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ORIGINAL STUDY

The Development and Psychometric Properties of Climate Change Awareness Scale Among Higher Education Students

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ABSTRACT

Higher education has a pragmatic and educational approach to mitigating climate change and solving environmental challenges by enhancing awareness. Therefore, the study aims to develop a scale in a survey model to measure higher education students' awareness of climate change. The study group comprises higher education students enrolled at Public Universities in Ankara during the 2023–2024 academic year. For data analysis, exploratory factor analysis, confirmatory factor analysis, convergent and divergent (discriminant) validity, item analysis, and reliability analysis were employed. The scale was rigorously validated through exploratory factor analysis, confirmatory factor analysis, and other measures. As a result of the exploratory factor analysis, a scale comprising 22 items and three dimensions was developed. The dimensions of the scale are as follows: Awareness of Causes, Awareness of Consequences, and Awareness of Solutions. Confirmatory factor analysis validated the scale's factor structure with three dimensions and 22 items. It was also determined that the scale met the convergent and divergent (discriminant) validity conditions, and all items were found to be distinctive. The scale's reliability was calculated using Cronbach's Alpha, McDonald's Omega, and Composite Reliability (CR) coefficients, and all reliability coefficients were adequate. Therefore, the study concluded that the climate change awareness scale is a psychometrically valid and reliable measurement tool.

Keywords: Climate, Climate change, Global warming, Higher education students, Scale development

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Introduction

Climate change, an urgent crisis that impacts all living things and ecosystems on a global scale, demands immediate action. The urgency of this crisis cannot be overstated. To contribute to the solution, individuals must urgently develop awareness about the issue (Ambusaidi *et al.*, 2012; Bai *et al.*, 2018; McKibbin & Wilcoxen, 2002). While basic information may suffice to understand the problem's existence, a deeper awareness is crucial. This profound understanding can start with grasping the causes of climate change, its processes, and the triggers of this issue.

Another vital aspect of climate change awareness is understanding the consequences of the process. Results such as increasing temperatures, extreme weather events, sea level rise, and biodiversity loss underscore the seriousness of the problem. The jeopardy of human health and food security, especially the disproportionately negative impact on vulnerable communities, deepens the problem (IPCC, 2022). However, individuals who develop awareness about these results can perceive that climate change does not only harm the environment but also has devastating effects on areas such as the economy, society, and health. This realization is a call to action. Finally, to develop practical solutions for combating climate change, the level of awareness must be raised to the highest level (Ministry of Environment Urbanisation and Climate Change, 2012). At this point, individuals are expected to understand the problems, take responsibility, and offer applicable solutions. This situation emphasizes the critical role of climate change education, which is necessary for the development of informed citizens who can actively participate in addressing environmental challenges (Açıkalın *et al.*, 2024; Ead, 2014).

Theoretical framework

Increasing awareness of individual climate change is a complex task, requiring a multidisciplinary and multidimensional approach (Cipriani *et al.*, 2024). The overall literature on climate change awareness mainly focuses on the relationship between behavioral change and awareness (Halady & Rao, 2010; Jürkenbeck *et al.*, 2021; Ricart *et al.*, 2023; Venghaus *et al.*, 2022). Also, some studies showed that a remarkable gap and variation portray individuals' awareness and knowledge about climate change (Kollmuss & Agyeman, 2002). The results demonstrated that social variables indicate climate change mitigation and vulnerability. Furthermore, educational initiatives should emphasize scientific results to improve public communication about climate change (Ruddell *et al.*, 2012). Some studies strongly suggested that raising climate change awareness through campaigns, K-12 education, or training produces better results in the long term to mitigate climate change (Alvi *et al.*, 2020; Thaller *et al.*, 2020). According to the Project on Climate Change, less than 20 percent of older people and more than 30 percent % of young generations cannot say whether global warming is happening (Leiserowitz *et al.*, 2012). Hence, the young generations are regarded as a focus group for awareness of climate change.

On the contrary, although scaling for level of awareness is the key to develop further and detailed education and training program, there is limited literature for developing scale. Especially, current works aim to measure awareness of specific groups of high school or sectoral individuals (Di Giusto *et al.*, 2018; Gönen *et al.*, 2022).

Existing literature on scales has typically been applied in various cultural contexts and educational levels. These scales primarily focus on assessing the awareness of the causes and consequences of climate change. In other words, the scale items were designed to gauge participants' knowledge regarding the causes and effects rather than potential

solutions. The literature reveals a gap in climate change awareness, indicating that developing a scale that includes solutions would be beneficial in addressing this gap. Additionally, future projects could be initiated to measure levels of awareness regarding climate change solutions for national and educational purposes.

In this context, the article presents a scale development study to address this gap with the purpose of this study is to assess higher education students' awareness levels by addressing climate change in three dimensions: causes, consequences, and solutions. The scale aims to provide clues to increase the effectiveness of education programs by evaluating how much knowledge and awareness individuals have in these three dimensions.

Materials and method

This scale development study utilizes a survey model to measure higher education students' awareness of climate change. The survey model is a research design that describes the current situation as it is, without any intervention, to reach a judgment (Erçetin & Açıkalın, 2020; Fraenkel *et al.*, 2008). The survey model in this study is chosen to develop a valid and reliable measurement tool to assess higher education students' awareness of climate change.

Data collections

The ethics committee approved the study (AHBV—2022/352). After ethical approval, data for two study groups were collected from November 17th, 2023, to January 17th, 2024. The research was conducted with two study groups. In addition, all the rules specified within the scope of the "Directive on Scientific Research and Publication Ethics of Higher Education Institutions" were followed. None of the actions listed under the second section of the directive, titled "Actions Violating Scientific Research and Publication Ethics," were committed. The Climate Change Awareness Scale (ACCS) was distributed to participants both online and in-person by the researchers.

Before distributing the scales, participants were informed about the purpose of the study, the fact that the study posed no risk, that the results would be used solely for scientific purposes, that they could withdraw from the study at any time, and that there would be no financial burden associated with participation. Additionally, participants were told that they did not need to provide their names on the scales, ensuring that they would respond to the questions sincerely.

Both the first and second study groups consist of higher education students enrolled in the Public Universities during the 2023–2024 academic year. The first study group was formed for exploratory factor analysis (EFA), while the second group was established for confirmatory factor analysis (CFA).

In scale development studies, the sufficient sample size should be five or ten times the number of items on the scale (Bryman & Cramer, 2004; Tabachnick & Fidell, 2012). According to the awareness of climate change scale 22-items, the analysis should include at least 300 participants. In this context, the analyses in the research were completed with 381 participants for EFA and 357 participants for CFA. The descriptive statistics for the first study group (EFA) were 64% (n = 244) female and 36% (n = 137) male. The ages of the participants in the first study group ranged between 19 to 44 years of age, and the mean age was calculated as 24.41 years (s = 5.848). The descriptive statistics for the second study group in which CFA was performed was 65.8% (n = 235) female and

34.2% (n = 122) male. The ages of the participants in the second study group (CFA) ranged between 17–48 years of age and the mean age was calculated as 23.35 years (s = 5.723).

ACCS development process

To guarantee the success of one of the larger projects, a literature search was conducted on the Web of Science using the queries 'awareness of climate change' and 'climate change awareness'. Thorough literature review results revealed a significant misalignment between existing measurement tools and our project's objectives. In response, a strategic approach was adopted to meticulously design and select items for the draft item pools, ensuring that every item met and exceeded our rigorous standards. This rigorous validation process, which included a thorough literature review and the examination of the questions, resulted in a 52-item draft item pool (Table 1). Draft forms were sent to two Turkish language and literature experts in terms of language and expression and three statistical experts in terms of scale psychometric properties. The draft version of the ACCS, which includes no reverse-coded items and is based on a 5-point Likert scale, is rated as follows: "1-Strongly Disagree, 2-Disagree, 3-Partially Agree, 4-Agree, and 5-Strongly Agree."

The feedback from language and statistics experts requested the deletion of two items from the scale. The content validity of the ACCS was determined using the coverage validity ratio (CVR) formula (Veneziano & Hooper, 1997). Twelve academics (four professors, six associate professors, and two doctoral lecturers) who study geography and climate change were consulted to determine the content validity of the ACCS. The CVR for each scale item should be at least 0.56, and the experts' input was invaluable in this process. This thorough process of scale development ensures the validity and reliability of the ACCS, providing a solid foundation for its use in research and practice.

Data analysis

The 32-item ACCS draft scale form was implemented on 60 participants as a pilot study. The thoroughness of the pilot study was evident in the fact that there was no negative feedback from the participants about the scale items, which is a promising sign of the study's potential. This positive response from the participants underscores the value of their input in the research process.

The 32-item ACCS draft scale was applied to two study groups. The first study group was selected for exploratory factor analysis (EFA), and the second study group was used for confirmatory factor analysis (CFA). The assumptions required for the analyses were checked. Missing values, normality assumptions, and outliers were examined. The missing values for the scale were corrected with the EM algorithm. The Shapiro-Wilks test was used to test the normality assumption. To identify univariate outliers, the standard Z-scores for each item in the scale were calculated. Two items in the EFA data and one item in the CFA data had Z-scores outside the −3 to +3 range and were therefore removed from the dataset. Mahalanobis distances were considered in determining the outliers (Geun Kim, 2000). Exploratory factor analysis (EFA) was done for the scale's validity, and confirmatory factor analysis (CFA) was performed for convergent and discriminant validity. Cronbach alpha coefficients were calculated to determine the scale's reliability, and average variance explained (AVE) and composite reliability (CR) were calculated to determine convergent and discriminant validity.

The Kaiser-Meyer-Olkin (KMO) test, Bartlett sphericity test, and anti-image correlation matrix were used to test the suitability of ACCS for factor analysis. For factor analysis, the

Table 1. Items pool selected from literature review.

Item no:	Items (TR: Turkish, ENG: English)	Literarture
1.	İklim değişikliği fosil yakıtların yakılmasıyla ortaya çıkmıştır. (TR) Climate change has been brought about by the burning of fossil fuels. (ENG)	Gönen, Ç., Deveci, E.Ü. and Aydede, M.N. (2022), "Development and validation of climate change awareness scale for high school students", *Environment, Development and Sustainability*, Springer Netherlands, No. 0123456789, doi: 10.1007/s10668-022-02213-w.
2.	Buzulların erimesi iklim değişikliğine işarettir. (TR) Melting glaciers is a sign of climate change. (ENG)	
3.	Atmosfere salınan sera gazları iklim değişikliğine yol açmıştır. (TR) Greenhouse gases released into the atmosphere have led to climate change. (ENG)	Kaddo, J.R. (2016), *Climate Change: Causes, Effects, and Solutions*, *A with Honors Projects. 164-Parkland College*, Vol. 14, doi: 10.1177/095968360401400620.
4.	İklim değişikliği içme suyu teminini güçleştirmiştir. (TR) Climate change has made it difficult to obtain drinking water. (ENG)	
5.	İklim değişikliği ısıtma ve soğutma giderlerini artırmıştır. (TR) Climate change has increased heating and cooling costs. (ENG)	
6.	Ormanlık alanlarının tahribi beraberinde iklim değişikliğini getirmiştir. (TR) The destruction of forest areas has brought climate change with it. (ENG)	Gustavsson, L., Nguyen, T., Sathre, R. and Tettey, U.Y.A. (2021), "Climate effects of forestry and substitution of concrete buildings and fossil energy", *Renewable and Sustainable Energy Reviews*, Vol. 136, p. 110435, doi: 10.1016/j.rser.2020.110435.
7.	İnsanların doğaya bilinçsiz müdahalesi iklim değişikliğiyle sonuçlanmıştır. (TR) The unconscious intervention of humans in nature has resulted in climate change. (ENG)	Ballew, M.T., Pearson, A.R., Schuldt, J.P., Kotcher, J.E., Maibach, E.W., Rosenthal, S.A. and Leiserowitz, A. (2021), "Is the political divide on climate change narrower for people of color? Evidence from a decade of U.S. polling", *Journal of Environmental Psychology*, Vol. 77, p. 101680, doi: 10.1016/j.jenvp.2021.101680.
8.	Doğaya zarar verebilecek her türlü girişim engellenmelidir. (TR) Any attempt to harm nature should be prevented. (ENG)	
9.	Ağaçlandırma çalışmaları iklim değişikliğinin olumsuz etkilerini azaltır. (TR) Afforestation works reduce the negative effects of climate change. (ENG)	
10.	Kentleşmeyle (şehirleşme) birlikte iklim değişikliği hız kazanmıştır. (TR) With urbanization (urbanization), climate change has accelerated. (ENG)	Chan, N.W. (2017), "Urbanization, Climate Change and Cities: Challenges and Opportunities for Sustainable Development", *Asia-Pacific Chemical, Biological & Environmental Engineering Society (APCBEES) International Conference*, pp. 1–12.
11.	Betonlaşma (yapılaşma) iklim değişikliğinde belirleyici olmuştur. (TR) Concretization (construction) has been a determinant in climate change. (ENG)	
12.	Aşırı gübreleme ve ilaçlama iklim değişikliğini tetiklemiştir. (TR) Excessive fertilization and spraying have triggered climate change. (ENG)	Macall, D., Phillips, P., Castle, D. and Smyth, S. (2022), *Climate Change Contributions From Seed And Crop Technologies*.

(Continued)

Table 1. Continued

Item no:	Items (TR: Turkish, ENG: English)	Literarture
13.	Endüstriyel atıklar iklim değişikliğine zemin hazırlamıştır. (TR) Industrial wastes paved the way for climate change. (ENG)	Fergusson, A. (2002), *Ozone Depletion and Climate Change: Understanding the Linkages*, Vol. 2002, Minister of Public Works and Government Services Canada, Canada.
14.	Ozon tabakasındaki incelme iklim değişikliğini kolaylaştırmıştır. (TR) The depletion of the ozone layer has facilitated climate change. (ENG)	
15.	İklim değişikliğine aşırı nüfus artışı neden olmaktadır. (TR) Climate change is caused by excessive population growth. (ENG)	Lal, P., Alavalapati, J. and Evan Mercer, D. (2011), "Socioeconomic impacts of climate change on rural communities in the United States", *USDA Forest Service - General Technical Report PNW-GTR*.
16.	İklim değişikliği sağlıklı ve güvenli gıdaya ulaşımı zorlaştırmıştır. (TR) Climate change has made it difficult to reach healthy and safe food. (ENG)	
17.	Tıbbi ve kimyasal atıklar iklim değişikliğine yol açmıştır. (TR) Medical and chemical wastes have led to climate change. (ENG)	United Nations. (2021), *Chemicals, Wastes and Climate Change: Interlinkages and Potential for Coordinated Action*.
18.	Orman arazilerinin amacı dışında kullanımına izin verilmemelidir. (TR) The use of forest lands for purposes other than their intended use should not be allowed. (ENG)	
19.	Ormanlık alanlara zarar verenlerin en büyük cezalara çarptırılması gerekir. (TR) Those who damage forested areas should be punished with the greatest penalties. (ENG)	
20.	İklim değişikliği donlu ve karlı gün sayısını azaltmıştır. (TR) Climate change has reduced the number of frosty and snowy days. (ENG)	
21.	İklim değişikliği çölleşme riskini artırmıştır. (TR) Climate change has increased the risk of desertification. (ENG)	
22.	İklim değişikliği hava olaylarında kestirilemeyen değişikliklere zemin hazırlamıştır. (TR) Climate change has paved the way for unpredictable changes in weather events. (ENG)	Ganase, S.A.S. and Sookram, S. (2021), "Climate change knowledge at the grass roots: the case of Bequia, St. Vincent and the Grenadines", *Environment, Development and Sustainability*, Springer Science and Business Media B.V., February, doi: 10.1007/s10668-020-00620-5.
23.	İklim değişikliğinin önlenmesinde örgütler ve sivil toplum kuruluşları faaliyetlerini artırmalıdır. (TR) Organizations and non-governmental organizations should increase their activities in the prevention of climate change. (ENG)	
24.	Kuraklık iklim değişikliği sonrasında ortaya çıkmıştır. (TR) Drought emerged after climate change. (ENG)	

(Continued)

Table 1. Continued

Item no:	Items (TR: Turkish, ENG: English)	Literarture
25.	Doğal afetler (sel, kasırga, hortum, yangın vb) iklim değişikliğiyle birlikte daha sık görülmeye başlanmıştır. (TR) Natural disasters (flood, hurricane, tornado, fire, etc.) have become more frequent with climate change. (ENG)	
26.	İklim değişikliği turizm sektöründe durgunluğa neden olmuştur. (TR) Climate change has caused stagnation in the tourism sector. (ENG)	
27.	İklim değişikliği uzun ve kalıcı hastalıkların artmasına ortam hazırlamıştır. (TR) Climate change has prepared the environment for the increase of long and permanent diseases. (ENG)	Oruonye, E.D. (2011), "An assessment of the level of awareness of the effects of climate change among students of tertiary institutions in Jalingo Metropolis, Taraba State Nigeria", *Journal of Geography and Regional Planning*, Vol. 4 No. 9, pp. 513–517.
28.	İklim değişikliği rahat ve konforlu bir yaşamı ortadan kaldırmıştır. (TR) Climate change has eliminated a comfortable and comfortable life. (ENG)	Kriezi, O., Lazarou, E. and Darra, N. (2021), *Climate Change and Environmental Sustainability*, *MAP Position Paper (Greece)-SHERPA Project*, doi: 10.5281/zenodo.5920876.
29.	İklim değişikliğiyle birlikte büyük orman yangınlarına daha sık rastlanmaya başlanmıştır. (TR) With climate change, large forest fires have become more frequent. (ENG)	Heshmati, H.M. (2021), "Impact of Climate Change on Life", *Environmental Issues and Sustainable Development*, IntechOpen, doi: 10.5772/intechopen.94538.
30.	İklim değişikliği canlı yaşamını tehlikeye sokmuştur. (TR) Climate change has put life in danger. (ENG)	USGCRP. (2017), *Impacts, Risks, and Adaptation in the United States - Volume II Impacts, Risks, and Adaptation in the United States*, *Fourth National Climate Assessment*, Vol. II.
31.	İklim değişikliği insanların yaşam kalitesini düşürmüştür. (TR) Climate change has reduced people's quality of life. (ENG)	
32.	Yenilenebilir enerji kaynakları (güneş, rüzgâr, jeotermal vb) iklim değişikliğinin yıkıcı etkilerini önler. (TR) Renewable energy sources (solar, wind, geothermal, etc.) prevent the destructive effects of climate change. (ENG)	Syropoulos, S. and Markowitz, E.M. (2022), "Perceived responsibility to address climate change consistently relates to increased pro-environmental attitudes, behaviors and policy support: Evidence across 23 countries", *Journal of Environmental Psychology*, Vol. 83, p. 101868, doi: 10.1016/j.jenvp.2022.101868.
33.	İklim değişikliği için toplu ulaşım araçlarına ağırlık verilmelidir. (TR) Public transportation should be given weight for climate change. (ENG)	
34.	İklim değişikliğiyle ilgili gerekli yasal düzenlemeler yapılmalıdır. (TR) Necessary legal regulations regarding climate change should be made. (ENG)	
35.	Çevreye duyarlı tesislerin kurulması yönünde yasal alt yapı oluşturulmalıdır. (TR) Legal infrastructure should be established for the establishment of environmentally sensitive facilities. (ENG)	

(Continued)

Table 1. Continued

Item no:	Items (TR: Turkish, ENG: English)	Literarture
36.	İklim değişikliğinin önüne geçmek için az yakıt tüketen araçlar tercih edilmelidir. (TR) In order to prevent climate change, vehicles that consume less fuel should be preferred. (ENG)	
37.	İklim değişikliğinin önlenmesinde deodorant ve parfüm gibi tüketimmallarına sınırlandırmalar getirilmelidir. (TR) Limitations should be imposed on consumer goods such as deodorants and perfumes to prevent climate change. (ENG)	Pastor-Nieto, M.-A. and Gatica-Ortega, M.-E. (2021), "Ubiquity, Hazardous Effects, and Risk Assessment of Fragrances in Consumer Products", *Current Treatment Options in Allergy*, Vol. 8 No. 1, pp. 21–41, doi: 10.1007/s40521-020-00275-7.
38.	İklim değişikliği konusu bilimsel yöntemlere uygun yaklaşımlarla ele alınmalıdır. (TR) The issue of climate change should be addressed with approaches in accordance with scientific methods. (ENG)	Teran, T., Lamon, L. and Marcomini, A. (2012), "Climate change effects on POPs' environmental behaviour: a scientific perspective for future regulatory actions", *Atmospheric Pollution Research*, Vol. 3 No. 4, pp. 466–476, doi: 10.5094/APR.2012.054.
39.	Öğretim programlarına iklim farkındalığına yönelik yeni dersler konulmalıdır. (TR) New courses on climate awareness should be included in the curriculum. (ENG)	Halady, I.R. and Rao, P.H. (2010), "Does awareness to climate change lead to behavioral change?", *International Journal of Climate Change Strategies and Management*, Vol. 2 No. 1, pp. 6–22, doi: 10.1108/17568691011020229.
40.	İklim değişikliğine yönelik geri dönüşümlü ürünler kullanılmalıdır. (TR) Recycled products for climate change should be used. (ENG)	Bauer, F., Nielsen, T.D., Nilsson, L.J., Palm, E., Ericsson, K., Fråne, A. and Cullen, J. (2022), "Plastics and climate change breaking carbon lock-ins through three mitigation pathways", *One Earth*, Vol. 5 No. 4, pp. 361–376, doi: 10.1016/j.oneear.2022.03.007.
41.	İklim değişikliğinin önlenmesinde medya aktif bir şekilde görev almalıdır. (TR) The media should take an active role in the prevention of climate change. (ENG)	Mavrodieva, Rachman, Harahap and Shaw. (2019), "Role of Social Media as a Soft Power Tool in Raising Public Awareness and Engagement in Addressing Climate Change", *Climate*, Vol. 7 No. 10, p. 122, doi: 10.3390/cli7100122
42.	İklim değişikliğini önlemeye yönelik girişimleri desteklerim. (TR) I support initiatives to prevent climate change. (ENG)	Turkish Ministry of Environment and Urbanization. (2011), "Republic of Turkey Climate Change Action Plan 2011–2023", p. 77.
43.	İklim değişikliğinin azaltım projelerinde aktif görev almaya hazırım. (TR) I am ready to take an active role in climate change mitigation projects. (ENG)	
44.	İklim değişikliğine yönelik oluşumlara üye olmayı önemserim. (TR) I care about being a member of organizations for climate change. (ENG)	
45.	İklim değişikliği göçlerin yaşanmasına zemin hazırlamıştır. (TR) Climate change has paved the way for migration. (ENG)	

(Continued)

Table 1. Continued

Item no:	Items (TR: Turkish, ENG: English)	Literarture
46.	Ulusal ve uluslararası düzeyde iklim değişikliğiyle ilgili işbirliğine ihtiyaç vardır. (TR) There is a need for cooperation on climate change at national and international level. (ENG)	Munasinghe, M. (2003), *Analysing the Nexus of Sustainable Development and Climate Change Finding Balanced Inclusive Green Growth(BIGG)Path to Sustainable Development View Project Covid-SD View Project*. Filho, W.L. (2010), "Climate change at universities: Results of a world survey", *Climate Change Management*, pp. 1–19, doi: 10.1007/978-3-642-10751-1_1.
47.	İklim değişikliği konusunda politik ayrışmalar bir kenara bırakılmalıdır. (TR) Political divergences on climate change should be set aside. (ENG)	Davenport, D. (2008). "The International Dimension of Climate Policy Turning down the Heat: The Politics of Climate Policy". In: Compston, H., Bailey, I. (eds) Turning Down the Heat. Palgrave Macmillan, London. https://doi.org/10.1057/9780230594678_4.
48.	İklim değişikliğine bağlı sorunların çözümü toplumsal ve politik uzlaşmayla sağlanır. (TR) The solution to the problems related to climate change is provided by social and political consensus. (ENG)	
49.	Siyasi otorite iklim değişikliği ile mücadelede yapılan çalışmalara destek olmalıdır. (TR) The political authority should support the work done in the fight against climate change. (ENG)	Kácha, O., Vintr, J. and Brick, C. (2022), "Four Europes: Climate change beliefs and attitudes predict behavior and policy preferences using a latent class analysis on 23 countries", *Journal of Environmental Psychology*, Vol. 81, p. 101815, doi: 10.1016/j.jenvp.2022.101815.
50.	İklim değişikliği konusunda yerel ve merkezi yönetimler gerekli tedbirleri almalıdır. (TR) Local and central governments should take the necessary measures on climate change. (ENG)	
51.	Yerel ve merkezi yönetimler iklim değişikliğine yönelik alınan kararları uygulamalıdır. (TR) Local and central governments should implement the decisions taken for climate change. (ENG)	
52.	Siyasi otorite iklim değişikliğiyle ilgili süreçlerin takipçisi olmalıdır. (TR) The political authority should follow the processes related to climate change. (ENG)	

KMO should be greater than .60, the Bartlett sphericity test should be significant, and the anti-image correlation coefficients should be higher than .50 (Field, 2000; Morgan *et al.*, 2019). In EFA, item factor loads, item-total correlation, and the common factor variance of the items and the total variance ratio explained should be greater than .30. With more than one factor, the differences between the factor load values of the items should be .10 and above. The eigenvalue of the factors also should be one and above. The items loaded on the same factor must be related to each other regarding the content (Abell *et al.*, 2009; Costello & Osborne, 2005).

The results of the EFA found three items had a factor load value less than .30; two items had item-total correlation coefficient less than .30; one item had a common factor variance less than .30, and the factor load value for the same item overlapped. Four item differences were less than .10. Four items were removed from the scale. Thus, a three-dimensional scale consisting of 22-items with an eigenvalue greater than one was obtained.

As a result, the analyses were conducted using responses from 381 participants in the EFA group and 357 participants in the CFA group. For EFA, varimax rotation and principal component analysis were employed, while maximum likelihood estimation was used for CFA.

In the second phase of the analyses, validity and reliability assessments were conducted. Within the scope of the validity study, EFA, CFA, and analyses for convergent and discriminant validity were performed. To determine the reliability of the scale, Cronbach's alpha coefficients were calculated, along with Average Variance Extracted (AVE) and Composite Reliability (CR) to assess convergent and discriminant validity. All analysis results of the study were reported using a significance level of .05, utilizing the statistical software packages JAMOVI 2.2.5 and LISREL 8.80.

Results

To test the suitability of the ACCS for factor analysis, the Kaiser-Meyer-Olkin (KMO) coefficient, Bartlett's test of sphericity, and the Anti-Image correlation matrix values were utilized. The KMO results for the ACCS was found to be .92, and Bartlett's test of sphericity yielded ($\chi^2 = 4208.585$; $df = 231$; $p < .001$). The Anti-Image values of the scale ranged between .85 to .96 in Table 2. A KMO results greater than .60, a significant Bartlett's test, and Anti-Image correlation matrix values above .50 indicate that the research data are suitable for factor analysis (Field, 2000; Morgan *et al.*, 2019).

In the process of determining the scale items in EFA, care was taken to ensure that item factor loadings, item-total correlation coefficients, and communalities were greater than .30, that items loading on multiple factors showed a difference of .10 or more among their factor loading values, that the eigenvalue associated with each factor was 1 or greater, and that the total explained variance was at least .30 or higher. Additionally, it was ensured that items within the same factor were related in terms of content (Abell *et al.*, 2009; Costello & Osborne, 2005; Stevens, 2012).

Based on these criteria, the EFA results of the study led to the removal of 3 items with factor loadings less than .30, 2 items with item-total correlation values less than .30, and 1 item with a communalities value less than .30. Additionally, 4 items with a difference of less than .10 among their factor loading values in multiple factors were excluded from the scale. Consequently, the EFA yielded a three-dimensional scale consisting of 22 items with eigenvalues greater than 1. The Scree Plot illustrating the factor structure of the ACCS is presented in Fig. 1.

As seen in Fig. 1, it has been determined that the curve of the Scree Plot flattens significantly after the third factor. Beyond the third factor, both the contribution of each factor to the variance is small and nearly identical. In this context, it has been decided that the number of factors in the ACCS is 3. The factor loadings, communalities, and item-total correlation values for the ACCS, as well as the eigenvalues for each factor, the variance explained by each factor, and the total variance explained by all factors are presented in Table 2.

The factor loadings for the items range from .50 to .80, with shared variance between .47 and .70, and item-total correlations varying from .43 to .68. In terms of eigenvalues, the first factor is identified as 8.503, the second factor as 2.522, and the third factor as 1.378. The explained variance ratio for the first factor is 38.650%, for the second factor is

Table 2. Results of exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

	Awareness of Climate Change Scale		
Sub-dimensions	Causes	Consequences	Solutions
# of Items	5	7	10
Items	6, 7,10,11,17 (5-items)	4, 5,16,27,28,31,45 (7-items)	35, 36, 38, 39, 40,42,46,47,48,49 (10-items)
Kaiser-Meyer-Olkin (KMO)	.92		
Bartlett test χ^2	4208.585		
Variance Explained	38.650%	11.466%	6.263%
Total Variance Explained	56.378%		
Factor Eigenvalues	8.503	2.522	1.378
Factor Loading	.50–.71	.56–.75	.64–.80
Common Factor Variances	.49–.56	.49–.62	.48–.70
Cronbach's Alpha	.77	.84	.91
	.91		
McDonald's Omega	.78	.84	.91
	.92		
Composite Reliability	.76	.83	.92
	.95		
Item-Total Correlation	.43–.60	.43–.58	.56–.68
NFI	.850		
NNFI	.870		
CFI	.890		
IFI	.890		
RMR	.035		
SRMR	.061		
RMSEA	.072		
χ^2/df	1.613		

11.466%, and for the third factor is 6.263%, resulting in a total explained variance ratio of 56.378% for the entire scale.

The three-factor structure revealed by the EFA was named based on the content of the items. Accordingly, the factor structure of the ACCS and the corresponding item numbers are presented in Table 2.

The scale does not include any negatively worded items and is structured as a 5-point Likert type, where responses range from "1 - Strongly Disagree" to "5 - Strongly Agree." The lowest possible score on the ACCS is 22, while the highest score is 110. A high score on the scale indicates that participants have a high level of awareness regarding climate change, whereas a low score reflects a lower level of awareness.

To determine whether the three-dimensional structure of the ACCS identified through EFA is confirmed, CFA was conducted. In this context, the path diagram of the CFA results for the scale, which consists of 22 items, is presented in Fig. 2.

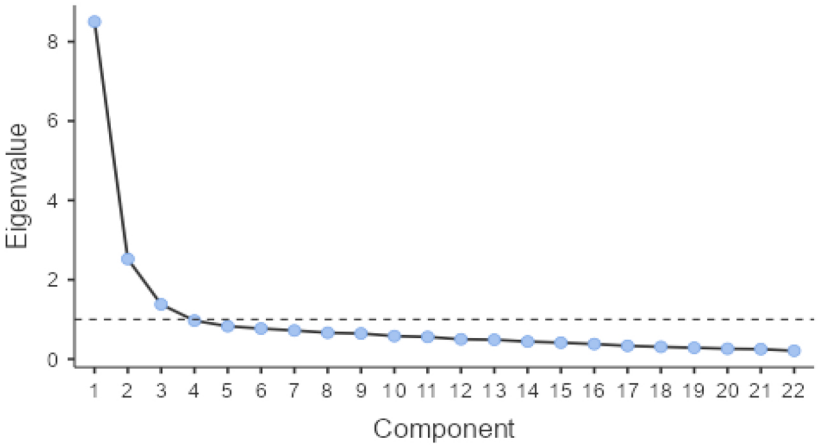

Figure 1. Scree plot of the ACCS

Fig. 1. Scree plot of the ACCS.

As shown in Fig. 2, the item factor loadings for the Causes dimension of the ACCS range from .51 to .70, with R^2 ranging from .45 to .68. The item factor loadings for the Consequences dimension range from .41 to .69, with R^2 ranging from .53 to .83. The item factor loadings for the Solution dimension range from .44 to .78, with R^2 ranging from .41 to .80. Additionally, the t-values for all items in the scale exceed 2.58, varying between 7.889 and 14.789, indicating significance at the .01 level (Jöreskog & Sörbom, 1993). The goodness-of-fit indices calculated for the CFA of the ACCS fall within appropriate ranges ($\chi^2/sd = 366.29/227 = 1.613$, RMSEA = .072, SRMR = .0613, RMR = .035, CFI = .89, NFI = .85, NNFI = .87, AGFI = .85, GFI = .86) (Hair *et al.*, 2019; Kline, 2011; Schermelleh-Engel *et al.*, 2003). Therefore, it can be concluded that the goodness-of-fit indices calculated within the framework of the CFA support the three-dimensional structure of the ACCS. Reliability analyses for the ACCS were determined by calculating the Cronbach alpha, McDonald's omega, and composite reliability (CR) (Table 2).

For the divergent (discriminant) validity of the ACCS, the square root of the AVE for each dimension was taken. The obtained square root for each dimension is expected to be greater than the correlation coefficients with the other dimensions of the scale and .50 (Fornell & Larcker, 1981). Accordingly, the correlations and square root AVE between each dimension of the ACCS are as followed: Causes- $\sqrt{AVE_{Causes}} = .62$; Consequences - $\sqrt{AVE_{Causes}} = .56$; Solutions - $\sqrt{AVE_{Causes}} = .54$; Consequences - $\sqrt{AVE_{Conseq}} = .65$; Solutions - $\sqrt{AVE_{Conseq}} = .54$; Solutions - $\sqrt{AVE_{Solutions}} = .73$. It has been determined that the square root AVE values calculated for each dimension of the ACCS are greater than the correlation coefficients between the other dimensions and the .50 criterion. Based on these results, it can be stated that the ACCS also demonstrates discriminant (divergent) validity.

In order to determine the item discriminability level of the ACCS related to item analysis, comparisons between the lower and upper 27% groups were conducted. Independent sample t-tests were utilized in the comparison of the lower and upper 27% groups. Accordingly, the results of the independent sample t-tests for the ACCS at the 27% level are shown in Table 3.

As seen in Table 3, the t values calculated for all items of the ACCS range between −15.619 to −9.236 and are significant at significant level. The significance of the t values related to the scale indicates that the items are discriminatory.

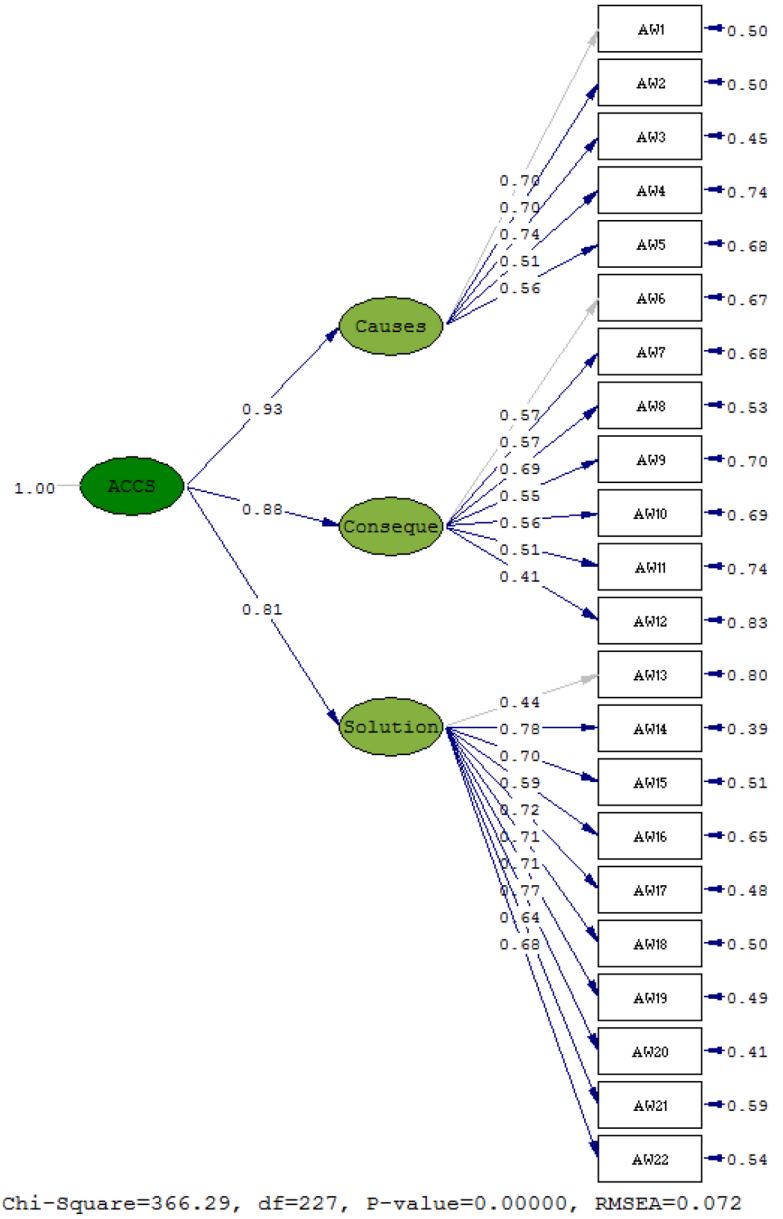

Fig. 2. Path diagram of confirmatory factor analysis.

For concurrent validation of the ACCS, the participants were also asked to complete the climate change awareness scale for high school students (CCA-HSS-17 item), Global Climate Change Awareness Scale (GACCS-21 item), and climate change perceptions scale (CCPS-30 item) (Deniz *et al.*, 2021; Gönen *et al.*, 2022; van Valkengoed *et al.*, 2021). The correlation coefficients were considered according to concurrent validity. The evaluation criteria were lower than .25 for weak correlation, between .25–.50 for moderate correlation, between .50–.75 for good correlation, and bigger than .75 for excellent correlation (Portney & Watkins, 2017). The correlation coefficients showed that there was good validity for ACCS and CCA-HSS ($\rho = .74$, $p < .01$), good validity for ACCS and

Table 3. Independent sample t-test results for the lower and upper 27% groups of the ACCS.

Item no:	Items	t	p
1.	İklim değişikliği içme suyu teminini güçleştirmiştir. (TR) Climate change has made it difficult to obtain drinking water. (ENG)	−11.831	<.001*
2.	İklim değişikliği ısıtma ve soğutma giderlerini artırmıştır. (TR) Climate change has increased heating and cooling costs. (ENG)	−14.489	<.001*
3.	Ormanlık alanlarının tahribi beraberinde iklim değişikliğini getirmiştir. (TR) The destruction of forest areas has brought climate change with it. (ENG)	−15.619	<.001*
4.	İnsanların doğaya bilinçsiz müdahalesi iklim değişikliğiyle sonuçlanmıştır. (TR) The unconscious intervention of humans in nature has resulted in climate change. (ENG)	−12.094	<.001*
5.	Kentleşmeyle (şehirleşme) birlikte iklim değişikliği hız kazanmıştır. (TR) With urbanization (urbanization), climate change has accelerated. (ENG)	−12.443	<.001*
6.	Betonlaşma (yapılaşma) iklim değişikliğinde belirleyici olmuştur. (TR) Concretization (construction) has been a determinant in climate change. (ENG)	−14.936	<.001*
7.	İklim değişikliği sağlıklı ve güvenli gıdaya ulaşımı zorlaştırmıştır. (TR) Climate change has made it difficult to reach healthy and safe food. (ENG)	−10.050	<.001*
8.	Tıbbi ve kimyasal atıklar iklim değişikliğine yol açmıştır. (TR) Medical and chemical wastes have led to climate change. (ENG)	−11.674	
9.	İklim değişikliği uzun ve kalıcı hastalıkların artmasına ortam hazırlamıştır. (TR) Climate change has prepared the environment for the increase of long and permanent diseases. (ENG)	−13.333	<.001*
10.	İklim değişikliği rahat ve konforlu bir yaşamı ortadan kaldırmıştır. (TR) Climate change has eliminated a comfortable and comfortable life. (ENG)	−9.236	<.001*
11.	İklim değişikliği insanların yaşam kalitesini düşürmüştür. (TR) Climate change has reduced people's quality of life. (ENG)	−15.571	<.001*
12.	Çevreye duyarlı tesislerin kurulması yönünde yasal alt yapı oluşturulmalıdır. (TR) Legal infrastructure should be established for the establishment of environmentally sensitive facilities. (ENG)	−9.501	<.001*
13.	İklim değişikliğinin önüne geçmek için az yakıt tüketen araçlar tercih edilmelidir. (TR) In order to prevent climate change, vehicles that consume less fuel should be preferred. (ENG)	−13.036	<.001*
14.	İklim değişikliği konusu bilimsel yöntemlere uygun yaklaşımlarla ele alınmalıdır. (TR) The issue of climate change should be addressed with approaches in accordance with scientific methods. (ENG)	−13.552	<.001*
15.	Öğretim programlarına iklim farkındalığına yönelik yeni dersler konulmalıdır. (TR) New courses on climate awareness should be included in the curriculum. (ENG)	−15.246	<.001*
16.	İklim değişikliğine yönelik geri dönüşümlü ürünler kullanılmalıdır. (TR) Recycled products for climate change should be used. (ENG)	−12.337	<.001*
17.	İklim değişikliğini önlemeye yönelik girişimleri desteklerim. (TR) I support initiatives to prevent climate change. (ENG)	−13.953	<.001*
18.	İklim değişikliği göçlerin yaşanmasına zemin hazırlamıştır. (TR) Climate change has paved the way for migration. (ENG)	−13.953	<.001*
19.	Ulusal ve uluslararası düzeyde iklim değişikliğiyle ilgili işbirliğine ihtiyaç vardır. (TR) There is a need for cooperation on climate change at national and international level. (ENG)	−13.330	<.001*
20.	İklim değişikliği konusunda politik ayrışmalar bir kenara bırakılmalıdır. (TR) Political divergences on climate change should be set aside. (ENG)	−10.126	<.001*

(Continued)

Table 3. Continued

Item no:	Items	t	p
21.	İklim değişikliğine bağlı sorunların çözümü toplumsal ve politik uzlaşmayla sağlanır. (TR) The solution to the problems related to climate change is provided by social and political consensus. (ENG)	−11.078	<.001*
22.	Siyasi otorite iklim değişikliği ile mücadelede yapılan çalışmalara destek olmalıdır. (TR) The political authority should support the work done in the fight against climate change. (ENG)	−11.384	<.001*

Note. *p < .001; n for lower 27% = 96 and n for upper 27% = 96.

GACCS ($\rho = .66$, $p < .01$), and good validity for ACCS and CCPS ($\rho = .51$, $p < .01$). The awareness of climate change scale is an appropriate measurement tool that can be utilized psychometrically, based on the evaluation of all the validity and reliability results (Fig. 1).

Discussion

This article aims to develop scale for measurement of awareness of climate change. This scale development project uses a survey approach to test higher education students' awareness of climate change. To enhance the validity of our findings, participants in both the exploratory (EFA) and confirmatory factor analyses (CFA) were selected to form a homogeneous group, thereby minimizing the effects of gender and age variables. In the EFA, 64% of participants were female and 36% were male, with ages ranging from 19 to 44 years. In the CFA, 65.8% of participants were female and 34.2% were male, with ages spanning from 17 to 48 years. This intentional selection process bolsters the reliability of the results.

Based on all the analyses conducted, the ACCS is a valid and reliable measurement tool for assessing higher education students' awareness of climate change. Further validity and reliability studies of the ACCS with more comprehensive and diverse sample groups may be beneficial. As mentioned, this scale address gap in the literature that has three dimensions causes, consequences and solutions that's why results should be discussed in these three dimensions. First of all, our research shows that students with high awareness in the causes of climate change dimension also reflect high awareness in consequences of climate change. This results are also matched with the previous research results in the literature (Tschakert & Sagoe, 2009; Yang *et al.*, 2018; Yepéz & Rodríguez, 2020).

Secondly, the study successfully developed the Climate Change Awareness Scale, a robust tool designed to measure critical awareness surrounding climate change through three essential sub-dimensions: Causes, Consequences, and Solutions. Cronbach α and other coefficients underscore the scale's high reliability. The strong fit to the data is demonstrated by favorable CFA goodness-of-fit coefficients, validating the results and ensuring confidence in the application.

The Causes sub-scale (Causes-ACCS) features five meticulously items; the Consequences sub-scale (Consequences-ACCS) includes seven thoughtfully designed items; and the Solutions sub-scale (Solutions-ACCS) incorporates ten relevant items. The overall scale (ACCS) boasts a remarkable reliability score of .91. At the same time, the sub-dimensions exhibit equally strong reliabilities: Causes-ACCS at .77, Consequences-ACCS at .84, and Solutions-ACCS at .91. The Composite Reliability for the entire scale reached .95, with the sub-dimensions showing robust scores of .76 for Causes-ACCS, .83 for Consequences-ACCS, and .92 for Solutions-ACCS. Which is quite similar to the results of the literature (Deniz *et al.*, 2021; Gönen *et al.*, 2022; Ruddell *et al.*, 2012; van Valkengoed *et al.*, 2021).

Moreover, the CFA goodness-of-fit coefficients for the main and sub-dimensions were commendable, indicating an excellent fit to the data. The compelling results affirm that the psychometrically evaluated measurement tools are not only reliable but also highly effective for measuring climate change awareness. The scale is an invaluable measure for researchers and practitioners alike.

Thirdly, measurement of awareness on solutions for climate change is unique in the literature. Results in this dimension is vital to produce policy programs, education and training programs. Our research reveals that most of the participants are partially aware for solutions of climate change however there is only small percentage to have more holistic understanding and awareness. It is also supportive for current researches which asserts that individuals have tendency to limited or local solutions (Carlson *et al.*, 2020; Grasso *et al.*, 2011; Sharma *et al.*, 2016). However, there is interesting results from our research indicates that high level of awareness.

Conclusion

Results from applied scale has various implications for policy makers, NGOs and experts of the climate change. In this respect, results of researches can be used to develop more efficient and innovative education and training program. In addition to this, it contributes to cross cultural studies in the literature in terms of demography and education background. Last but not least, the scale for instance, new scale development studies could be conducted on different sample groups, including primary and secondary school students, as well as participants who are teachers or administrators. In addition, the pilot study did not conduct more problem statement examinations and related statistical analyses to eliminate the complexity. Models could be made for future studies or projects, whether at a national or international level, that could be performed in different geographical regions (regional-spatial, continental-spatial, etc.). Mapping can be done and then compared longitudinally. Determining whether the ACCS works psychometrically in organizations or institutions outside of educational organizations is thought to contribute significantly to the literature, inspiring further research and development in the field.

This study presents several critical limitations that warrant careful consideration. First, the data was gathered solely through an online survey, which limited opportunities for in-person assessments that could have yielded more prosperous, more nuanced insights. Moreover, the study's cross-sectional nature limits the ability to draw conclusions about changes over time, as longitudinal validation is not feasible. Given that the sample consisted exclusively of Turkish higher education students, it is essential to pursue cross-cultural validation to ensure the results are relevant and applicable to a broader population. Lastly, while the absence of reverse-coded items may seem like a limitation, it's important to note that some studies suggest reversed items can have detrimental effects on results (Suárez-Álvarez *et al.*, 2018; Zhang *et al.*, 2016). Recognizing these limitations is vital for accurately interpreting the findings and guiding future research.

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Conflict of interest

All authors declare that there's no financial/personal interest or belief that could affect our objectivity.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contribution

Ş.A. contributed to the Conceptualization and Resources. N.P. contributed to the Validation and Visualization. Ş.Ş.E. contributed to the Writing – Review & Editing, Supervision, and Project Administration. N.P., S.Ç., Ş.A., Ş.Ş.E. contributed to the Methodology and Investigation. N.P., Ş.A., Ş.Ş.E. contributed to the Data curation. S.Ç., N.P. contributed to the Formal Analysis. N.P., Ş.A. contributed to the Writing – Original Draft.

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