actions. However, social support does not appear to moderate the relationship: receiving more support does not necessarily reduce eco-anxiety, indicating a non-linear pattern [115]. Furthermore, findings on the direction of this relationship are inconsistent: while some studies have reported a positive association between social support and climate anxiety [115], others have found a small negative relationship [90], reinforcing the notion of a complex interaction. Non-linear associations have also been observed between climate-related actions and perceived readiness to change. For instance, Coates et al. [116] identified a curvilinear relationship (i.e., inverted U-shaped) between climate anxiety and pro-environmental behavior: people with either very low or very high levels of anxiety were less likely to take action compared to those with moderate anxiety levels. A similar pattern was reported by Maduneme [117], who found a significant non-linear association between anxiety and intentions to engage in environmentally friendly behavior.

Moreover, as shown in other studies [118,119], a consistent relationship between climate anxiety and pro-environmental choices was not always found. This underscores the complex interplay of emotions involved in responses to climate change by also partially supporting the results of the present study concerning the presence of non-linear links between anxiety and both RTC dimensions in terms of action and effectiveness of the proposed solution.

Finally, research has shown a linear association between eco-sorrow and self-efficacy, effectiveness of the proposed solution, and social support. On the other hand, non-linear links have been observed between this kind of eco-emotion and perceived importance of the problem, motivation, and perceived readiness. In this scenario, several studies sug-

gested that the connection between climate-related sorrow and pro-environmental behavior may follow a non-linear pattern. For instance, higher levels of grief may initially hinder immediate action but may encourage more sustainable behaviors in the long term [120]. Similarly, Latkin et al. [121] found a curvilinear relationship between depressive symptoms and engagement in climate action: people with moderate symptoms were more likely to take action, whereas those with very high symptoms were less engaged. Ballew et al. [81] also reported a non-linear, L-shaped effect of climate distress on collective action, in which moderate levels of distress were associated with greater participation, but extreme distress beyond a certain threshold reduced involvement.

Additionally, climate sorrow has not been consistently linked to clear behavioral outcomes [122]. This inconsistency points to the likelihood of a non-linear relationship that requires further investigation to fully capture the complex dynamics between eco-sorrow and readiness to change, as also evidenced by the findings presented in this paper.

5. Implications of the Study

The inconsistent findings observed in previous studies may be explained by the complex interplay of emotional factors involved in environmental engagement. This emphasizes the variety of emotional motivations behind environmental involvement and indicates that these may not always act consistently. Instead, the direction and magnitude of their impact may depend on the intensity of the emotion and the psychological processes at play. This understanding suggests that traditional models may be insufficient for capturing the intricacies of these relationships. To address this limitation, future research, policymaking, and intervention designs should consider employing models that accommodate such findings.

The integration of emotional components into environmental campaigns appears to be particularly promising. Climate communication strategies could be significantly bolstered by recognizing how emotions interact with the various dimensions of RTC differently. A comprehensive paradigm that covers these emotional dynamics could enhance the effectiveness of climate-related messaging and interventions. For instance, participatory models for decision-making process could allow individuals to express not only their opinions but also their emotional responses to climate risks and their readiness to change.

One practical example is the use of deliberative mini-publics (e.g., [123]), which facilitate discussions on complex issues, such as the climate crisis, through a participatory approach. By expressing and reflecting on emotions at the individual, societal, and cultural levels, participants can raise awareness of their emotional experiences, understand their significance for both climate action and community engagement, and consciously move toward transformative change.

Building on these participatory experiences, communication campaigns could develop content grounded in emotional storytelling and narrative approaches. Leveraging emotions and people's experiences, rather than solely information and scientific facts about climate change, such content can collectively strengthen emotional engagement and the dimensions of readiness to change, fostering awareness and encouraging sustainable behaviors. Indeed, previous research has shown that storytelling can effectively influence sustainable behavior change in other contexts (e.g., [124]), and that audience authenticity [125] and emotional appeal can play a pivotal role (e.g., [126]).

Furthermore, emotionally sensitive and tailored interventions aimed at promoting sustainability may be particularly effective. Since different dimensions of RTC are associated with distinct eco-emotions, identifying emotional predispositions can offer targeted motivational support.

For example, in educational institutions, tailored initiatives could take the form of practical workshops and forums that raise awareness and support the co-creation of strategies for pro-environmental behavior, starting from students' and educators' own emotional experiences. This approach aligns with recent pedagogical perspectives that emphasize the importance of educators and learners drawing on collective action and emotions to promote sustainable practices [127]. Moreover, guided decision-making scenarios that integrate emotional reflection could help participants recognize the influence of emotions on real-life choices while also encouraging the open sharing of eco-emotions within the community. Finally, small-scale projects developed through collaboration between universities and local communities should be encouraged, using collective emotional insights as a basis for designing and implementing tangible sustainability actions.

In addition, since a variety of digital technologies are used to encourage sustainability [128], future applications could incorporate emotional assessment and responsive strategies to help boost readiness to change, such as apps that adapt content and messaging based on users' real-time emotional input.

Finally, from our point of view, considering the effects of eco-emotions on the readiness to change dimensions, the development of future environmental policies should consider and leverage climate emotions, in particular anger, enthusiasm, and sorrow, in order to promote and favor risk perception, motivation, self-efficacy, the perception of the effectiveness of the proposed solution, social support, action, and perceived readiness that are in turn able to support a greater engagement in sustainable and pro-environmental behaviors [72].

6. Strengths and Limitations

The present research has some limitations. Primarily, it is not possible to detect any potential cause-effect relationships between the investigated variables due to the use of a cross-sectional design. Moreover, despite the collection of anonymous data [129], the use of self-report measures may have induced social desirability bias or been influenced by reduced self-awareness and introspection abilities. The snowball sampling method may have also introduced selection bias, which could limit the generalizability of the findings. Similarly, the generalizability of the results may be limited, as the study did not analyze the influence of cultural factors, which are known to influence norms on sustainability [130] and pro-environmental behaviors [131]. Furthermore, from a demographic perspective, another aspect that highlights the lack of generalizability depends on the inclusion of 14-year-olds in the sample. In particular, factors such as the maturity of cognitive and emotional processing can strictly depend on age and therefore be different among individuals at different stages of their development [132,133]. On the other hand, the present study has valuable strengths. In fact, despite the need to interpret the results with caution and to take into consideration the putative presence of multicollinearity between factors, the use of GAMs supported the investigation of non-linear associations between the observed factors, overcoming a reductionistic perspective. In keeping with this, the results add new valuable findings to the literature concerning the field of eco-emotions by representing a solid groundwork for the development of further studies.

7. Conclusions

In conclusion, the results of the present study highlighted and supported the presence of both linear and non-linear relationships between several different kinds of eco-emotions and the dimensions of the Readiness to Change construct. Notably, by taking into consideration the limits of the present study (e.g., the impossibility to infer causality), the application of GAMs to analyze eco-emotions and RTC dimensions provides a more sophisticated understanding of the emotional underpinnings of environmental behavior. In particular,

the results of this study pointed out the importance and effects of eco-emotions on attitudes and behavior, representing a potential groundwork for the establishment of both effective intervention programs and policies related to climate change and sustainability. In detail, the findings advocate for the development of complex, emotionally attuned strategies in research, policy, and intervention design to effectively address the multifaceted nature of human engagement with environmental issues.

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