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Social engagement in coastal adaptation processes: Development and validation of the CoastADAPT scale

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ABSTRACT

Introduction: Engaging citizens and communities is considered a central element and a good practice in coastal management. However, individuals still demonstrate a general disengagement with coastal risks. To understand the factors that underlie the citizens' engagement in coastal risks processes and to implement evidence-based strategies aimed at enhancing public participation in coastal management, is pivotal to the success of coastal adaptation.
Goals: Therefore, this study sought to develop and validate an assessment tool aiming at measuring individuals' engagement in coastal adaptation processes and their underlying factors.
Methods: A cross-sectional and 2-phase research was implemented to analyze the psychometric properties of the CoastADAPT scale. The Phase 1 study ($N = 491$) determined the CoastADAPT scale's factorial structure, through Exploratory Factor Analysis; its reliability, through internal consistency and test-retest reliability; and construct validity, through convergent and divergent validity. The Phase 2 study ($N = 207$) confirmed the CoastADAPT scale's factorial structure, through Confirmatory Factor Analysis.
Results: Analyses indicated that the CoastADAPT scale showed good psychometric properties and a 3-factor structure consisting of the following domains: Experiential Processing (Affective component), Risk Awareness (Cognitive component) and Environmental Justice (Social value orientation component).
Conclusions: The CoastADAPT scale is a reliable and valid measure of citizens' engagement in coastal risk adaptation processes. It may be a useful tool to facilitate the development of strategies to overcome individuals' disengagement with coastal management and to provide a deeper understanding of the predictors of individuals' engagement in coastal risk processes.

1. Introduction

It is unarguable that a substantial proportion of shorelines, worldwide are particularly exposed to heightened risks due to meteorological, geological and anthropogenic factors (Luijendijk et al., 2018; Tavares et al., 2021; Vousdoukas et al., 2018, 2020). It is also undeniable, that climate change is arriving to significantly exacerbate coastal risks. A worrisome sea-level rise, as a result of increasing global temperature, is expected to accelerate coastal dynamics (Intergovernmental Panel on Climate Change, 2013; Wong et al., 2014), posing major threats to coastal zones, such as coastal erosion, frequent and intensified cyclonic activity and associated storm surge flooding (Mavromatidi et al., 2018). All these pressures, together with the fact that most threatened coastal areas are in densely populated areas, underlines the urgency for the design and implementation of effective adaptive measures that not only take into account the physical processes driving hazardous coastal processes, but also considers the characteristics of both natural and human environments and their interactions (Bruno et al., 2020; Luís et al., 2015).

Politically feasible and socially acceptable coastal hazard adaptation strategies will not happen without broad public support, and ideally, exposed populations' active engagement (Bongarts Lebbe et al., 2021;

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Moser and Pike, 2015). Whilst, many countries have been implementing integrated strategies for coastal management based on “bottom-up” approaches in which community members are expected to be actively involved, barriers of adaptation in practice are starting to be realized (Rosendo et al., 2018; Fitton et al., 2021; Silver, 2021; Ziervogel and Parnell, 2014). Some of these barriers relate to the citizens’ participation throughout the iterative implementation cycles of coastal management, as individuals still demonstrate a general disengagement with coastal risks adaptation processes (Silver, 2021; McKinley et al., 2021). Consequently, a limited collaboration between citizens and other coastal management actors (e.g., shoreline and coastal planners, decision-makers) unequivocally compromise the success of the implementation of coastal adaptation strategies (McKinley et al., 2021; Moser and Pike, 2015).

As engaging citizens and communities is considered a central element and a good practice in coastal management processes (Ballinger et al., 2010; Dean et al., 2016, 2019; Ellsworth et al., 1997), it seems clear that addressing these barriers is key for achieving more systemic and successful adaptation (Dean et al., 2019; Ziervogel and Parnell, 2014). At this point, human psychology allows us to better understand the processes that underlie the citizens’ engagement in coastal risks and adaptation processes. By providing evidence-based data on the latent variables related to individuals’ engagement in coastal risk adaptation processes, innovative and targeted tools and/or community interventions may be developed and implemented allowing for participative processes of coastal management and augmenting the success of coastal adaptation strategies (Areia et al., 2021).

In the absence of an empirically validated scale to accurately measure the level of citizens’ engagement in coastal risk adaptation processes, the aims of this study are (1) to develop and validate a scale which is able to measure the above-mentioned construct and (2) to identify the social-psychological aspects explaining the individuals’ active involvement with coastal risks and coastal management processes.

2. Methods

2.1. Scale development

An initial pool of 31 items were generated based on an exhaustive review of literature, previous research conducted by the research team and in consultation of environmentally-applied social scientists from the researchers’ network. This initial prototype of the CoastADAPT Scale was applied to 30 expert judges (see “Expert Judges’ sociodemographic data” in Supplementary Material) to assess its content validity, particularly the 31 items’ content adequacy, relevance, representativeness and technical quality (Boateng et al., 2018; Haynes et al., 1995; Morgado et al., 2017). Then, cognitive interviews were administered to 35 adult respondents (see “Pre-testing participants’ sociodemographic data” in Supplementary Material), to ensure that the items were meaningful to the target population (i.e., adult citizens whether or not from coastal communities), in order to minimize misunderstanding and subsequent measurement error, and cognitive burden on research participants (Beatty and Willis, 2007; Boateng et al., 2018). Following the analysis of content validity and pre-testing inputs, several items were reworded for clarity and poorly worded items were eliminated, resulting in a preliminary 20-item test version of the CoastADAPT scale.

2.2. Scale evaluation

2.2.1. Data collection and participants

Face-to-face interviews and a web-based survey were employed to gather participants’ data for studies of Phase 1 and 2. However, the web-based survey was privileged to gather participants’ data, due to the current socio-epidemiological situation (i.e., SARS-CoV-2/Covid-19). The inclusion criteria considered for both study phases were as follows: (1) being 18 years of age or over, (2) living in Portugal and being a native speaker of Portuguese, and (3) having given informed consent to participate in the study. For the Phase 1 study, data were collected in September and October 2021, through face-to-face interviews ($n = 49$, 10.0%) and the web-based survey ($n = 442$, 90.0%). For the Phase 2 study, data were collected in November and December 2021, through face-to-face interviews ($n = 15$, 7.2%) and the web-based survey ($n = 192$, 92.8%).

For the Phase 1 study, the sample was composed of 491 adult participants (mean age = 44.6; $SD = 13.93$). The majority of participants were women ($n = 247$, 50.3%) and have a bachelor’s degree ($n = 204$, 41.5%). Most participants live at a distance of 10–50 km from the shoreline ($n = 227$, 46.2%) and spend many ($n = 134$, 27.3%) or few ($n = 134$, 27.3%) times a year at the shoreline. Almost 90% of the participants and/or their households do not depend economically from coastal resources ($n = 432$, 88.0%). For the Phase 2 study, the sample was composed of 207 adult participants (mean age = 45.29; $SD = 13.02$). The majority of participants are women ($n = 130$, 62.8%) and have a bachelor’s degree ($n = 91$, 44.0%). Most participants live at a distance of 10–50 km from the shoreline ($n = 81$, 39.1%) and spend many times a year at the shoreline ($n = 57$, 27.5%). Only 15% of the participants and/or their households economically depend upon coastal resources. Table 1 presents the detailed sample characteristics for Phase 1 and 2 studies.

2.2.2. Data Analyses

Phase 1 studies encompassed the analyses of the initial items’ properties of the CoastADAPT scale, exploratory factor analysis, reliability and validity assessment.

Specifically, the mean, standard deviation, asymmetry, and kurtosis of each one of the 20 initial items were analysed. Only items with values for asymmetry and kurtosis between − 2 and + 2 were considered for further analyses (George and Mallery, 2003).

The best practices to perform Exploratory Factor Analysis (EFA) (Watkins, 2018) were strictly considered. In order to determine the

Table 1
Samples characteristics for Phase 1 and 2 studies.

		Phase 1 study N = 491		Phase 2 study N = 207	
		n	%	n	%
Sex					
	Female	247	50.3	130	62.8
	Male	244	49.7	77	37.2
Age[a]		44.36 (13.93)		45.29 (13.02)	
Education					
	Primary education (≥ 3rd cycle)[1]	8	1.6	1	0.5
	Secondary education[1]	136	27.7	46	22.2
	Bachelor’s degree	204	41.5	91	44.0
	Master’s degree	116	23.6	56	27.1
	Doctoral degree	27	5.5	13	6.3
Residency’s distance from shoreline					
	< 1 km	67	13.6	31	15.0
	1 – 10 km	141	28.7	73	35.3
	10 – 50 km	227	46.2	81	39.1
	> 50 km	56	11.4	22	10.6
Average time spent in the shoreline					
	Everyday	43	8.8	30	14.5
	At least once a week	104	21.2	50	24.2
	Many times a year	134	27.3	57	27.5
	Few times a year	134	27.3	50	24.2
	Rarely	73	14.9	19	9.2
	Never	3	0.6	1	0.5
Economic activity					
	Dependent from coastal resources	59	12.0	31	15.0
	Independent from coastal resources	432	88.0	176	85.0

[1] Based on the Education System levels in Portugal
[a] Mean (SD)

appropriateness of the data for EFA, Bartlett's test of sphericity (Bartlett, 1954) and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Kaiser, 1974) were considered. As variables for which the common factors explain little variance may distort EFA results (Fabrigar et al., 1999), the items showing low communality coefficients ($h^2 <$ 0.30) were eliminated. An eigenvalue Monte Carlo simulation (parallel analysis) (Horn, 1965; O'connor, 2000) and a Velicer's minimum average partial (MAP) test (O'connor, 2000; Velicer, 1976) were performed in order to determine the correct number of factors to retain. Since it was also hypothesized that the different factors may be dependent, an oblique promax rotation was finally applied to allow factor intercorrelations to emerge and to identify the factorial structure of the CoastADAPT scale.

The reliability assessment of the scale was based on the analysis of its internal consistency and its test-retest reliability. For internal consistency analysis, the Cronbach's alpha (α) for the whole scale score and for its factors was computed, taking into account the acceptable threshold for reliability ($\alpha > 0.70$) (Cronbach, 1951; Tavakol and Dennick, 2011). For test-retest reliability, the intra-class correlation coefficient (ICC), with two-way mixed effects and absolute agreement, was calculated for the whole scale and its factors' results.

The construct validity of the CoastADAPT scale was ascertained through convergent validity and discriminant validity, using the Pearson product-moment correlation based on Fisher's Z transformation. For convergent validity, the CoastADAPT scale's constructs were correlated with variables related to risk perception of coastal risks, such as *"Coastal erosion probability perception"* and *"Coastal flooding probability perception."* For discriminant validity, the CoastADAPT scale's constructs were correlated with variables related to individuals' disbelief in the coastline's exposure to coastal hazards and in human influence on coastal hazardous processes, such as *"Skepticism: coastal risk processes"* and *"Skepticism: anthropogenic influence on coastal hazards."* The statements used to perform construct validity analyses are displayed in Supplementary Material.

Phase 2 study aimed at exploring the evidence of structural validity CoastADAPT scale. For such, Confirmatory Factor Analysis (CFA), using the maximum likelihood method, was performed to analyse the model structure obtained in the EFA (Phase 1), through structural equation modelling. Critical assumptions for the CFA analysis were considered, specifically the presence of multivariate outliers and the multivariate normality of the data. To determine the model's fit, the following indices were considered: Pearson chi-square (χ^2) statistic with degrees of freedom (df); Goodness-of-fit index (GFI); Adjusted goodness-of-fit index (AGFI); Comparative fit index (CFI); Tucker-Lewis index (TLI); and the Root mean square error of approximation (RMSEA). Recommendations for model fit cut-off criteria were taken into account, as follows: for χ^2/df ratio, a value of ≥ 3.00 is considered indicative of good fit (Wheaton et al., 1977); for GFI, AGFI, CFI and TLI, values equal or higher than 0.90 are indicative of a good fitting model (Schumacker and Lomax, 2015; Tucker and Lewis, 1973), whilst values between ≥ 0.80 and < 0.90 are indicative of an acceptable fitting model (Mâroco, 2014); finally, for RMSEA a value of < 0.08, $p \geq 0.05$ is indicative of good fit (Browne and Cudeck, 1992).

Statistical analyses were performed using IBM SPSS Statistics (Phase 1 studies) and AMOS (Phase 2 study), version 26.

2.2.3. Ethics

All studies encompassing the CoastADAPT scale development and validation were developed in accordance with the international ethical and methodological guidelines (American Psychological Association, 2017). The consent for participation was obtained at the beginning of the survey, and only the responses of the participants who agreed to voluntarily participate in the studies were considered eligible. The Portuguese version of the informed consent form used for these studies, is displayed in Supplementary Material.

3. Results

3.1. Phase 1 studies

3.1.1. CoastADAPT scale properties

The initial version of the CoastADAPT Scale was composed by 20 items. The English-translated original items, means, standard deviations, skewness and kurtosis values are detailed in Table 2. The values for asymmetry and kurtosis were between − 2 and + 2, except for items *"Storm surges will have fatal consequences for coastal communities"* ($M = 4.47$, $SD = 0.79$), *"Protecting dunes is critical to contain the erosion processes in our coastline"* ($M = 4.51$, $SD = 0.77$) and *"I am concerned with the loss of sand in some Portuguese beaches"* ($M = 4.56$, $SD = 0.69$), which demonstrated to have a leptokurtic distribution. Therefore, these items were eliminated and thus not considered in the further analyses.

3.1.2. Exploratory factor analysis (EFA)

The obtained Kaiser-Meyer-Olkin (KMO) value (KMO=0.81) and

Table 2
Original items, means, standard deviations, skewness and kurtosis values.

	M	*SD*	*Sk*	*Ku*
1. I experience, or have already experienced, the effects of coastal erosion.	3.66	1.26	-0.66	-0.59
2. Climate change amplifies the coastal erosion processes.	4.35	0.84	-1.31	1.68
3. Storm surges will have fatal consequences for coastal communities.[a]	4.47	0.79	-1.69	3.09
4. In my daily life, I take actions to protect the environment.	4.26	0.76	-0.75	0.13
5. In the next 20 years, we will not be able to delight in coastal zones, like we do today.	3.73	1.02	-0.66	0.80
6. I feel concerned about the danger of a storm surge in the Portuguese coastline.	4.22	0.89	-1.18	1.27
7. Coastal communities should be moved to areas far from the coastline.	3.28	1.03	-0.23	-0.19
8. Protecting dunes is critical to contain the erosion processes in our coastline.[a]	4.51	0.77	1.95	4.73
9. It is the government's responsibility to compensate families and the business owners affected by coastal flooding.	3.24	1.12	-0.09	-0.61
10. Recently, I have been changing some behaviours in order to reduce my carbon emissions.	4.11	0.85	-0.85	0.74
11. I usually choose to go to a beach whose natural characteristics remain preserved.	4.04	0.95	-0.73	0.02
12. There is a great probability of occurring storm surge episodes that will cause coastal flooding in Portuguese coastal areas.	4.21	0.82	-0.99	1.13
13. I feel directly or indirectly affected by the problems posed by coastal erosion in the Portuguese coastline.	3.39	1.17	-0.30	-0.71
14. I would like to actively participate in the planning and management of the Portuguese coastline.	3.62	1.13	-0.45	-0.42
15. The restoration of dunes is an effective measure to contain coastal erosion.	4.21	0.81	-0.92	0.79
16. I am concerned with the loss of sand in some Portuguese beaches.[a]	4.56	0.69	-1.80	3.86
17. I am available to pay to use the beach, if that means that it will be protected from erosion processes.	2.39	1.31	0.46	-1.00
18. I feel concerned about the well-being of the inhabitants of coastal communities and I would be available to contribute to guarantee their security.	3.37	1.13	-0.29	-0.51
19. Usually, for recreational or relaxing activities, I prefer to visit natural environments.	4.29	0.91	-1.35	1.65
20. Wave overtopping and coastal flooding will be more frequent in Portugal.	4.27	0.84	-1.14	1.20

Note: The items in italics were further eliminated in the next steps of this study (cf. 3.1.2. Exploratory Factor Analysis)
[a] Item with a leptokurtic distribution (Ku>3)

Bartlett's test of sphericity (= 1478.88, $p < 0.001$) supported the factorability of the correlation matrix. The items "*Coastal communities should be moved to areas far from the coastline*" and "*The restoration of dunes is an effective measure to contain coastal erosion*" showed communality coefficients below 0.30 ($h^2 = 0.22$ and 0.29, respectively), so they were not considered in the EFA.

The EFA was performed using parallel analysis with Velicer's minimum average partial, followed by an oblique promax rotation. A solution with three factors was obtained, explaining 45.85% of the total variance. Factor loadings ranged from 0.58 to 0.79 and cross-saturations were not found. Table 3 displays the detailed results obtained for the EFA with oblique promax rotation and communality coefficients.

The factors were named "Experiential processing" (Factor 1) ($M = 3.91$, $SD = 0.62$), "Risk awareness" (Factor 2) ($M = 4.16$, $SD = 0.62$) and "Environmental justice" (Factor 3) ($M = 3.00$, $SD = 0.85$). Correlations between factors do not exceed 0.80, as recommended by Brown (2015).

Table 3
Results of EFA with oblique promax rotation and communality coefficients.

	CoastADAPT Scale			
	Factor 1	Factor 2	Factor 3	h^2
1. I experience, or have already experienced, the effects of coastal erosion.	0.61			0.39
2. Climate change amplifies the coastal erosion processes.		0.65		0.49
3. In my daily life, I take actions to protect the environment.	0.60			0.38
4. In the next 20 years, we will not be able to delight in coastal zones, like we do today.		0.58		0.38
5. I feel concerned about the danger of a storm surge in the Portuguese coastline.		0.75		0.57
6. It is the government's responsibility to compensate families and the business owners affected by coastal flooding.			0.66	0.45
7. Recently, I have been changing some behaviours in order to reduce my carbon emissions.	0.55			0.35
8. I usually choose to go to a beach where its natural characteristics remain preserved.	0.61			0.40
9. There is a great probability of occurring storm surge episodes that will cause coastal flooding in Portuguese coastal areas.		0.74		0.55
10. I feel directly or indirectly affected by the problems posed by coastal erosion in the Portuguese coastline.	0.60			0.44
11. I would like to actively participate in the planning and management of the Portuguese coastline.	0.66			0.48
12. I am available to pay to use the beach, if that means that it will be protected from erosion processes.			0.67	0.46
13. I feel concerned about the well-being of the inhabitants of coastal communities and I would be available to contribute to guarantee their security.			0.73	0.55
14. Usually, for recreational or relaxing activities, I prefer to visit natural environments.	0.59			0.38
15. Wave overtopping and coastal flooding will be more frequent in Portugal.		0.79		0.63
Variance percentage	25.66%	11.28%	8.92%	
Inter-factor correlations				
Factor 1	1	0.37**	0.28**	
Factor 2	0.37**	1	0.31**	
Factor 3	0.28**	0.31**	1	

* *Correlation is significant at a level of significance of 0.01 (with a two-tailed hypothesis).

3.1.3. Reliability assessment

The reliability assessment of the CoastADAPT scale was ascertained through internal consistency and test-retest reliability. Internal consistency reliability was assessed to ascertain the degree of interrelationship among the CoastADAPT scale, such that they are consistent with one another and measure the same construct/latent traits (Tavakol and Dennick, 2011), this is engagement in coastal risk processes (Total Scale), experiential processing (Factor 1), risk awareness (Factor 2) and environmental justice (Factor 3). Cronbach's alpha was computed for the whole scale and for the three dimensions of the scale, produced by the EFA. The whole scale presented an alpha of 0.76. For the "Experiential processing" ($\alpha = 0.71$) and "Risk awareness" ($\alpha = 0.74$) dimensions, acceptable Cronbach alphas were obtained. The lowest alpha was obtained for the "Environmental justice" ($\alpha = 0.53$) dimension, which was not considered problematic, as this dimension is composed by a small number of items (Taber, 2017). The deletion of any item would not improve the whole scale reliability, as the obtained Cronbach's alphas if item deleted ranged between 0.73 and 0.75. Considering the obtained Cronbach alpha for "Environmental justice" dimension, means inter-item correlations were also calculated, as an alternative measure of internal consistency. All items strongly correlated with the mean of the "Environmental justice" dimension ($r = 0.66 – 0.75$, $p < 0.001$). Furthermore, weak correlations ($r = 0.17 – 0.34$, $p < 0.001$) were found between the three items, indicating the absence of the item's redundancy.

Test-retest reliability was the method used to measure the extent that the CoastADAPT scale produces similar results over time (i.e., temporal stability). The intra-class correlation coefficient (ICC) with two-way mixed effects and absolute agreement was employed to measure the test-retest reliability of the scale. From the total sample ($N = 491$), 225 participants were randomly selected and invited to redo the questionnaire survey after three to four weeks, of which 75 participants agreed to do so. According to Koo and Li (2016), the CoastADAPT scale demonstrated moderate to good reliability, as the values of ICC based on the 95% confident interval were 0.75 for the CoastADAPT scale as a whole, 0.83 for "Experiential processing," 0.66 for "Risk awareness" and 0.78 for "Environmental justice".

3.1.4. Construct validity assessment

For convergent validity, correlations between the CoastADAPT scale constructs and "*Coastal erosion probability perception*" and "*Coastal flooding probability perception*" were estimated. With exception for the relationship between "Environmental justice" and "*Coastal erosion probability perception,*" a consistent pattern of positive and significant ($p < 0.001$) correlations were obtained, ranging from 0.13 to 0.41.

For divergent validity, correlations between the CoastADAPT scale constructs and "*Skepticism: coastal risk processes*" and "*Skepticism: anthropogenic influence on coastal hazards*" were estimated. With exception the of "Environmental justice" that did not correlate with the abovementioned constructs, a consistent pattern of significant low ($p < 0.001$) correlations were obtained, ranging from − 0.10 to − 0.25.

The moderate convergent and divergent validity confirms the construct validity of the CoastADAPT scale (Table 4).

3.2. Phase 2: confirmatory factor analysis

A Confirmatory Factor Analysis was performed to ensure that the 3-factor structure obtained in EFA (Phase 1) would fit data correctly in a different sample. The first order model showed the following goodness of fit statistics: $\chi^2 = 179.77$, df = 87, $\chi^2/df = 2.07$, $p < 0.001$, GFI = 0.90, AGFI = 0.86, CFI = 0.87, TLI = 0.84, RMSEA = 0.07, $p = 0.01$.

To improve the goodness of fit statistics, modification indices were analyzed to determine the existence of residual correlations between the items. Three covariances among error terms of observed variables

Table 4
Convergent and divergent validity assessment for CoastADAPT scale constructs.

	CoastADAPT scale constructs			
	E-CRP	EP	RA	EJ
Convergent Validity				
Coastal erosion probability perception	0.39**	0.36**	0.37**	0.09
Coastal flooding probability perception	0.41**	0.35**	0.41**	0.13**
Divergent Validity				
Skepticism: coastal risk processes	-0.24**	-0.23**	-0.25**	-0.02
Skepticism: anthropogenic influence on coastal hazards	-0.18**	-0.10**	-0.24**	-0.06

**Correlation is significant at a level of significance of 0.01 (with a two-tailed hypothesis).
RPE Coastal constructs: E-CRP = Engagement with coastal risks processes, EP = Experiential processing, RA = Risk awareness, EJ = Environmental justice

within the same factor were added. From the analyses of the Mahalanobis D^2 values, six multivariate outliers were detected and thus removed. Further to the performed misspecifications, the fit indices show that the proposed model is adequate ($\chi^2 = 157.17$, df = 84, χ^2/df = 1.87, $p < 0.001$, GFI = 0.90, AGFI = 0.86, CFI = 0.91, TLI = 0.88, RMSEA =0.06, $p < 0.001$), confirming the 3-factor structure of the CoastADAPT scale (Fig. 1).

4. Discussion

Coastal communities' well-being has been seriously affected (Sinay and Carter, 2020), as the inhabitants of coastal areas have been continuously confronted with minor or major events such as storm surges, coastal erosion and/or flooding (Lemée et al., 2019). Climate change brings heightening coastal hazardous processes, making it urgent to design and implement effective adaptive measures for increasing coastal communities' and coastal ecosystems' resilience to the posed threats. Participatory approaches of coastal management are considered

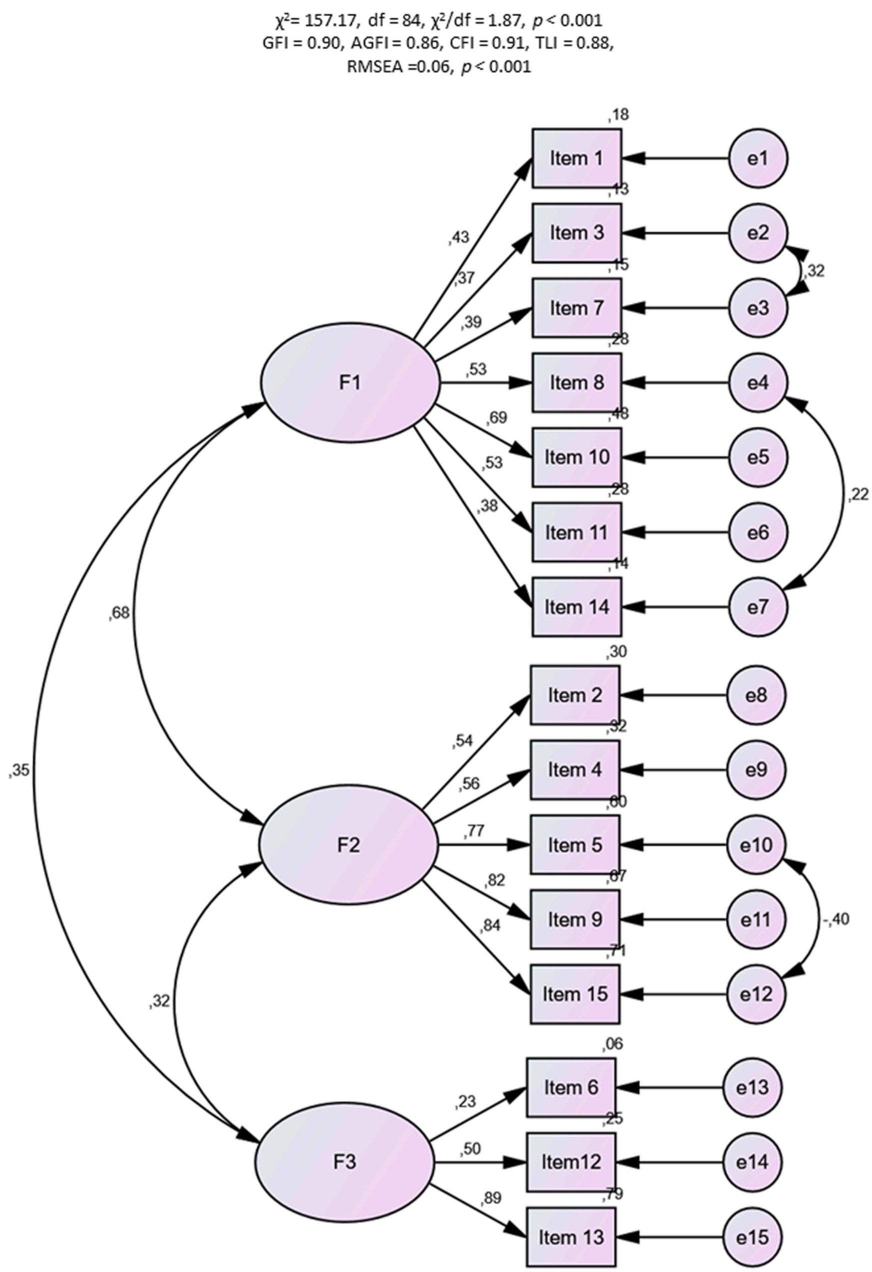

Fig. 1. Final model of the CoastADAPT scale.

critical to the success and sustainability of adaptation processes to coastal risks (Creed et al., 2018). Yet, barriers related to citizens' engagement in such processes persist and are proven to compromise the success of the implementation of coastal adaptation strategies (McKinley et al., 2021).

In response to the above-mentioned barriers regarding the implementation of participatory initiatives of coastal management, the goals of this study were to develop and validate a pioneer scale (CoastADAPT scale) to measure citizens' engagement in coastal risk adaptation processes and to identify the factors explaining such engagement. The CoastADAPT scale was thoroughly designed to have the potential to provide a deeper understanding of the citizens' active involvement is coastal risk processes and to determine its social-psychological determinants. Furthermore, the CoastADAPT scale may be a valuable tool for future research and/or initiatives aiming at developing evidence-based strategies to overcome the barriers related to citizens' engagement in coastal management.

The analyses carried out confirm the good psychometric properties of the 15-item CoastADAPT scale, particularly its reliability (internal consistency and test-retest reliability) and construct validity (convergent and divergent validity). Therefore, individuals' engagement in coastal adaptation processes can be measured on one continuous dimension ranging from low-to high-engagement. This is, individuals with low-engagement in coastal risk adaptation processes tend to demonstrate lower levels of coastal risk perception and a disengagement from coastal management and/or climate action. Whereas, individuals with high-engagement with coastal risk adaptation processes not only tend to demonstrate a heightened coastal risk perception, facilitated by knowledge and/or personal experience, but also demonstrate willingness to participate in coastal management and/or to take climate action.

Furthermore, from the Exploratory Factor Analysis conducted in Phase 1 studies, it was possible to ascertain that the citizens' engagement in coastal risk adaptation processes is explained by three components, accounting for ≈ 46% of the total variance: *Experiential Processing* (Factor 1), *Risk Awareness* (Factor 2) and *Environmental Justice* (Factor 3). Subsequently, in the Phase 2 study, the values of the various fit indices obtained from the Confirmatory Factor Analysis further justified the pertinence of the 3-factor structure of the CoastADAPT scale.

The dimension *Experiential Processing* (Factor 1) is measured by 7 items (items 1, 3, 7, 8, 10, 11, and 14). This dimension consists of a strong affective component and is a non-rational dimension (Epstein, 1994) of risk perception and engagement in coastal adaptation processes. The experiential processing is particularly driven by affect (Epstein, 1994; Finucane, 2012; Slovic et al., 2007; Zajonc, 1980), in which the respondent relates coastal risks to memories of one's own or others' experience, which tend to be dominant in information processing and judgment (Slovic et al., 2007), or may be facilitated by an emotional affinity toward nature (Kals et al., 1999; Schultz, 2002). Experiential processing often leads to emotion-, value-driven decisions and attitudes (Marx et al., 2007; Slovic et al., 2007; Zajonc, 1980), such as the willingness to participate in coastal management initiatives or to adopt pro-environmental behaviors.

The dimension *Risk Awareness* (Factor 2) is measured by 5 items (items 2, 4, 5, 9, and 15). This dimension consists essentially of a cognitive and rational component of engagement in coastal adaptation processes (Zaval and Cornwell, 2016). Particularly, it is related to the respondents' understanding, perception and judgement of coastal risk, particularly its drivers (D), pressures (P), states (S) and impacts (I), according to the DPSIR framework (Gari et al., 2015).

Finally, the dimension *Environmental Justice* (Factor 3) is measured by 3 items (items 6, 12, and 13). This dimensions consists of a social value orientation component of engagement in coastal adaptation processes. Adapted from Dobson (1999), this dimension is based on the notion that coastal hazardous processes are disproportionately suffered by coastal communities and on the assumption that environmental justice is only achievable exclusively through adaptation processes (e.g., compensation of coastal communities' inhabitations following coastal hazards, shared responsibility to reduce coastal communities' exposure to coastal threats).

In summary, individuals' engagement in coastal adaptation processes seem to depend on the interplay of affective, cognitive and social value orientation dimensions. These components must be considered when developing strategies to promote public engagement in coastal management, instead of solely relying on traditional forms of transferring scientific information and knowledge resources, which have already been proven to fail (Areia et al., 2019; Tavares et al., 2020; Tribbia and Moser, 2008). Aligned with the results of this study, past research has already demonstrated that the affective dimension of risk is a strong motivator of behavior (Slovic and Peters, 2006) and that social value orientation predict greater involvement in environment-related problems and action taking (Joireman et al., 2001). Therefore, it is possible to argue that tailoring community interventions to target the affective, cognitive and social value orientation dimensions of coastal risks, may result in an augmented engagement of citizens in coastal management and thus in a greater success of the adaptation processes.

4.1. *Strengths*

The present evaluation of the CoastADAPT scale is encouraging. A robust set of statistical analyses has demonstrated the good psychometric properties of the CoastADAPT scale, showing it to be a reliable and valid measure of citizens' engagement in coastal risk adaptation processes. The development and validation of such a pioneering scale has the potential to be an opening move towards a deeper understanding of citizens' engagement in risk management processes and of the social-psychological predictors of such involvement. Greater knowledge on the factors predicting public participation in coastal management, may prompt the development of tailored, community-based interventions and/or initiatives effective at enhancing citizens' active engagement in coastal adaptation processes.

4.2. *Limitations and future research*

Despite the robustness of the testing described above, this study has some limitations. Results presented here cannot be extrapolated to the entire Portuguese population, since it was not used as stratified random sampling. Furthermore, as far as we know, gold-standard measures for the purpose of construct validity studies are not available to the Portuguese population. Therefore, construct validity studies relied exclusively on the statements developed by the research team. For future studies, it is strongly recommended to conduct construct validity studies using gold-standard measures. Finally, the CoastADAPT scale was only validated for the Portuguese population. Future studies are encouraged to conduct cross-cultural validation of the CoastADAPT scale, in order to ascertain its psychometric properties in different cultural and geographical contexts.

5. Conclusion

To best of our knowledge, the CoastADAPT scale is the first assessment tool of an individual's engagement with coastal adaptation processes. The scale demonstrates good psychometric properties and comprises three dimensions related to affective, cognitive and social value orientation components of engagement with risk adaptation processes. The CoastADAPT scale has the strong potential of providing a deeper understanding of the factors associated with individuals' involvement with coastal risk processes and, as a result, to facilitate the development of evidence-based strategies to promote public participation in coastal management.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2022.03.011.

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