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Narrative Review

Ecological Grief, Eco-Anxiety and Climate Change; Development and Validation of the Solastalgia Scale

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Conflict of Interest: None.

Batool A., et al. (2024). 4(2): DOI: https://doi.org/10.61919/jhrr.v4i2.1067

ABSTRACT

Background: As environmental changes accelerate, psychological impacts such as ecological grief and eco-anxiety become more pronounced. This study focuses on the validation and enhancement of the Solastalgia Scale, originally a unidimensional measure, to assess these complex psychological responses more effectively.

Objective: To expand and validate the Solastalgia Scale into a three-dimensional tool encompassing ecological grief, environmental identity, and eco-anxiety, addressing gaps in current research methodologies.

Methods: Our methodology involved two main phases: exploratory and confirmatory factor analysis. Initially, exploratory factor analysis was conducted on a purposive sample of 317 participants from Punjab (125 men, 192 women), using Principal Component Analysis, scree plots, and eigenvalues to extract 13 items across three factors. This was followed by confirmatory factor analysis on a new sample of 319 participants (141 men, 178 women) to validate the scale's three-dimensional structure and ascertain model fit indices.

Results: The exploratory factor analysis identified three distinct factors, resulting in a 13-item scale. Confirmatory factor analysis confirmed the three-dimensional structure with excellent fit indices (CFI = 0.95, TLI = 0.93, RMSEA = 0.05, SRMR = 0.04). This multi-dimensional approach contrasts with previous research that employed a single-dimensional focus.

Conclusion: The revised Solastalgia Scale is a robust tool for assessing the psychological impact of environmental change across multiple dimensions. This scale is instrumental for researchers and practitioners in understanding and mitigating the psychological effects of ecological grief, enhancing resilience and well-being in the face of environmental disruptions.

Keywords: Ecological grief, Eco-anxiety, Environmental changes, Environmental identity, Solastalgia.

INTRODUCTION

Solastalgia is a concept that refers to a disruptive psychological response as a result of environmental changes and degradation(1). The ecological grief and loss associated with solastlagia which is caused by climate change, degradation and environmental change (2). These two constructs are framed interconnected on the basis of theoretical grounds and literature. Solastalgia is also rooted in the Freudian tradition of grief and mourning (3).

Distress such as lack of identity and attachment to home environment, and lack of comfort were the consequences of negative changes in environmental circumstances that made people detached from their familiar surroundings (4, 5). Solastalgia is composed of the Latin concept the solace which means the consolation and comfort generated by home environment and the Greek word algia which means pain. A deep nostalgic feeling suffered by people who reside in their homes, communities and territories that became degraded with the passage of time. The definition of solastalgia consisted of two dimensions. The first was distress caused by the degradation and the second was desolate due to degradation of the home environment of people (6-8).

So, solastalgia is a feeling of distress caused by environmental changes in familiar places and it has a greater impact on the psychological health of people who live in those familiar places. The people who are psychologically attached to their places they inhabit consider their geographical places valuable. When those places degrade with the negative changes in environment, it causes distress among the people. Moreover, degradation resulting in loss of ecosystems, landscapes and species cause ecological pain related to the concept of eco-anxiety which is developed by living in an uncertain and changing environment (9).

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The implications of the concept of solastalgia and its potential utility for foreseeing the psychological consequences and impacts of environmental drift were explored by researchers (6). After disaster occurrences, people presented spatial patterns in those places where they have greater exposure to environmental degradation and change. In this context, the concept of solastalgia is considered as psychopathologies like PTSD (10).

The residents of rural areas experienced solastalgia and environmental grief induced by forcibly displacement due to a strong sense of environmental identity, deep emotional connection to geographical location. Moreover, the study revealed potential strategies to eradicate the repercussions of displacement on mental health and reinforced social harmony and cohesion (11).

Solastalgia was first measured by Higginbotham et al. who studied the effect of mining activities on the population of Australia. He obtained single dimensions using principal component analysis (5). Furthermore, the construct validity of solastalgia was evaluated on the population exposed to an eruption of the volcano (8). Three dimensions of solastalgia were extracted whereas two were theoretically defined such as solace and melancholy but its implications were not recommended because the findings have fewer dimensions that are not based upon the robust method. Moreover, the third dimension called as lack of control consisted of only one item which didn't define a strong dimension which showed a two dimensional construct of solastalgia (12-14).

Environmental Distress Scale was used on participants who were experiencing forest fires in the USA; the findings of principal component analysis (PCA) concluded that solastalgia had only one dimension (15). Solastalgia was demonstrated as a one-dimensional construct in two studies. The solastalgia scale was used on people who were exposed to loss of beach territory as a result of coastal erosion in the first study but robust exploratory factor analysis was not used in that study (16, 17).

Two scales of solastalgia, consisting of eight and thirteen items, were used on a population who was continuously exposed to construction of reservoirs in order to generate electricity. The results of PCA affirmed that solastalgia was a one dimensional scale (18). A seven item solastalgia scale on a population affected by climate change was developed by applying exploratory factor analysis and confirmatory analysis. The findings showed excellent model fit and were associated with other psychological problems such as PTSD, anxiety, and depression (19).

In another study, researchers developed and subsequently validated a Scale of Solastalgia (SOS) by administering it to 223 residents in the municipalities. Concurrently, participants underwent assessment using the Short Post-traumatic Stress Disorder Rating Interview. The study explored two dimensions of solastalgia by using rigorous validation techniques such as Parallel Factor Analysis and Omeg. Both dimensions demonstrated significant correlations with the SPRINT-E scale ($r = 0.150$, $p < 0.01$ and $r = 0.359$, $p < 0.01$, respectively) and showed 58% sensitivity and 67% specificity in detecting cases of post-traumatic stress disorder (PTSD) (10).

Building on the strengths of previous research and addressing its limitations, there is a clear rationale for developing a three-dimensional solastalgia scale. By incorporating dimensions such as solace, melancholy, lack of control, and potentially others identified in the literature, a three-dimensional scale can provide a more comprehensive assessment of solastalgia and its impact on individuals and communities facing environmental distress. A three-dimensional solastalgia scale, developed using rigorous validation techniques and tested across diverse populations and contexts, has the potential to enhance the validity and utility of solastalgia measurement. Such a scale could provide researchers, policymakers, and practitioners with a valuable tool for assessing the complex interplay between environmental changes and human well-being and informing interventions to mitigate the adverse effects of solastalgia.

METHOD

The current study consisted of three consecutive studies. The first study was pertinent to the development of new Solastalgia Scale. The second study used factorial analysis which was based upon robust exploratory and confirmatory factor analysis. Whereas, the third study affirmed the empirical evidence of the content and construct validities.

Study 01: Development of Solastalgia Scale

Solastalgia Scale development consisted of three distinct phases. The Phase 01 consisted of generation of item pool and focused group discussions based on robust literature review and theoretical framework followed by the second phase in which experts' opinions were taken in order to refine and finalize items. Third phase underwent exploratory factor analysis.

Phase 1: Item Pool Generation of Solastalgia Scale

Item pool for the Solastlagia Scale was generated by reviewing a vast literature and focused group discussions. The literature review and theoretical framework revealed different themes of solastalgia such as environmental grief, environmental identity and eco anxiety. So, these themes were included in the new Solastalgia Scale.

Focused Group Discussions

Three focused group discussions (FGDs) were conducted for generation of item pool. Each focus group contained 5 to 8 participants. The members of the focused group were highly qualified and had scale development expertise. The members were given incentives

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and a comfortable environment for the discussion. The open-ended questions were asked. The focused group discussions paved the way for better insight of the construct.

The first focus group consisted of experts in the field of environmental psychology, psychometrics and psychotherapy. The five experts who were teachers were taken from the Department of Applied Psychology, Bahauddin Zakarya university, Multan. The further three experts were the clinical psychologists taken from DHQ Layyah, Punjab Pakistan. All the experts had expertise in psychometrics, validation, assessment and diagnosis, and were involved in research.

The second focused group discussions were the five participants taken via purposive sampling. The answers to the asked focused group discussion questions revealed the feelings ecological grief, mood swings, psychological distress, environmental identity crisis and eco anxiety among participants. 58 items were generated by pursuing focused group discussions.

In order to finalize the appropriateness of items, relevancy and response type in the line of major themes from the premier two focused group discussions the third focused group discussions was held. Two experts were PhD scholars (Applied Psychology) taken from the University of Punjab, Lahore and three experts were lecturers in the field of psychology taken from different government colleges of Dera Ghazi Khan division. The experts finalized 48 items by removing 20 items due to ambiguous statements and repetitions of the same domain.

Phase 2: Experts' Opinion

Seven experts were recruited for expert opinion for the scale development. All judges were competent and had experience in the field of instrument construction. In the light of experts' opinion, overlapping and unnecessary items were eliminated. Two judges were male professional psychologists. Another three female judges were from the Department of Applied Psychology, Bahauddin Zakarya University, Multan. The two experts were participants who have been experiencing solastalgia symptoms for one year. Their opinion was helpful for calculating CVI, S-CVI and Kappa for validity. Out of 48 items, only one item was in poor rating with value lower than 0.4 according to Kappa calculations and it was removed from the item pool. The remaining items were selected for data collection. Moreover, the judges suggested a 5-point Likert scale format of frequency for the Solastalgia Scale.

Phase 03

Exploratory Factor Analysis

Sample

The data were collected from 317 participants including men (n=125), women (n=192) using purposive sampling. The demographic information included age, gender, profession, geographical region, marital status, years of living in the area, education, and home ownership. The age range was from 18 years to 70 years. The data were collected across Southern Punjab.

Measures

A 47-item questionnaire of Solastalgia was constructed through Google Form. The scale adopted 5-point Likert scale consisted of 5=always, 4=often, 3= sometimes, 2=rarely, and 1= never. The data were collected through web-based surveys from participants across Pakistan. The scale didn't have negative scoring. The greater score on the Solastalgia scale depicted a higher level of solastalgia and the low score showed a lower level of solastalgia among participants.

Ethical Consideration

Informed consent was assured before collecting data from participants. They were assured of confidentiality and the right to privacy. The right to withdrawal from study was affirmed. The researcher refrained from any partiality and biases due to culture, ethnicity and age. The participants were informed about the objectives and practical implications of the study.

RESULTS

Exploratory Factor Analysis was performed with Principal Component Analysis and Varimax rotation by setting the value of communalities 0.5. Bartlette's test of Sphericity was used to check correlation matrices that showed significant correlation among its factors, N=317, 1330.773, p=.000 <.01. Whereas KMO analysis was applied for sample adequacy and the results found .889 which proved excellent sample adequacy (Kaisar, 1974). Figure 01 showed scree plot with Eigen values greater than .01 extracting three factors for solastalgia scale (Kim & Mueller, 1978).

Moreover, variance obtained from the factor analysis extracted three factors for the scale which accounted for 57.22 % of variation in the data. The EFA component rotation results showed that only 13 items remained based on loadings greater than ≥ .50 and all other items were removed due to poor loading. It extracted three factors of the Solastalgia scale including ecological grief, environmental identity, and eco-anxiety.

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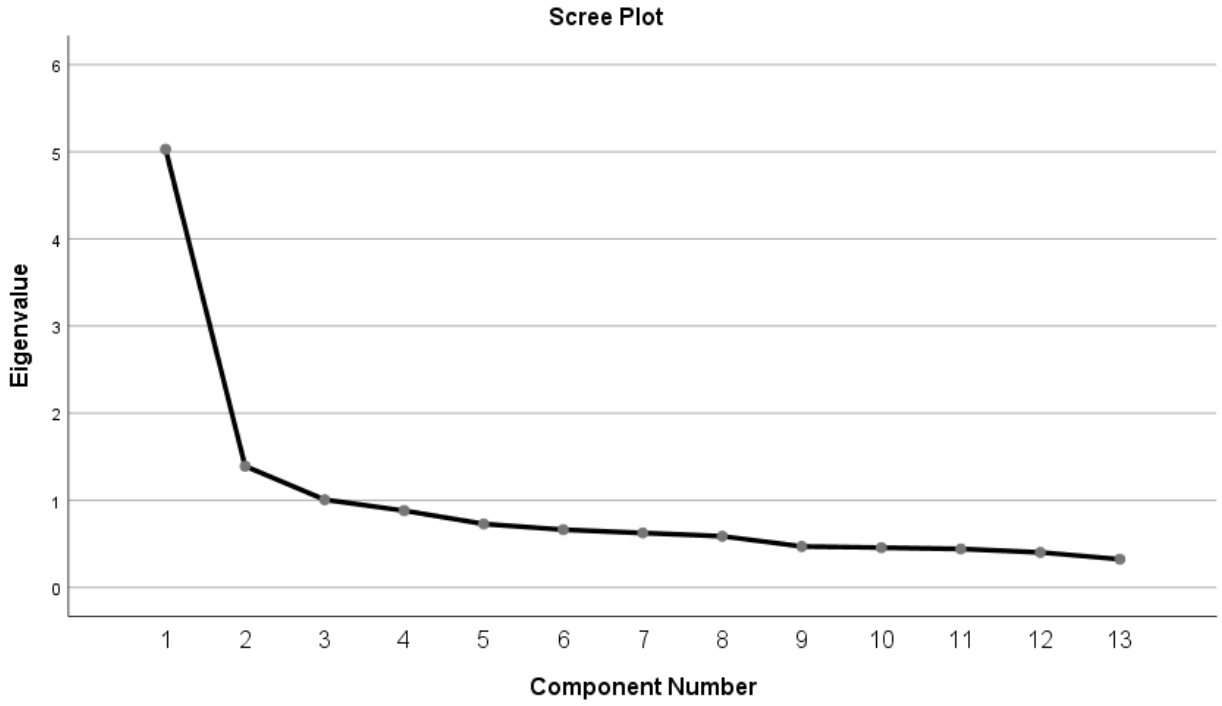

Figure 1 Scree plot with Eigenvalues

Table 1: Rotated Factor Matrix

Items	Factors		
Ecological Grief	1	2	3
My emotional wellbeing is connected to nature in my region.	.672		
I experience mood swings due to extreme weather events in my region	.692		
I feel sad that nature has lost its healing power due to climate change.	.713		
I feel environmental grief when I suspect climate change will threaten my survival in the future.	.556		
Environmental Identity			
I feel pleasant to spend time in natural landscapes.		.796	
I think nature is not separate from me.		.757	
I identify with my local environment.		.595	
Eco Anxiety			
I feel helpless when I can't control climate change.			.764
I feel powerless when I cannot prevent environmental loss in my region.			.726
I always worried about long term threats of environmental shifts in my region.			.581
I used to feel nostalgic about losing healthy things such as fresh air, clean water, clear weather and greenery in my region.			.677
It distresses me to see the effects of climate change (for example, fires, droughts on the place I live.			.667
I feel heavy rains, floods, droughts and earthquakes in my region create death anxiety in me			.734

Study 02

Confirmatory Factor Analysis

EFA explored model fit and dimensional structure of the Solastalgia scale in study 01. The approved findings of EFA paved the way towards confirmatory factor analysis. So, AMOS 26.0 version was used to affirm the dimensional model of Solastalgia scale and model fit indices.

Batool A., et al. (2024). 4(2): DOI: https://doi.org/10.61919/jhrr.v4i2.1067

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Sample

An independent sample of participants (N = 319), recruiting women (n = 178) and men (n = 141) was purposively selected across Punjab. The age range was from 18 to 65 years (M = 34.5, SD = 19.2). Moreover, education, career, residency, homeownership, area, marital status, homeownership and years of living in the area were demographic variables for the Solastalgia scale.

Measures

A 13-item solastalgia scale on the 5-point Likert Scale (1 = never to 5 = always) was used to assemble data from the participants. No reverse coding was added in the scale. Maximum scores on the scale demonstrated higher levels of solastalgia in participants and minimum scores resulted in lower levels of solastalgia in participants.

Procedure

The study engaged participants across various settings, including rural and urban residences, educational institutions, and housing colonies, reflecting the diverse demographics of the sample. Upon introduction to the study's objectives, participants were duly briefed, and their informed consent was obtained, assuring them of the confidentiality and exclusive research purpose of the information collected. Subsequently, a questionnaire was administered to a cohort of 319 individuals, with an emphasis on sincerity and accuracy in responses. While a majority promptly completed and returned the questionnaire, some participants required additional time. Gratitude was expressed towards participants for their invaluable cooperation.

To mitigate potential data loss, incompleteness, or erratic responses, a deliberate decision was made to maintain a smaller sample size. Remarkably, participants demonstrated remarkable enthusiasm and cooperation, with 319 out of 367 questionnaires being returned, meeting the criteria for inclusion in the study. Following meticulous scrutiny to ensure the adequacy of assumptions such as sample size, normal distribution, outlier identification, correlation matrix, and commonalities, confirmatory factor analysis was conducted.

The table no. 2 which showed confirmatory factor analysis of the Solastalgia scale revealed a strong fit between the data and the proposed measurement model, supported by various indices of model fit (χ^2 (62) = 129.464, p = .00; CFI = .96; RMSEA = .05; pclose = .15).

Table 2: Initial Model Fit Indices of Confirmatory Factor Analysis Solastalgia Scale (N=319)

Model	X2	Df	X2/df	SRMR	CFI	PCLOSE	RMSEA
Initial model fit indices	129.46	62.00	2.088	0.047	0.963	0.15	0.058

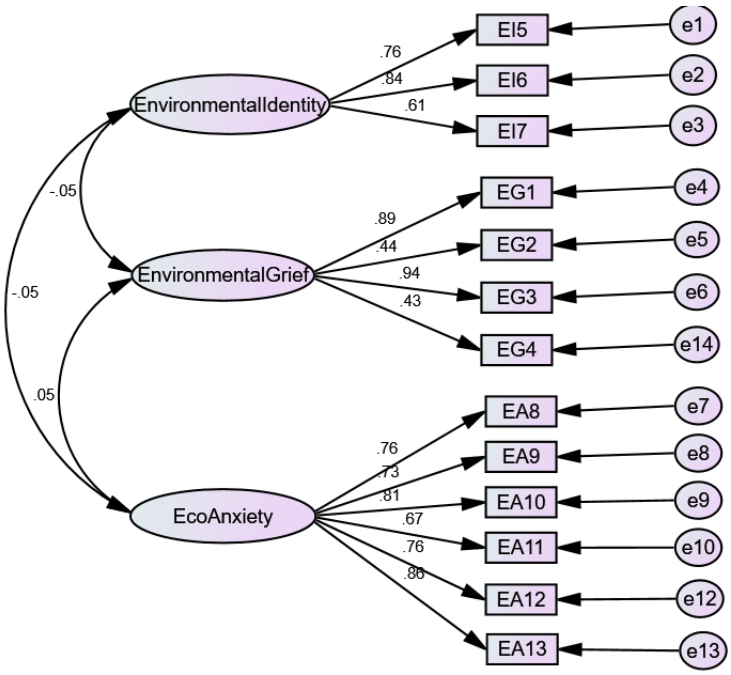

Figure 2 Measurement Model of Solastalgia Scale

Figure 02 depicted that the factor loadings expanded from .43 to .94 extracting three factors consisting of 13-items affirmed excellent model fit indices to the data. The validity and reliability analysis provided compelling evidence supporting the construct validity, as all 13 items exhibited notably strong loadings on the underlying latent factor of Solastalgia scale. Internal consistency of the Solastalgia scale was measured through Cronbach's alpha which was found .91 depicting robust internal consistency of Solastalgia scale.

Moreover, descriptive statistics of Solastalgia scale showed that the data were normally distributed on the basis of mean score, standard deviation, range, variance and skewness (N=319, M= 35.9, SD= 7.68, Var.= 59.03, SK=.25, R= 14-59). The findings justified the utilization of Solastalgia scale for further analysis.

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Table 3: Reliability and Validity Metrics for Psychological Constructs

Items	Ω	CR	AVE	MSV	Λ
Ecological grief	0.90	0.78	0.527	0.003	
EG1					0.67
EG2					0.69
EG3					0.71
EG4					0.56
Environmental Identity	0.88	0.79	0.553	0.003	
EI1					0.79
EI2					0.75
EI3					0.59
Eco-Anxiety	0.89	0.89	0.599	0.003	
EcoA1					0.76
EcoA2					0.72
EcoA3					0.58
EcoA4					0.56
EcoA5					0.68
EcoA6					0.67

Note. Λ(lambda) = standardized factor loading ≥ .50, ω= Macdonald reliability, CR=composite reliability, MSV= maximum shared variance, AVE = average variance extracted

Table no. 3 showed psychometric properties of the scale. Psychometric properties of the Solastalgia scale were measured by Confirmatory Factor Analysis. All calculated alpha coefficients, estimates, Average Variance Extracted (AVE), and Composite Reliability (CR) values surpassed the established thresholds of .70, .50, and .70, respectively, as indicated by previous studies (20, 21). Convergent validity was assessed by considering the loadings of scale items on their respective constructs. Additionally, discriminant validity was rigorously evaluated using the Fornell and Larcker criteria (1981), providing further compelling evidence. Estimates surpassed the established threshold values, and the Mean Shared Variance (MSV) remained below .50, in accordance with guidelines provided by (20, 21). The McDonald's reliability coefficient exhibited a commendable range of .79 to .90, affirming the scale's internal consistency across different dimensions.

DISCUSSION

The Solastalgia scale was purposefully validated in this study for measuring solastalgia, aligns with Albrecht's initial concept. By pursuing the gaps in literature, the current study was intended to develop new dimensions of Solastalgia scale. Item pool was generated with identified themes with the help of focused group discussions and expert opinion. 48 items were selected for data collection. The data were collected from the participants in two phases. A sample of 317 participants were recruited purposefully for data collection for EFA, whereas; the data were collected for participants (N=319) to apply for CFA. Exploratory factor analysis was used to examine factorial structure of the scale. Confirmatory factor analysis was used to confirm the existing dimensional structure with three dimensions and provided empirical evidence for construct validity of the Solastalgia scale. Adhering to Hu and Bentler's (1999) recommendations and your preference, the confirmatory factor analysis of the Solastalgia scale exhibited a robust fit between the data and the proposed measurement model.

Therefore, the three-dimensional Solastalgia scale with ecological grief, environmental identity, and eco-anxiety were developed. This study was a new addition to the previous studies which were based on development of the solastalgia scale with single dimensions (15-17). The findings were contrary to previous studies on Solastalgia scale development except one study that had included three dimensions: solace, melancholy and loss of control, although the latter was represented by just one item, which may not adequately define a dimension (8). The Solastalgia scale measured ecological grief, eco-anxiety, and sense of powerlessness and helplessness experienced in a changing environment as aligned with the concept of desolation proposed by Abrecht (2006) in his theory. Moreover, these dimensions were suggested by a study that future research could improve the SOS scale with two dimensions by explicitly linking items in the "algia" dimension to changes in the person's environment, enhancing respondents' understanding (10). The loss of control and powerlessness were a part of eco-anxiety as it should be the part of melancholy dimension in a previous study (7). In solastalgia theory, ecological grief refers to the emotional distress and sorrow experienced by individuals due to the degradation or destruction of their natural environment. The solastalgia was directly comorbid with

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environmental grief called ecological pain leading to emotional distress and eco-anxiety caused by unprecedented changes in the environment (9). In the degraded environmental settings, individuals often experienced ecological grief including distress, fear, isolation, nostalgia, uncertainty, and broader mental health challenges (22, 23).

CONCLUSION

In conclusion, this study aimed to validate and expand the Solastalgia scale, aligning with Albrecht's initial concept while addressing gaps in literature. Through rigorous methodological procedures including exploratory and confirmatory factor analyses, a three-dimensional Solastalgia scale was developed, encompassing ecological grief, environmental identity, and eco-anxiety. These dimensions capture the emotional responses individuals experience amidst environmental change, shedding light on the complex interplay between human well-being and the environment. Contrary to previous studies, which often focused on single-dimensional scales, this research offers a more comprehensive understanding of solastalgia, acknowledging its multifaceted nature. By incorporating dimensions such as ecological grief and eco-anxiety, the scale provides a nuanced assessment of individuals' experiences within changing environments. Moreover, the findings highlighted the importance of considering the psychological impacts of environmental change, particularly in degraded settings where individuals may experience heightened distress and emotional challenges. The Solastalgia scale offered a valuable tool for researchers and practitioners alike to assess and address the psychological consequences of environmental degradation, ultimately contributing to efforts aimed at promoting resilience and well-being in the face of environmental change.

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