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Understanding technological, cultural, and environmental motivators explaining the adoption of citizen science apps for coastal environment monitoring

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ABSTRACT

Environmental and nature conservation authorities are calling for a collective effort to break or reduce the current cycle of environmental degradation. Much of the response depends on scientific knowledge production based on thematically and geographically comprehensive datasets. Citizen science (CS) is a cost-effective support tool for scientific research that provides means for building large and comprehensive datasets and promoting public awareness and participation. One of the greatest challenges of CS is to engage citizens and retain participants in the project. Our work addresses this challenge by (1) defining the role that technological, cultural, and environmental dimensions play in the adoption of CS apps for coastal environment monitoring, and (2) providing base knowledge about the profile of the apps' most likely users and the functional features they require to be successful. Collectivists and people who assume a green identity are the most likely users of these apps. Drivers of their use are the promotion of citizen empowerment, habit development, provision of facilitating conditions, and proof of environmental performance.

The outcome of this study is a set of guidelines for project managers, app developers, and policymakers for citizens' engagement and retention in CS coastal environment monitoring projects through their apps.

1. Introduction

The unprecedented level of exploitation of our planet's resources, biosphere pollution, the introduction of non-indigenous species, habitat degradation, and climate change are causing various threats to nature and human lives, health, and well-being (O'Hara et al., 2021). Climate change impacts such as global warming, glacier melting, sea-level rise, extreme weather events (e.g., heat waves, floods, hurricanes, wildfires, droughts), and increasing carbon dioxide in the atmosphere are depleting natural and cultural values and resources and simultaneously putting local, regional, and global economies at risk (McMichael & Lindgren, 2011; Ward et al., 2020). The global community is currently trying to respond to the numerous fronts of environmental degradation, namely the impacts of climate change and the great biodiversity crisis (Fajardo et al., 2021).

During the United Nations (UN) Summit on Biodiversity, the heads of state and governments of 64 countries (today 91) of all World regions, and the President of the European Commission signed the Leaders' Pledge for Nature in September 2020, committing to a concerted and effective response to current and future global environmental crises (United Nations, 2020; European Commission, 2021). Only a collective effort can break the current cycle of environmental degradation, starting by accomplishing the UN Sustainable Development Goals (SDGs) until the year 2030 (United Nations, 2021).

The UN SDGs depend on the datasets provided by official sources, which have some cost, time, and heterogeneous data availability limitations, undermining the UN SDGs reporting process. Regarding these limitations, Fritz et al. (2019) argued that Citizen Science (CS), or Public

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Participation in Scientific Research (PPSR), is a promising means for tracking the progress of the UN SDGs by providing new opportunities to (1) acquire data at lower costs, (2) achieve more extensive data coverage and variability across and within nations, and (3) promote data transparency. CS depends on voluntary participation by citizens to contribute to scientific work (e.g., data collection, analysis, interpretation, and dissemination) usually coordinated by a team of professional scientists (Assumpcao et al., 2019; Haklay, 2013). Haklay (2013) identified two types of participants in CS: i) people who enjoy scientific work and see it as a hobby, and ii) people pursuing environmental justice – usually as part of a local community that is conscious of, or affected by, environmental conflicts, who seek a solid evidence base to capture the attention of policymakers and decision-makers.

CS is growing worldwide in marine and coastal ecological matters such as climate change (Marlowe et al., 2021), marine litter and debris (Papakonstantinou et al., 2021; Uhrin et al., 2020), environmental status assessment of communities, and habitats (Johnson et al., 2020; Turicchia et al., 2021), beach erosion (Pucino et al., 2021), early detection of invasive species (Datta et al., 2021; Sullivan & York, 2021), phytoplankton seawater discolorations (Siano et al., 2020), inland and coastal water quality (Malthus et al., 2020; Menon et al., 2021), microplastics (Camins et al., 2020), threatened species (LaRue et al., 2020), noise and air pollution (El-Kholei, 2020), and other areas of concern. Nevertheless, their success may be undermined by one very common setback in CS: the struggle to maintain citizens' motivation for continuous and sustained long-term participation (Kloetzer et al., 2021; Paul et al., 2020). It is in this critical issue that we seek to contribute by bridging existing gaps in prior research on this subject, as (1) we still need to understand the factors driving CS coastal environment monitoring projects in order to achieve greater success, a problem intrinsic to the gains to be made through their digital platforms (Newman et al., 2012; Tsybulsky, 2020); (2) past literature has mainly studied the motivations to participate in CS environmental monitoring projects but rarely the drivers to use their digital platforms – hereinafter CS apps – as these are primarily mobile app-based (Aitkenhead et al., 2014; Lemmens et al., 2021).

Our work provides two major contributions to this objective: (1) we define the role that technological, cultural, and environmental dimensions (retrieved from prominent models and theories) play in the adoption and use of CS apps for coastal environment monitoring; and (2) we provide base knowledge and guidelines for the effective design and promotion of new CS apps for coastal environment monitoring, including the profile of the most likely participants/app users, the features and services the app must offer to be successful, and the values to be fostered for citizens' engagement and retention. We address the following research questions:

(1) What are the main drivers of environmental CS apps adoption?
(2) How do individuals' beliefs and technology characteristics influence environmental CS apps adoption?

In answering these questions, the remainder of the paper is structured as follows. Section 2 provides a literature review; Section 3 includes the research model and its hypotheses; Section 4 describes the data collection process; Section 5 presents the results; Section 6 the discussion, implications, and limitations; and Section 7 closes with the conclusions.

2. Theoretical background

2.1. Citizen science for environmental monitoring

The concept of Citizen Science (CS) – generically, the participation of citizens in the production of scientific research and its related terminologies, have been recently explored by several authors with expertise in the matter (e.g., Eitzel et al., 2017; Fan & Chen, 2019; Haklay et al., 2021). A consensus exists that the definition of CS may be context-sensitive. Multiple research fields see value in CS, and their actors define it based on different norms, methodologies, values, and expectations around the co-production of knowledge, and according to the different objectives and goals outlined for their CS activities (Haklay et al., 2021). The evolution of the CS concept over time between disciplines and across borders is exposed in detail elsewhere (Eitzel et al., 2017; Fan & Chen, 2019; Haklay et al., 2021; Kullenberg & Kasperowski, 2016).

CS has been described as a participatory approach and support tool for scientific research that allows for continuous and geographically comprehensive data collection and processing at lower costs. It brings potential benefits from the production and dissemination of scientific knowledge to improve literacy, thereby raising citizen awareness and engagement with public interest issues (Eitzel et al., 2017; Johnson et al., 2014). Another strand of CS, originated by Irwin (1995, p. xi) from the social sciences, describes it as a means of science democratization –" (…) a science which assists the needs and concerns of citizens (…) developed and enacted by citizens themselves (…)" – in which citizens are part of the scientific decision-making processes (Kullenberg & Kasperowski, 2016). Though representing polarized views of CS, the "productivity view" (as a tool for increasing scientific knowledge production) and the "democratization view" defined by Sauermann et al. (2020), can be integrated to meet current sustainability challenges where environmental and socioeconomic issues cross (Sauermann et al., 2020). The exchange of experience among disciplines is encouraged for future developments in CS (Hecker et al., 2018).

CS projects have various purposes, for instance: regional and global environmental justice; modification of individual and collective behaviors; better human health and safety; sustainable management and development; and base knowledge for improved multidisciplinary strategies and policymaking (Johnson et al., 2014). In Europe, by 2016 CS projects of natural and life sciences (e.g., ecology, environmental sciences, and biology) represented>80 % of all CS projects (Hecker et al., 2019).

CS projects are often categorized according to different levels of involvement, as proposed by Bonney et al. (2009): i) contributory projects – representing the lowest level of involvement and encompassing the majority of existing CS projects (Hecker et al., 2019) – in which participants contribute to data collection only using protocols exclusively designed by professional scientists; ii) collaborative projects, in which participants can contribute with their own ideas to adjusting the project's pre-defined protocols, analyzing data, and disseminating conclusions; iii) co-created projects – representing the highest level of involvement – in which participants are involved in all steps of the project. Subsequently, the "Do-It-Yourself Science" model emerged, in which citizens can be autonomous in all steps of the research, including the definition of the research topic and project goals, without the leadership, coordination, or involvement of professional scientists (Figueiredo Do Nascimento, 2014; Sauermann et al., 2020). As the level of involvement increases, so does social capital, collective knowledge, scientific capacity, and inclusiveness in decision-making processes, making CS projects more sustainable (Robinson et al., 2021). The type of involvement planned for the CS project will determine the level of investment in it (Robinson et al., 2021). CS projects' budgets are often limited; most CS projects have opted for less involvement of the citizens, which means less investment in their software and, consequently, less motivation for long-term participation (Robinson et al., 2021).

Several studies have identified success drivers of CS participation, and it is well accepted that citizens must feel motivated to volunteer. San Llorente Capdevila et al. (2020) developed a systematic literature review to identify the success factors of CS projects in water quality monitoring, highlighting citizens' knowledge and experience, environmental awareness, motivation, and socio-economic background, along with institutions' motivation, type of organization, and adequate funding. Another review on citizen scientists' motivations, developed by Lee et al. (2018), indicated four compelling motivations on the part of potential participants: contributing to science (the most effective), helping professional scientists, learning about science, and joining a community (the least effective). CS projects require an adequate number of participants to be engaged in their activities over a generous time frame (Luna et al., 2018). However, mobilizing participants and sustaining engagement are some of CS projects' main challenges (De Rijck et al., 2020). Thus, it is essential to address what drives people to adopt and use CS apps for environmental monitoring projects. Nevertheless, we still lack quantitative data on environmental CS apps' adoption, making it challenging to assess citizen scientists' intention to use them (San Llorente Capdevila et al., 2020).

2.2. The role of technology in CS projects

The widespread dispersal of internet-capable mobile phones, derived from the significant cost reduction of these devices and their storage systems, paired with the evolution of Global Positioning Systems (GPS), qualify them as scientific instruments for CS initiatives (Ashraf et al., 2021; Haklay, 2013). Besides the innovations in sensor technologies, social networks have also evolved and derived into multiple new tools that can be integrated into mobile or web-based apps (Robinson et al., 2021). CS apps today aim to provide scientists, managers, surveyors, and local authorities the means to closely observe trends and make timely responses to problems that may emerge (De Rijck et al., 2020). Thus, CS apps are useful for environmental monitoring, for instance, to evaluate the impacts and the effects of protection measures inside and outside marine protected areas (Garcia-Soto et al., 2021).

One of the main challenges of CS projects and their apps is to drive motivation for sustained participation, as participants' motivations, interests, and availability (which are mutable) must correspond somehow to the projects' motivations and their digital platform's capacity (Golumbic et al., 2020). Thus, motivations for CS participation and how citizens interact with CS projects and platforms must be carefully examined to choose appropriate citizen engagement tools and to predict behavior intention of citizen participation and retention (Cox et al., 2018; Golumbic et al., 2020). Understanding participants' motivations to adopt CS apps will also improve the project's cost-effectiveness, especially in the recruitment and retention processes (Alender, 2016).

Data quality and recognition by the scientific community are also challenges facing CS (Turrini et al., 2018). Data quality may be compromised by poor project design, varying data quality standards, non-experts' lack of commitment and skills, deliberate provision of fabricated data, and others (Balázs et al., 2021; Weber et al., 2019). Still, project elements and digital platforms can be designed to avoid, detect, and correct data issues (Kosmala et al., 2016; San Llorente Capdevila et al., 2020; Kasten et al., 2021). Relatedly, insufficient funding and resources are often pointed out owing to CS projects' duration (usually these are long-term projects and funding is temporary), and difficulty in evaluating them following the traditional funding frameworks (Gunnell et al., 2021; Hecker et al., 2018; Turrini et al., 2018). In this regard, CS projects must provide clarity on their necessities and develop evaluation tools that make use of appropriate indicators, and current funding programs must account for the iterative design process of CS (Hecker et al., 2018).

The potential of CS apps increases with the near real-time availability of data visualization and processing tools, complemented by public online access to information sources (De Rijck et al., 2020). Furthermore, using these devices seems to increase public engagement and awareness and help solve common CS data quality issues generated by human error (Newman et al., 2012; San Llorente Capdevila et al., 2020). CS is, by definition, an inclusive process seeking to involve a specific or diverse community in a scientific mission. This makes it imperative to study the traits and motivations of that community (Golumbic et al., 2020). Participants should be provided the opportunity to be involved in the design process of the CS app, thereby working together with developers, scientists, and other stakeholders to achieve a more suitable and satisfactory system to increase the likelihood of success in CS projects (Robinson et al., 2021).

2.3. Technology adoption models

The use of CS apps for coastal environment monitoring depends upon a series of factors, from technical (i.e., those related to the technology itself) to non-technical (i.e., those pertaining to each individual and their inner and external beliefs). Therefore, we must use the right theoretical lenses to understand the main drivers behind it. With this in mind we looked into the published literature in the information systems field for the main theories that could explain such platforms' adoption and use. In the end we combined four theories in a tailor-made comprehensive conceptual model for investigating the adoption of CS apps. These are:

(1) UTAUT 2, arguably the most prominent IT adoption theory in the information systems field, which focuses on technological and social factors driving technology adoption and use (Venkatesh et al., 2012; Venkatesh et al., 2003);
(2) Citizen Empowerment, which evaluates the influence of personal beliefs/ motivations on citizen participation success (Rappaport, 1987; Spreitzer, 1995; Zimmerman & Rappaport, 1988; Zimmerman, 1995);
(3) Green self-identity, which assesses the effect that environmental awareness and personal values have on pro-environmental behavior (Barbarossa et al., 2017; Sparks & Shepherd, 1992); and.
(4) Hofstede's cultural dimensions, which assess cultural variation in an individual's values, beliefs, and behaviors (Hassan et al., 2011; Srite & Karahanna, 2006).

The reasons for choosing these models are detailed in the following sections. However, considering the unique characteristics of CS apps for coastal environment monitoring, especially the mix between inner (environmental) beliefs and technology aspects, we felt the need to develop a specific model combining different features of those that are already well-established. In other words, we did not find the most important aspects of environmental CS apps covered in earlier theories.

2.3.1. Unified theory of adoption and use of technology (UTAUT-2)

To assess the drivers for adopting and using information and communication technologies (ICTs), which typically host CS apps, we chose the Unified Theory of Adoption and Use of Technology (UTAUT). The UTAUT model (Venkatesh *et al.*, 2003), including its extension UTAUT-2 (Venkatesh et al., 2012), is arguably the most prominent theory of technology adoption and use (Blut et al., 2022). Venkatesh et al. (2003; 2012) combined eight recognized theories, resulting in a single model with seven constructs: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit, which together provide vital information on both the technological and social factors influencing technology's potential users. UTAUT-2 has been consistently demonstrated to be useful in explaining technology adoption in a wide variety of settings. For instance, Taghizadeh et al. (2021) used this model to find the determinants of students' satisfaction and continuous usage intention of online learning during the COVID-19 pandemic. Another example is Li (2021), who used it to understand the factors influencing the intention to adopt E-Government.

Though its representation in CS studies is still sparse, UTAUT-2 constructs are relatable to the technology's characteristics and motivational factors identified for CS participation. We have adapted this theory's original constructs to the topic and chose to exclude "price value" – which defines the extent to which users are willing to spend their money in exchange for the benefits brought by the technology (Venkatesh et al., 2012) – as it was considered unsuitable for the nature

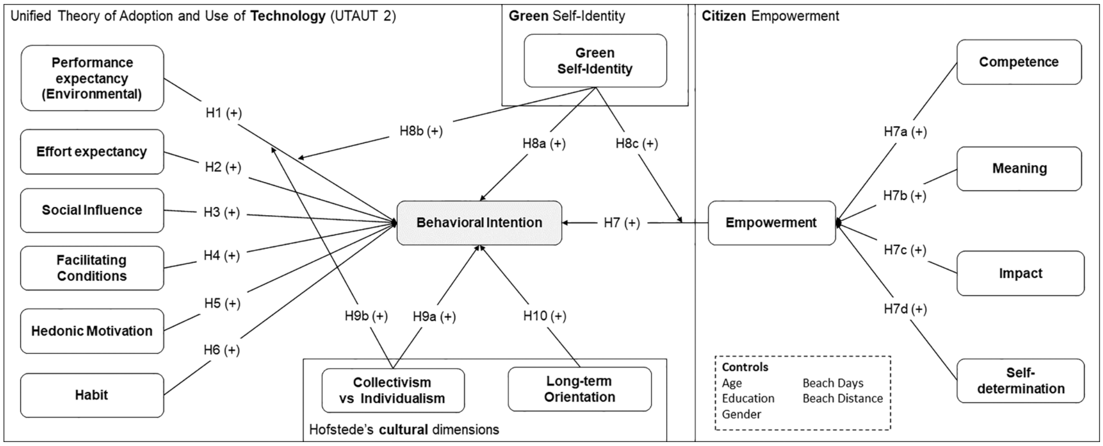

Fig. 1. Research model.

of the voluntary work proposed by CS apps, which are free.

2.3.2. Citizen empowerment

The key to the success of citizen participation projects, such as CS apps, is motivating individuals, as citizens, to participate in them (hence the term CS). We therefore screened the literature for a theoretical lens focused on understanding the factors influencing people's intention/motivation to volunteer for public causes. Citizen Empowerment is one of the leading models mentioned in studies assessing citizen participation drivers. In the context of the psychological empowerment theory (Rappaport, 1987; Zimmerman & Rappaport, 1988; Zimmerman, 1995), Citizen Empowerment results from the relationship between the citizen's perception of their skills and their willingness to apply them in public domain services (Naranjo-Zolotov et al., 2019). It proposes that empowerment, its main dimension, is a second-order construct comprising competence, meaning, impact, and self-determination (Spreitzer, 1995).

Citizen Empowerment has already been integrated with UTAUT-2, with relative success. For instance, Naranjo-Zolotov et al. (2019) used these to design a research model to investigate the adoption drivers of e-participation – a derivation of e-government for citizens' engagement and participatory governance through ICTs. They found that the Citizen Empowerment constructs of competence, meaning, impact, and self-determination were positively related to e-participation. Interestingly, these constructs are also widely used concepts to characterize individuals' motivations for initial and continuous long-term participation in CS projects (Geoghegan et al., 2016; Golumbic et al., 2020; Gonçalves et al., 2014; van Noordwijk et al., 2021; Wehn & Almomani, 2019).

2.3.3. Green self-identity

Together with individuals' willingness to act as citizens, another strong driver of CS apps adoption is the extent to which one values the environment and environmental issues. It seems reasonable to assume that people involved in pro-environmental projects do so because they are sensitive to this issue and will very likely adopt environmentally friendly behaviors in other aspects of their lives. We therefore resort to green self-identity, which is a construct determining the adoption of pro-environmental behavior (Barbarossa et al., 2017). If one sees himself/herself as a green individual, he/she will score high on the green self-identity measure (Barbarossa et al., 2017).

2.3.4. Hofstede's cultural dimensions

Finally, in addition to the two previous aspects of CS apps adoption, we also believe that one's cultural beliefs can play a critical role. Hence, we looked at Hofstede's cultural dimensions to assess how cultural context can influence participants' values, beliefs, and behaviors in society. It is one of the most noteworthy theories in studies assessing a national culture's effects on multiple domains (Kumar et al., 2019). In the 1980 s Hofstede hypothesized that cultural variation drives people's beliefs and behaviors and initially identified four dimensions to explain it: the power of distance, uncertainty avoidance, individualism versus collectivism, and masculinity versus femininity; later adding a fifth dimension – long-term orientation (Nagy & Molnárné, 2018). In our study's context we chose to focus on two of these dimensions, which we believe are especially suitable to explain pro-environmental behavior: collectivism (versus individualism) and long-term orientation. The first is the degree to which the society's identity is shaped from the individuality of its members rather than from a social group (Hofstede, 2001). Individualists cherish their sense of freedom and autonomy, whereas collectivists can more easily concede these values for the greater good of their social group (Kaasa & Andriani, 2021). The second dimension is the degree to which the focus of individuals is on the future and not on the present/past (Nagy & Molnárné, 2018). Long-term-oriented individuals are committed to hard work for a future cause (Sreen et al., 2018), such as reversing or diminishing the regional and global impacts from the environmental crisis in which we are living.

3. Research model and hypotheses

We present the research model in Fig. 1 to investigate the drivers of adoption and use of CS apps for coastal environment monitoring and understand the relationships among users' perceived values. We have integrated the four theories presented above into a tailor-made, comprehensive research model for the specific case of CS apps.

3.1. Utaut 2

In this subsection we summarize the definition of each construct within UTAUT-2 (Venkatesh et al., 2012) as well as the rationale for each specific CS apps hypothesis.

3.1.1. (Environmental) performance expectancy (EPE)

Performance expectancy is the degree to which the technology benefits individuals (Venkatesh et al., 2012). Herein we adapted the concept to environmental performance expectancy, i.e., the degree to which the goals and objectives proposed by the environmental CS apps are achieved through the technology. From a logical point of view users must recognize the usefulness of the technology to consider adopting it

(Shevchuk & Oinas-Kukkonen, 2020). In this regard, it should be said that performance expectancy is usually indicated to be one of the most important drivers of technology adoption in many areas. Thus, we hypothesize that environmental performance expectancy will also positively affect CS apps adoption.

H1: Environmental performance expectancy (EPE) is positively associated with CS apps behavioral intention (BI).

3.1.2. Effort expectancy (EE)

Effort expectancy is the degree of ease associated with using technology (Venkatesh *et al.*, 2003; Venkatesh et al., 2012). Naturally, the perception of having to face difficulties to use technology will serve as a deterrent for its adoption. We believe that in CS apps this is even more important because not only is their use voluntary, but also the potential CS apps' benefits are not as much for the individual but for the whole community in the long term (Naranjo-Zolotov et al., 2019). Thus, the perceived lack of time for the voluntary act is even more of a discouragement for participation (West & Pateman, 2016). Main short-time interactions in these platforms include: consulting online open-access information sources, entering/uploading observed data (e.g., text, image, audio, time, GPS coordinates), data processing, and visualization of the uploaded records; while interactions that may take more time are data analysis and validation (usually performed by professional scientists) (Garcia-Soto et al., 2017; Luna et al., 2018).

Effort expectancy is operationalized in terms of perceiving technology to be easy (effortless) to use and we therefore hypothesize:

H2: Effort expectancy (EE) is positively associated with the behavioral intention (BI) of using CS apps for coastal environment monitoring.

3.1.3. Social influence (SI)

Social influence refers to the user's idea of how a social group perceives his/her identity, personality, or social image as a result of membership (Ashraf et al., 2021). As such, social influence is widely regarded in the literature as a determinant of pro-environmental behavior (Estrada et al., 2017; Göckeritz et al., 2010). Chao et al. (2021) claim that the perceptions and support of significant others might similarly influence pro-environmental behavior, based on testimonials from citizen scientists of CS apps on waterbird refuges. Bouman et al. (2020) also found that individuals who initially underestimate biosphere values (non-humanized environmental concerns) are more likely to increase their environmental engagement if their social group strongly endorse those same values. Hence, we hypothesize:

H3: Social influence (SI) is positively associated with CS apps BI.

3.1.4. Facilitating conditions (FC)

Facilitating conditions measure the degree of perceived support, training, and availability of resources to the technology user (Venkatesh et al., 2012). Access to facilitating conditions such as data availability, guidance, and training is paramount in CS apps to promote citizens' awareness, motivation, and self-efficacy (San Llorente Capdevila et al., 2020). An adequate support system is also essential to ensure input data quality and to foster trust between citizen scientists and project managers (De Rijck et al., 2020; San Llorente Capdevila et al., 2020).

For instance, Kasten et al. (2021) conducted a participatory coastal biodiversity monitoring project with>51 participants. They checked for similarities between their data and data collected by experts and concluded that higher complexity tasks could interfere with data quality and highlighted the importance of identifying participants' main challenges for developing adequate CS protocols. For these reasons we hypothesize that:

H4: Facilitating conditions (FC) is positively associated with CS apps BI.

3.1.5. Hedonic motivation (HM)

Hedonic motivation is the degree of perceived enjoyment derived from using technology (Ashraf et al., 2021). Citizens motivated to use technology due to its perceived enjoyment are more prone to develop the habit of using it (Ashraf et al., 2021). In the context of citizen science, hedonic values such as enjoyment, recreation, and social interaction (especially within a community that shares similar interests) are motivations that improve the chances of citizens' participation in volunteer activities (Land-Zandstra et al., 2021; van Noordwijk et al., 2021). Therefore, we posit that:

H5: Hedonic motivation (HM) is positively associated with CS apps BI.

3.1.6. Habit (HA)

Both conscious (intention) and unconscious (habit) decision-making affect human behavior (Ashraf et al., 2021). Habit measures the extent to which an individual believes the behavior to be automatic (Limayem et al., 2007). As CS apps are recent and mostly unknown, we have redirected habit to public participation apps in general. Usually, public e-participation projects are intended to design apps that successfully recruit and engage citizens for active, long-term participation (Tinati et al., 2017; Naranjo-Zolotov et al., 2019). Experts involved in developing technology adoption models and using them widely recognize the variable "habit" to contribute positively to the continuous use of the technology (Venkatesh et al., 2012; Naranjo-Zolotov et al., 2019). Thus, we hypothesize that:

H6: Habit (HA) is positively associated with CS apps BI.

3.2. Citizen empowerment

In this subsection we summarize Citizen Empowerment's four first-order constructs (competence, meaning, impact, and self-determination) as well as the second-order formative-reflective one (empowerment).

3.2.1. Competence (CO).

Competence is defined as the degree of perceived self-efficacy (or competence) to perform a task with skill (Spreitzer, 1995). Gonçalves et al. (2014) applied the psychological empowerment theory principles to study the motivation drivers for citizen participation. They concluded that perceived competence is one of the main drivers of participation.

3.2.2. Meaning (ME)

Meaning is the degree of the perceived value of a determined goal or purpose, according to the individual's ideals or standards (Spreitzer, 1995). Regarding community-based environmental monitoring, citizens usually attribute more meaning to a purpose when they feel they are involved at the strategic level, which is associated with self-determination (Wehn & Almomani, 2019). Contributory projects, i.e., projects initiated and regulated by scientists that involve citizens only in pre-determined data collection tasks, present low levels of engagement when compared to inclusive projects, such as co-created CS projects (Golumbic et al., 2020). In co-created CS projects, citizens are involved at all phases of the scientific process, including the choice of research direction. Thus, the perceived value/meaning of the project's goals and outcomes is/are enhanced compared to contributory or collaborative projects, along with citizens' willingness to collaborate (Gunnell et al., 2021; Sauermann et al., 2020).

3.2.3. Impact (IM)

The impact is the degree to which an individual's behavior or action appears to produce the desired effects for a determined purpose (Spreitzer, 1995). In this study's context, environmental impact-motivated citizens are those who want to make a difference to science or an ecological issue. Acknowledging the impacts of their actions concerning the outlined objectives has proven to be one of the greatest motivations for their participation in environmental CS projects (van Noordwijk et al., 2021). Therefore, it is essential in these initiatives that the participant is aware of the whole process beyond data collection –

how data are treated and used to make a difference – and what results have already been achieved by the project (van Noordwijk et al., 2021). In this regard, one of the Ten Principles of Citizen Science defined by ECSA is that "Citizen scientists are acknowledged in project results and publications".

3.2.4. Self-determination (SD)

Self-determination is the degree to which an individual senses that he/she has the autonomy to make decisions over the work process – initiative and regulation (Spreitzer, 1995). Ryan and Deci (2000) developed the self-determination theory and the cognitive evaluation sub-theory to explain variability in intrinsic motivation – the individual's motivation to engage in an activity for the simple pleasure of performing it. By contrast, they also explain extrinsic motivation – the individual's motivation to engage in an activity to achieve an outcome that is external to that activity. In this scope, Tiago et al. (2017) express the importance of nurturing intrinsic motivation in addition to extrinsic motivation instruments (e.g., prizes, certificates, etc.) in encouraging CS. The self-determination theory argues that while intrinsic motivation instruments result in higher achievement, extrinsic motivation instruments can undermine citizens' engagement and activity performance, especially if they perceive it as a form of external control (Ryan & Deci, 2020).

3.2.5. Empowerment (EM)

Empowerment, as a motivational construct, creates conditions for increased motivation for production by expanding the sense of personal efficacy (Sreelakshmi, 2016). In the scope of public participation in scientific research, citizens can get more involved in such initiatives if these are participatory in nature (Wilmsen et al., 2012). If citizens are given the opportunity to use their experience and be part of the decision-making process, and choose to embrace it, they will more likely feel empowered by the process itself and become more interested in its outcomes (Gunnell et al., 2021; Shirk et al., 2012). Deeper involvement in the process and personal contribution to its outcomes will also promote increased awareness, learning, and willingness to change individual and the community's attitudes (Sauermann et al., 2020).

Naranjo-Zolotov et al. (2019) found that psychological empowerment and its first-order constructs of competence, meaning, impact, and self-determination, positively influence the intention to engage in e-participation. Therefore, based on the evidence, we posit that:

H7a-d: Empowerment (EM) is a second-order formative-reflective construct formed by competence (H7a), meaning (H7b), impact (H7c), and self-determination (H7d) that positively influences CS apps BI.

3.2.6. Green self-identity (GSI)

Participating in CS projects is a form of pro-environmental behavior (Chao et al., 2021). Pro-environmental behaviors may result from altruistic feelings about nature (Chao et al., 2021). In fact, "helping the environment" was widely documented as one of the main motivations for participating in conservation projects (Bruyere & Rappe, 2007; Clary & Snyder, 1999; He et al., 2019). Hart et al. (2011) argued that individuals with strong environmental values are more concerned about how the government is managing environmental issues. Thus, they are also more prone to engage in the management process (Johnson et al., 2014). With this in mind we hypothesize that individuals who recognize a green identity in themselves are more likely to use CS apps. Therefore:

H8a: Green self-identity (GSI) is positively associated with CS apps BI.

We also believe that green self-identity will reinforce the effect of EPE and EMP on BI. It seems reasonable to assume that for someone who score higher on GSI, the eventual performance CS apps will have on monitoring coastal areas, and ultimately protect the environment will be more important than to one who scores lower on GSI, i.e., for whom environmental issues are not that important. The same rationale applies to EMP as the sense of empowerment will be increasingly important as one's GSI is also higher. Hence, we posit that:

H8b: Green self-identity will moderate the effect of EPE on CS apps BI, such that the relationship will be stronger among individuals with greater green self-identity.

H8c: Green self-identity will moderate the effect of EMP on CS apps BI, such that the relationship will be stronger among individuals with greater green self-identity.

3.2.7. Hofstede's cultural dimensions

This subsection explains the potential role of Hofstede's collectivism (versus individualism) and long-term orientation cultural dimensions in influencing CS participants' values, beliefs, and behaviors in society.

Collectivism versus individualism and long-term orientation are widely accepted in the literature to explain cultural variation in green purchase intention – a "private-sphere" pro-environmental behavior (Mi et al., 2020; Sreen et al., 2018). Mi et al. (2020) classify the act of participation in environmental protection activities as a "public-sphere" pro-environmental behavior if it contributes to the promotion of environmental regulations, policies, and activities. In this study, we consider the act of participating in a CS project for coastal environment monitoring to be a "public-sphere" pro-environmental behavior.

3.2.8. Collectivism (CI)

Jakučionytė-Skodienė and Liobikienė (2021) argue that cultural perspective is essential to predict environmental concern and pro-environmental behavior. However, they also posit that environmental concern and pro-environmental behavior are not always positively related. One can find controversial opinions and results in the literature about which societies are more likely to engage in pro-environmental behaviors or environmental performance. If individualists were found to be less concerned and/or more skeptical about climate change than collectivists, they are also more likely to assume personal responsibility and to do their part in pro-environmental actions (Jakučionytė-Skodienė & Liobikienė, 2021; Kaasa & Andriani, 2021). Nevertheless, collectivists also have an acute sense of social responsibility for initiatives fostering pro-environmental sustainable behaviors, as their overarching objectives are to protect the environment and society. Collectivists generally prioritize the goals of their community over their own (Nagy & Molnárné, 2018; Parboteeah et al., 2012; Rotman et al., 2014).

Very few studies related to the CS topic include Hofstede's cultural dimensions to explain cultural variation in CS participation. Among the exceptions are Beza et al. (2017), who studied the effect of cultural variation in farmers' motivations to participate in CS projects. They found that farmers' motivations vary across national cultures, such that in more collectivist societies farmers were more inclined to share information. Rotman et al. (2014) also studied cultural variation in motivations for initial participation and long-term participation in CS apps using the United States (US), India, and Costa Rica as case-studies. They concluded that initial motivation to participate in CS projects depended on the individual's drive (personal interest, self-promotion, self-efficacy, and social responsibility); social responsibility was observed for only the collectivistic society of Costa Rica. On the other hand, motivation for long-term participation relied on interpersonal interactions (between scientists and participants, and participants and communities) – trust, common goals, acknowledgement, mentorship, education and outreach, and policy and activism (accountability for and acknowledgment of the

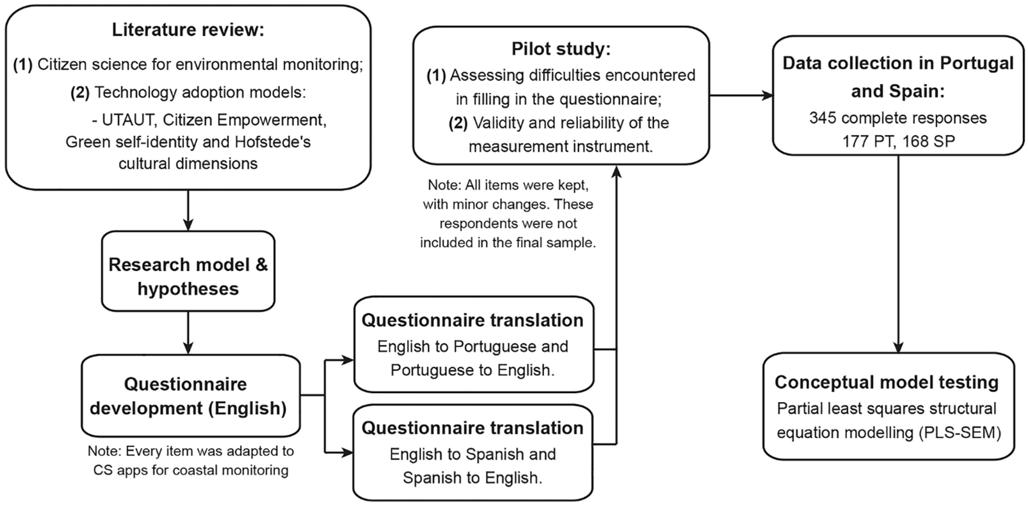

Fig. 2. Data collection and analysis process.

project's values beyond participants' tasks).

Although there is global awareness of the climate change and biodiversity crisis (Secretariat of the Convention on Biological Diversity, 2020), we believe that the willingness to participate in CS apps – aiming to assess coastal habitats and biological communities' diversity and structure, ecosystem health status, climate change impacts, and other activities – requires individuals to be sensitive to collective/societal goals. We therefore hypothesize:

H9a: Collectivism (CI) is positively associated with CS apps BI.

Moreover, because collectivists are more concerned with the well-being of others, it seems also reasonable to hypothesize that those who score higher on CI will value the environmental performance (EPE) of CS Apps more than those who score low in their intention to use them. Hence,

H9b: CI will moderate the effect of EPE on CS apps BI, such that the relationship will be stronger among individuals with greater green self-identity.

3.2.9. Long-term orientation (LTO)

Long-term-oriented individuals usually have a positive attitude toward environmental and green products, as they value the future long-term positive effect that their choice represents (Mi et al., 2020; Sreen et al., 2018). Moreover, Mi et al. (2020) found that long-term orientation positively affects public and private-sphere pro-environmental behaviors. Hence, we posit that the positive relationship that collectivism and long-term orientation cultural dimensions have with green purchase intention (Sreen et al., 2018) could be similar to their relationship with citizen participation in environmental CS projects. Although we are already experiencing the effects of climate change and the biodiversity crisis, the reality-check is that worse effects are still to come if we do not act regionally and globally (Bohensky et al., 2011). Thus, long-term orientation will be pivotal to overcoming these issues. Therefore, we hypothesize:

H10: Long-term orientation (LTO) is positively associated with the behavioral intention (BI) of using CS apps for coastal environment monitoring.

3.2.10. Controls

We used the control variables age, education, gender, number of days at the beach per year, and distance of respondents' residences to the beach. While the first three (socio-demographic) control variables are commonly used (see, e.g., Chan et al., 2021), the last two are specific to this study's context. Note that to use environmental coastal monitoring apps, one needs to live near coastal regions and/or be in these regions often. Hence, we added these two parameters as controls.

4. Procedure and data

The research design is presented in Fig. 2. We collected the data using an online survey made available through Qualtrics and shared it through social media. In order to get a more accurate sample of Portuguese and Spanish citizens, we hired a firm, Prolific Academic, to collect the data from respondents in exchange for a small monetary contribution. Prolific is one of the world's largest crowdsourcing on-demand platforms that enables large-scale data collection by connecting researchers to participants. Participants from Portugal and Spain were recruited from a population of 123,375 eligible people. They were informed that the study was about "Coastal & Marine Environmental Monitoring Digital Platforms", in a ten-minute online survey. To ensure the best data quality, we have also recorded the participants' metadata, regarding the platform ID (Prolific ID), as well as the study and session IDs, to prevent issues associated with such crowdsourcing data collection platforms (Kennedy et al., 2022). Because the instrument was administered in Portuguese and Spanish, we hired a professional to translate the original questions from English to both languages, and then another to translate both back into English to assess the instrument's translation equivalence.

The survey started with an informed consent question, and if the respondent agreed to participate in the study, they proceeded to some basic instructions and a short video explaining CS apps for environmental monitoring, their types, examples, and a glossary of related definitions. The survey then proceeded with the measurement items and subsequently with the sociodemographic questions. The material used in the survey is available upon request.

The instrument was developed to reflect our above-described research model. Every questionnaire item was adapted to CS apps from the original theories, which have all been widely used and tested separately, although not specifically in this context. Every item (question) of the instrument thus has solid theoretical and empirical support. More specifically, the UTAUT constructs (EPE, EE, SI, FC, HM, HA, and BI) were adapted from Venkatesh et al. (2003; 2012); Citizen empowerment (EM, CO, ME, IM, and SD) come from Spreitzer (1995); green self-identity was adapted from Sparks and Shepherd (1992) and Barbarossa et al. (2017); and, finally, Hofstede's cultural dimensions (CI and LTO) from Srite and Karahanna (2006) and Hassan et al. (2011). All items were measured on a seven-point interval scale anchored between (1) "strongly disagree" to (7) "strongly agree" to guarantee their metric properties. As the original items were not developed for the specific context of CS apps, some slight adjustments were made. The measurement items can be seen in Appendix A.

We started by conducting a pilot test for each country, with 30

Table 1
Sample characteristics.

	Total	Portugal	Spain
Age	**31.5**	28.2	34.7
Female	**156**	98	58
Male	**188**	79	109
Other	**1**	0	1
Basic or no education	**4**	2	2
High School	**83**	46	37
Undergraduate	**133**	52	81
MSc or PhD	**125**	77	48
Student	**112**	75	37
Employed	**206**	91	115
Retired	**6**	2	4
Unemployed	**21**	9	12
Total	**345**	**177**	**168**

respondents each. We assessed if the respondents had complications in answering the questions with the pilots. We also used the pilot to examine the instruments' reliability and validity. Some questions were adjusted slightly or even deleted in this process if they were ambiguous. Because of these minor adaptations, the pilot responses were not used in the final study.

For the final study we obtained 345 responses (177 from Portugal and 168 from Spain), of which we recorded the IP addresses to avoid duplicates. We employed Harman's single-factor test to test for common method bias (MacKenzie et al., 2011). As the first factor accounted for only 32.9 % of the covariance among all constructs, well below the threshold of 50 %, we concluded that common method bias was not a risk (MacKenzie & Podsakoff, 2012; Podsakoff et al., 2003). We also added a theoretically irrelevant marker variable in the research model, obtaining<5 % as the maximum shared variance with other variables, a value that can be considered as low (Johnson et al., 2011). The sample's sociodemographic characteristics can be seen in Table 1.

A partial least squares structural equation modeling (PLS-SEM) was performed supported on the software SmartPLS 3 (Ringle et al., 2015). The analysis of the PLS-SEM was assessed in two parts: the measurement and structural models.

5. Data analysis and results

5.1. Measurement model

Following Hair et al. (2017), because our model includes only reflective constructs we evaluated it to assess the internal consistency, and convergent and discriminant validities. Composite reliability was assessed to verify the internal consistency, which, as suggested by Hair et al. (2017), were all above the threshold of 0.70 (see Table 2). Convergent validity was assessed through average variance extracted (AVE) and indicator reliability. The Fornell and Larcker (1981) criterion was met, as the AVE is above 0.50 (see Table2). Moreover, the indicator reliability criterion was also fulfilled as all the loadings were above 0.70 and statistically significant (see Appendix B), thereby demonstrating convergent validity (Fornell and Larcker, 1981; Götz et al., 2010).

We consider three criteria to assess discriminant validity: the Fornell-Larcker, the cross-loadings, and the Heterotrait-to-Monotrait (HTMT) ratio. The first of these was proposed by Fornell and Larcker (1981) and indicated that the square root of AVE needs to exceed the correlation between all the other constructs (see Table 2). The second criterion states that the cross-loadings should be lower than the loadings of each indicator (Hair et al., 2017) (see Appendix B). Third, HTMT ratios (Table 3) were below the conservative threshold of 0.85 (Hair et al., 2017), thus supporting discriminant validity. We conclude that our

Table 2
Average (AVG), standard deviation (SD), composite reliability (CR) and average variance extracted (AVE).

Construct	AVG	SD	CR	AVE	EPE	EE	SI	FC	HM	HA	CO	ME	IM	SD	CI	LTO	GSI	BI
EPE	5.81	1.04	0.91	0.72	**0.85**													
EE	5.47	1.20	0.94	0.80	0.39	**0.90**												
SI	3.67	1.45	0.93	0.77	0.35	0.32	**0.88**											
FC	5.68	1.12	0.89	0.61	0.44	0.62	0.26	**0.78**										
HM	4.94	1.25	0.93	0.73	0.60	0.45	0.49	0.47	**0.85**									
HA	3.03	1.52	0.91	0.73	0.27	0.31	0.60	0.21	0.47	**0.85**								
CO	4.60	1.46	0.91	0.77	0.30	0.61	0.25	0.57	0.40	0.35	**0.88**							
ME	4.16	1.58	0.96	0.88	0.51	0.37	0.52	0.43	0.61	0.60	0.47	**0.94**						
IM	4.37	1.48	0.94	0.83	0.50	0.30	0.40	0.33	0.51	0.41	0.37	0.58	**0.91**					
SD	5.23	1.40	0.94	0.84	0.32	0.51	0.20	0.53	0.42	0.24	0.62	0.49	0.41	**0.92**				
CI	4.79	1.49	0.90	0.82	0.11	0.10	0.20	0.10	0.14	0.13	0.08	0.19	0.15	0.05	**0.91**			
LTO	4.93	1.09	0.83	0.55	0.07	0.06	0.11	0.09	0.16	0.15	0.07	0.16	0.19	0.13	0.22	**0.74**		
GSI	5.91	1.05	0.90	0.75	0.32	0.21	0.20	0.37	0.34	0.21	0.25	0.46	0.27	0.25	0.17	0.18	**0.87**	
BI	4.42	1.59	0.97	0.88	0.50	0.38	0.46	0.49	0.58	0.60	0.44	0.71	0.52	0.43	0.25	0.22	0.51	**0.94**

Table 3
Heterotrait-Monotrait Ratio (HTMT).

Construct	EPE	EE	SI	FC	HM	HA	CO	ME	IM	SD	CI	LTO	GSI	BI
EPE														
EE	0.44													
SI	0.39	0.34												
FC	0.50	0.70	0.25											
HM	0.67	0.49	0.53	0.51										
HA	0.30	0.32	0.68	0.22	0.52									
CO	0.35	0.70	0.28	0.67	0.46	0.40								
ME	0.57	0.40	0.56	0.44	0.66	0.66	0.54							
IM	0.56	0.32	0.45	0.36	0.57	0.47	0.42	0.63						
SD	0.36	0.56	0.21	0.61	0.46	0.26	0.71	0.54	0.45					
CI	0.13	0.13	0.24	0.12	0.17	0.16	0.09	0.21	0.17	0.06				
LTO	0.10	0.09	0.15	0.15	0.20	0.18	0.09	0.19	0.23	0.16	0.28			
GSI	0.38	0.23	0.22	0.39	0.38	0.23	0.29	0.52	0.31	0.28	0.20	0.23		
BI	0.54	0.40	0.49	0.48	0.62	0.64	0.49	0.75	0.56	0.46	0.28	0.26	0.57	

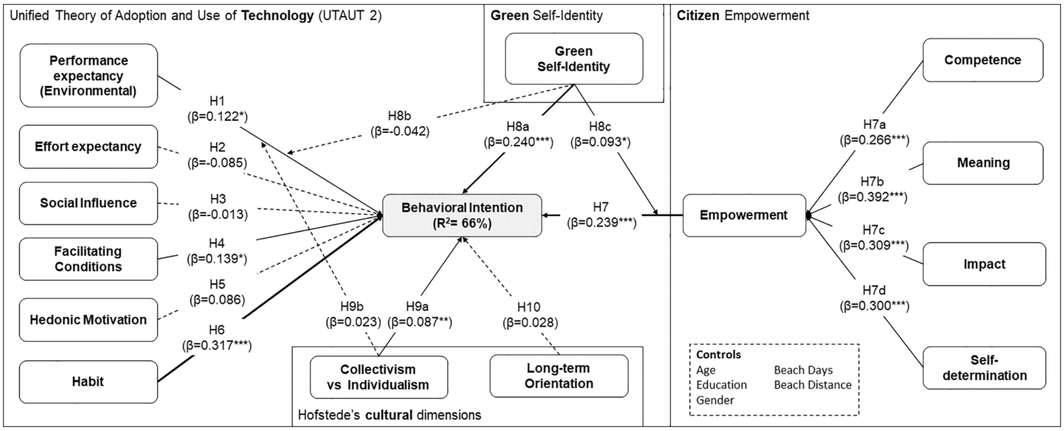

Fig. 3. Structural model results. Notes: *Significant at 0.05; **Significant at 0.01; ***Significant at 0.001.

Table 4
Results of hypotheses tests.

Hypothesis	Beta	p-value	Support	R^2 Inc. - exc.	f^2	Effect Size
CS Apps BI ($R^2 = 0.66$)						
H1: EPE –> BI	0.122	$p < 0.05$*	Supported	0.01	0.03	Small
H2: EE –> BI	−0.085	$p > 0.05$	Not Supported	0.01	0.01	None
H3: SI –> BI	−0.013	$p > 0.05$	Not Supported	0.01	0.00	None
H4: FC –> BI	0.139	$p < 0.05$*	Supported	0.01	0.03	Small
H5: HM –> BI	0.086	$p > 0.05$	Not Supported	0.01	0.01	None
H6: HA –> BI	0.317	$p < 0.001$***	Supported	0.05	0.15	Medium
H7: EMP –> BI	0.239	$p < 0.001$***	Supported	0.03	0.06	Small
H8a: GSI –> BI	0.240	$p < 0.001$***	Supported	0.03	0.09	Small
H8b: EPE × GSI –> BI	−0.042	$p > 0.05$	Not Supported	0.01	0.01	None
H8c: EMP × GSI –> BI	0.093	$p < 0.05$*	Supported	0.01	0.02	Small
H9a: IC –> BI	0.087	$p < 0.01$**	Supported	0.01	0.02	Small
H9b: EPE × IC –> BI	0.023	$p > 0.05$	Not Supported	0.01	0.01	None
*H*10: LTO –> BI	0.028	$p > 0.05$	Not Supported	0.01	0.01	None

Notes: R-Squared (R2); R2 Change = R2 included minus excluded (R2 Inc.-exc.); Effect size: [0.20; 0.150] - small;]150; 0.350] medium; >= 0.350 - large.

measurement model is adequate, as it presents good indicator reliability, constructs reliability, convergent validity, and discriminant validity.

5.2. Structural model

Before assessing the structural model, we examined if multicollinearity was an issue using the variance inflation factor (VIF). The highest VIF is 2.7, well below the threshold of five (Hair et al., 2017). Hence, we conclude that multicollinearity among the independent constructs is not a problem (Lee & Xia, 2010). The results related to the model testing are presented in Fig. 3, which shows that 11 of the 17 hypotheses were supported (please see Table 4).

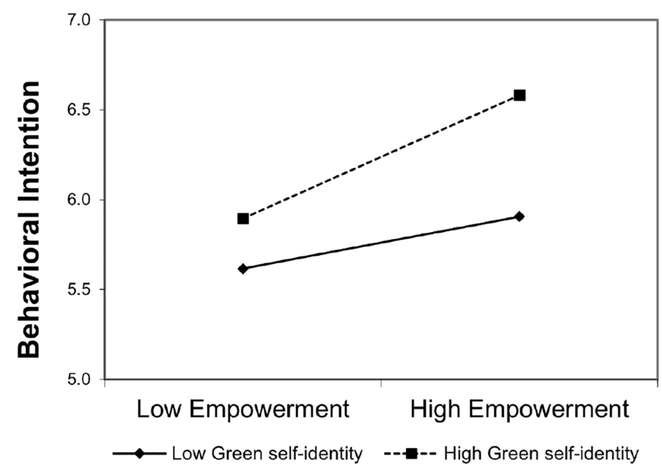

Fig. 4. Moderation effect.

Looking at the hypotheses derived from UTAUT (H1-H6), EE, SI, and HM were not confirmed (H2, H3, and H6, respectively). Hence, we show that EPE (H1: $\beta = 0.122$, $p < 0.05$), FC (H4: $\beta = 0.139$, $p < 0.05$), and HA (H6: $\beta = 0.317$, $p < 0.001$) have a positive effect on BI. As for the hypotheses developed based on citizen empowerment theory, we see that they are all supported (H7 a-d). These findings demonstrate that empowerment is, in fact, a second-order reflective-formative construct of competence, meaning, impact, and self-determination, and that this is a strong driver of CS apps BI (H7: $\beta = 0.239$, $p < 0.001$). Findings also demonstrate the usefulness of green self-identity, as two of three hypotheses related with it were confirmed. We have thus shown that GSI is positively associated with BI (H8a: $\beta = 0.240$, $p < 0.001$) and that it also positively moderates the relationship between empowerment and BI (H8c: $\beta = 0.093$, $p < 0.05$). However, contrary to our expectations, we did not find evidence that GSI works as a moderator between EPE and BI (H8b: $\beta = -0.042$, $p > 0.05$). Finally, looking at the hypotheses supported by Hofstede's cultural dimensions, we were able to support only H9a, attesting that collectivism is positively associated with BI (H9a: $\beta = 0.087$, $p < 0.01$). Hence, we were unable to demonstrate that

Table 5
Proposed guidelines for designing and promoting CS apps for coastal environment monitoring.

Effect	Guidelines for project managers	Guidelines for app developers	Guidelines for policymakers
1. Habit (β = 0.317***)	- Account for the provision of incentives to participants. Prefer intrinsic motivational instruments (direct feedback and acknowledgment of their contributions) over extrinsic rewards (Tiago et al., 2017). Otherwise, use them carefully so as not to undermine the sense of empowerment (Ryan & Deci, 2020). - Incorporate the monitoring activities into citizens' daily routines and hobbies (e.g., a walk-in nature) (Sharma et al., 2019).	- Through the app, citizens perform enjoyable/ easy/ intuitive tasks (White et al., 2019). - Favor automatized functionalities – automatic data filling when possible and desirable via available sensors (e.g., GPS, image, sound). - Enable notifications with gentle reminders (e.g., triggered by the citizen's proximity to the area of interest) as prompts for regular contributions.	- Publicize CS activities and display relevant information and friendly reminders about them at beaches, plazas, and other convenient places. - Carefully plan and design coastal urban environments to provide a context that influences people to adopt pro-environmental behaviors (Linder et al., 2022).
2. Green self-identity (β = 0.240***)	- Recruitment and retention communication plans can be channeled to focus groups of "green consumers." - Promote CS projects in areas where the socio-economic system is already favoring pro-environmental behaviors. - Include in the project's program activities for increased contact with nature and its processes (ensure that participants are exposed to healthy and unhealthy environments for greater awareness of the impacts)(Chao et al., 2021; Measham & Barnett, 2008).	- Develop a media section in which the contents planned by the project managers are displayed (e.g., testimonials of the ongoing activities by participants, environmental awareness content).	- Promote outdoor activities: invite citizens to explore and experience nearby nature settings. - Promote environmental awareness and pro-environmental behaviors through structural changes in the socio-economic system (Mantovani & Vergari, 2017).
3. Citizen empowerment (β = 0.239***)	- Promote collaborative or co-created CS projects instead of contributory (Golumbic et al., 2020; Robinson et al., 2021). -Provide access to all the necessary training materials (Robinson et al., 2021). - Provide timely and regular feedback (positive and constructive) about citizens' contributions (Robinson et al., 2021). - Allow contact from citizens through the app and promote the exchange of views about the process and its results (Frensley et al., 2017; Froeling et al., 2021).	- Enable citizens to participate in the design process of the app (Robinson et al., 2021). - Enable functionalities that allow citizens to choose the type of contribution made (i.e., the degree of involvement). - The app is prepared to receive any contribution from participants (e.g., through e-mail, social networks, forums, and Q&A sections). - The app allows for consultation and sharing of stable results and related news.	- Promote public discussions with a diverse group of representatives of the CS project to participate in decision-making processes and policy development. - Provide evidence of using CS contributions for informed decision and policymaking (Schade et al., 2017).
4. Facilitating conditions (β = 0.139*)	- Project managers are available to be contacted by citizens through the app to provide guidelines or clarify doubts. - More than high-level digital platforms, choose appropriate ones, which better fit the context where activities are developed (Senabre Hidalgo et al., 2021).	- The app provides an adequate user support system. -The app has open access to fundamental training materials. - The app is user-friendly.	- Secure all the important infrastructures, including internet connection at the places being monitored (e.g., open WI-FI network). - Help promoting training events that are open to the general public.
5. Environmental performance expectancy (β = 0.122*)	-Invite participants to carry out a pilot test of the app's prototype usefulness, aiming to turn it into a custom-made app (Bojovic et al., 2021). - Provide proof of the app's effectiveness and justify citizens' efforts to the public by setting performance indicators and thresholds, to track its progress in achieving established goals (Schaefer et al., 2021). Conduct regular assessments and provide access to intermediate results and achievements. -Disseminate achievements to the public intelligently through effective communication strategies, clarifying the importance of CS in solving environmental issues and its impact on political and socio-economic systems.	-The app displays CS performance indicators' measurements and the progress toward achieving established goals (whether ecological, political, or socio-economic). Data should be presented using functional and attractive infographics to improve scientific knowledge transfer between scientists and the public (Perra & Brinkman, 2021).	- Demand from CS project developers clear information about the objectives, goals, and the outcomes they plan to achieve, and help find how these can serve the place and the community beyond scientific production (Hecker et al., 2018). - Develop communication actions to 1) understand the community's expectations regarding the project's outcomes; 2) inform about the goals achieved by CS projects and their added value for the community in the scientific, socio-economic, and political dimensions (Hecker et al., 2018).
6. Collectivism (β = 0.087**)	- Acknowledge participants' work and publicly disclose its importance to meet the outlined objectives and help solve current environmental, societal, socio-economic, and political problems.	- Develop a "social impact" section, sharing how project outcomes are benefiting the local community (e.g., improved ecosystem services, behaviors, well-being, quality and closeness of relationships, and so on).	- Promote collectivistic values – every individual should do their part for the greater good of society. - Promote public events where participants can share their experience and knowledge gained during the CS project.

collectivism mediates the relationship between EPE and BI (H9b: β = 0.023, $p > 0.05$), or that the long-term orientation has any effect on BI (*H*10: β = 0.028, $p > 0.05$).

The hypothesized moderation effect that is significant (H8c) is shown in Fig. 4. From its analysis, one can see that, as mentioned above, empowerment has a positive effect on BI (comparing the left with the right side), but that this effect is even more substantial in those with greater levels of green self-identity. This is noticeable in the fact that the slope of the dashed line is steeper than the continuous one (high and low green self-identity, respectively).

Finally, we should note that our model is able to explain two-thirds of the variation in BI (R^2 = 66 %), which is a substantial amount. This fact indicates, in our view, the benefits of building tailor-made comprehensive adoption models for the specific technology under study, highlighting the role that the four main theories play in CS apps adoption.

6. Discussion and implications

6.1. Discussion of findings and theoretical implications

Given the growing importance of CS as a support tool for informing scientists, raising awareness, and encouraging people's habits to change toward more sustainable behaviors, we developed a multidisciplinary theory to identify the determinants for the adoption and use of CS apps for coastal environment monitoring. The use of CS apps depends on technological, cultural, and environmental dimensions. However, not all of the significant factors are of equal importance. Habit (UTAUT-2), green self-identity, and citizen empowerment are by far the most influential drivers of CS apps BI. Table 4 presents the summary of hypotheses.

Our results suggest that successful CS apps adoption requires habit formation. Habit comes from unconscious and automatic behaviors, and these are developed by repetitive actions (Gardner & Rebar, 2019). As suggested by White et al. (2019), to foster a habitual behavior, the proposed measures should be easy, while participants should be encouraged to comply with their tasks, either through prompts such as notifications (e.g., whenever the participant approaches a beach), or incentives (e.g., direct feedback or acknowledgment of their work's implications). In this regard, CS project managers should be careful about using rewards as incentives (extrinsic motivation tools) as they can undermine the citizens' sense of autonomy and competence valued by participants (Ryan & Deci, 2020). Sharma et al. (2019) suggest another possibility to create the habit of using CS apps: to incorporate the monitoring activities into citizens' daily routines and hobbies (e.g., a walk-in nature).

The use of CS apps is also more likely if participants feel empowered by using them. Fundamental sentiments of empowerment come from internal and external recognition of participants' contributions to science and their integration during all steps of the process (Froeling et al., 2021; Lee et al., 2018). This behavior is consistent with the fourth, fifth, seventh, and eighth principles laid out by the European Citizen Science Association (ECSA) (ECSA, 2015; Robinson et al., 2019).

People who identify as having a green self-identity are more inclined to use CS apps. Though green consumption and voluntary participation in CS for coastal environment monitoring are different forms of pro-environmental behavior, both come from self-transcendental values that give rise to environmental concerns (Barbarossa et al., 2017; Steg et al., 2014a). Green self-identity seems to be a cause and effect of CS participation (Dean et al., 2018). CS mobile apps for environmental monitoring provide an opportunity for people to apply their knowledge in close natural settings. This convenience will increase the frequency of contributions, which will improve citizens' environmental awareness, knowledge, and experience. Sharma et al. (2019) remarked that when citizens closely observe species behavioral patterns, they become more aware of the importance of preserving them and their habitat and the impacts of their actions (e.g., trampling in rocky intertidal ecosystems or littoral dunes). Dean et al. (2018), who studied marine and coastal CS engagement, underlined the benefits of exposing participants to healthy and disturbed environments so that there is greater sensitivity and cooperation with marine conservation. In turn, this sensitiveness promotes pro-environmental behavior and the willingness to share acquired knowledge with others.

Aside from the direct effect that green self-identity has on CS apps BI, we also found that it works as a catalyst for citizen empowerment's impact on CS apps BI. As hypothesized, we demonstrate that citizen empowerment's influence on CS apps BI is even more substantial for people who are "green" (see Fig. 4). If CS apps stakeholders can use this joint effect in their efforts, they are more likely to succeed. In this regard, it should be noted that contrary to what we hypothesized, green self-identity does not have this effect on the relationship between environmental performance expectancy and CS apps BI, probably because the first two are independent.

Environmental performance expectancy and facilitating conditions are also technological determinants positively related to the intention to adopt and use CS apps. Surprisingly, effort expectancy, social influence, and hedonic motivation's effects were not shown to drive CS app BI. This finding contradicts those reported in earlier studies regarding the drivers of pro-environmental behaviors adoption (Estrada et al., 2017; Jakučionytė-Skodienė & Liobikienė, 2021) and the motivations to participate in CS projects (Land-Zandstra et al., 2021). We believe that our study did not observe these potential drivers' effects because our model comprehends other CS apps determinants (e.g., green self-identity and cultural dimensions) that may have outweighed them. We posit that the non-confirmation of the effort expectancy hypothesis may be justified by the fact that users already know the technology in depth (mobile phone apps) and that the importance of effort expectancy is thus lower when compared to the adoption of more recent technologies (Naranjo-Zolotov et al., 2019). Although respondents were contextualized, another possible explanation could be that they were in part new to the subject and had not yet experienced coastal environmental monitoring and the way it uses technology. An additional explanation regarding effort expectancy is that citizens' perceptions of effort is a pleasure-seeking activity in the context of CS apps (i.e., walks on the beach and observation of different species and habitats), although this may seem inconsistent with the lack of significance of hedonic motivation. Still, hedonic motivations are developed for "improving one's feelings and reducing effort" (Steg et al., 2014b, p. 107), and therefore the non-confirmation of effort expectancy is reasonably in line with the non-confirmation of hedonic motivation. Regarding the non-confirmation of social influence, we suggest that internal motivations may overlap social influence when it comes to pro-environmental behaviors, which explains why having a green self-identity is so important (Juaneda-Ayensa et al., 2020). Another possible explanation is the fact that CS is voluntary work and, in this sense, there are no expectations for this behavior nor a social norm to conform with (Perry et al., 2021).

The significant impact of environmental performance expectancy on CS apps BI reveals that it is essential for the participants that the technology be effective – for instance, technical utility, effective monitoring of coastal ecosystems' health status, improving scientific knowledge, raising people's environmental awareness, accountability and compliance with environmental policies, and promoting adequate governance and socio-economic response, among other general benefits of CS projects listed by De Rijck et al. (2020). Participants will likely feel more motivated and effective if the app provides the desirable facilitating conditions, i.e., adequate training materials and a user support system to perform the voluntary work (San Llorente Capdevila et al., 2020).

Our results also demonstrate that to some extent culture plays a role in CS apps adoption. We confirmed a positive, although relatively weak, impact of collectivism versus individualism in CS apps BI. This discovery sheds some light upon ambiguity found in the earlier literature. Collectivists seem to be more likely to use these apps, probably because they are usually more concerned about the impacts that climate change and biodiversity crises are having and will have on society. They are also more easily moved by altruistic values than egoistic values. This means they will be more likely to perform selfless acts such as volunteering in CS projects. Long-term participation in CS apps is motivated by education outreach, accountability, and acknowledgment of one's work in one's social group (Rotman et al., 2014). Thus, it is essential that CS apps disseminate their results to the public pragmatically, measuring their usefulness for public matters. It may not be enough merely to respond to the CS apps' specific objectives, but to show how citizens' effort for this initiative has helped solve current environmental issues and societal concerns and how it has impacted political and socio-economic decision-making.

The effect of long-term orientation was, contrary to our expectations, nonsignificant. In previous studies, long-term orientation was reported to be positively related to pro-environmental behavior (Dangelico et al., 2020; Mi et al., 2020). This is because environmental causes are based primarily on long-term goals, while short-term-oriented persons are less likely to jeopardize their self-interests and goals in favor of community/global causes (Wittmann & Sircova, 2018). CS apps may provide several outcomes: some relatively short-term – improved knowledge, environmental awareness, the opportunity for joining a community – and others long-term – environmental justice, modification of behaviors, enhanced human health and safety, sustainable management and development, and improved political and socio-economic systems (Johnson et al., 2014; Lee et al., 2018). Therefore, a possible explanation for this cultural dimension not being a determining factor could be recognizing the short and long-term benefits of CS apps.

6.2. Implications for practice and resulting guidelines

To the best of our knowledge, this research is the first to create a comprehensive, tailor-made, conceptual model for CS apps, thereby addressing the gap identified in the literature regarding what drives citizens' engagement for participating in CS initiatives within the scope of environmental monitoring (Kasten et al., 2021). Coastal ecosystems are widely affected by climate change and other anthropogenic pressures, as they are subject to land and sea-based activities (He & Silliman, 2019). Thus, CS apps for coastal environment monitoring are different from other CS apps and need direct and custom-made guidelines. This is increasingly urgent and important to achieve effective public participation and trustworthy monitoring datasets of these ecosystems. Intelligent approaches in implementing these apps can also increase awareness and compliance with environmental policies among different stakeholders.

Our study may provide valuable insights to CS stakeholders regarding the profile of the target user groups (i.e., those who are more likely to engage in these initiatives) and adequate functional features to be regarded in the app's design and development. This information can be beneficial for the rational management of (usually scarce) resources allocated to the citizens' recruitment and retention processes of CS projects. Hence, we propose the following guidelines (Table 5) to help project managers, app developers, and policymakers to promote CS apps for coastal environment monitoring.

6.3. Limitations and future work

As with any study, our work also entails some limitations that should be addressed in future research undertakings. First, our data refer to a specific point in time. Therefore, this study does not capture possible changes in the perception of individuals toward CS apps and environmental issues. Hence, future research should seek to capture individuals' perceptions over time. Second, although we were able to collect data from two countries, cautions should be taken when generalizing our results to other geographical/cultural contexts. Finally, as CS apps for environmental monitoring are widespread, future studies should target post-adoption behaviors, such as outcomes.

7. Conclusions

Our research provides a model that joins theories of technology adoption and use with the effect of culture in individuals' values and behaviors, and the motivations for pro-environmental behavior, to provide unique insight about what drives citizens to use CS apps for coastal environment monitoring. This multidisciplinary approach is of utmost importance to understand the various factors that promoters, professional scientists, developers, and other stakeholders must consider when designing and developing successful CS apps for coastal environment monitoring. In turn, successful CS apps for coastal environment monitoring will most likely improve citizens' attraction and retention in CS projects. Well-designed and developed CS platforms can also intelligently use the project's resources. In response to our research questions, people who will more likely engage with CS apps in the context of coastal environment monitoring are collectivists, usually more aware and concerned about the environmental crisis and the extended impacts on societies at regional and global scales. They also are assumed to have a green identity, i.e., their behaviors are typically environmentally conscious and sustainable. Drivers of CS apps used for coastal environment monitoring are the sense of empowerment, habit development, provision of facilitating conditions, and environmental performance expectancy.

This study provides clear guidelines for project managers, app developers, and policymakers to improve the chances of sustained public participation in CS projects for coastal environment monitoring through their apps.

CRediT authorship contribution statement

Mariana Cardoso-Andrade: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization. **Frederico Cruz-Jesus:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing. **Jesus Souza Troncoso:** Conceptualization, Methodology, Writing – review & editing. **Henrique Queiroga:** Conceptualization, Methodology, Writing – review & editing. **Jorge M. S. Gonçalves:** Conceptualization, Methodology, Writing – review & editing.

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

Table A1.
Table B1.

Table A1
Survey questions.

Construct	#	Item	Source
Environmental Performance Expectancy (EPE)	EPE1	I find CS apps for coastal environment monitoring useful to conserve the environment.	Adapted from: (Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	EPE2	Using CS apps for coastal environment monitoring increases the chances of achieving conservation goals that are important to me.	
	EPE3	Using CS apps for coastal environment monitoring helps me accomplish conservation tasks more quickly.	
	EPE4	Using CS apps for coastal environment monitoring increases my productivity in conserving the environment.	
Effort Expectancy (EE)	EE1	Learning how to use CS apps for coastal environment monitoring is easy.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	EE2	It is easy for me to become skillful at using CS apps for coastal environment monitoring.	
	EE3	My interaction with CS apps for coastal environment monitoring is clear and understandable.	
	EE4	I find CS apps for coastal environment monitoring easy to use.	
Social Influence (SI)	SI1	People who are important to me think I should use CS apps for coastal environment monitoring.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	SI2	People who influence my behavior think I should use CS apps for coastal environment monitoring.	
	SI3	CS apps for coastal environment monitoring use are a status symbol in my community.	
	SI4	People whose opinions I value want me to use CS apps for coastal environment monitoring.	
Facilitating Conditions (FC)	FC1	I have the necessary resources to use CS apps for coastal environment monitoring.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	FC2	I have the necessary knowledge to use CS apps for coastal environment monitoring.	
	FC3	CS apps for coastal environment monitoring are compatible with other technologies I use.	
	FC4	I can get help from others when I have difficulties using CS apps for coastal environment monitoring.	
Hedonic Motivation (HM)	HM1	Using CS apps for coastal environment monitoring is fun.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	HM2	Using CS apps for coastal environment monitoring is enjoyable.	
	HM3	Using CS apps for coastal environment monitoring is entertaining.	
	HM4	Using CS apps for coastal environment monitoring is interesting.	
	HM5	I feel a sense of adventure when using CS apps for coastal environment monitoring.	
Habit (HA)	HA1	The use of CS apps for coastal environment monitoring has become a habit.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	HA2	I must use CS apps for coastal environment monitoring.	
	HA3	Using CS apps for coastal environment monitoring has become natural to me	
	HA4	I am addicted to using CS apps for coastal environment monitoring.	
Competence (CO)	CO1	I have mastered the use of CS apps for coastal environment monitoring.	(Kim & Gupta, 2014; Rappaport, 1987; Spreitzer, 1995; Zimmerman & Rappaport, 1988; Zimmerman, 1995)
	CO2	I am self-assured about my capabilities to use CS apps for coastal environment monitoring.	
	CO3	I am confident about my ability to use CS apps for coastal environment monitoring.	
Meaning (ME)	ME1	The CS apps for coastal environment monitoring I use are very important to me.	(Kim & Gupta, 2014; Rappaport, 1987; Spreitzer, 1995; Zimmerman & Rappaport, 1988; Zimmerman, 1995)
	ME2	The CS apps for coastal environment monitoring I use are meaningful to me.	
	ME3	The activities of the CS apps for coastal environment monitoring I use are personally meaningful to me.	
Impact (IM)	IM1	Based on CS apps for coastal environment monitoring usage, my impact on what happens in the community is immense.	(Kim & Gupta, 2014; Rappaport, 1987; Spreitzer, 1995; Zimmerman & Rappaport, 1988; Zimmerman, 1995)
	IM2	Based on CS apps for coastal environment monitoring usage, I have significant influence over what happens in the community.	
	IM3	Based on CS apps for coastal environment monitoring usage, I have a great deal of control over what happens in the community.	
Self-determination (SD)	SD1	I have autonomy in determining how I use CS apps for coastal environment monitoring.	(Kim & Gupta, 2014; Rappaport, 1987; Spreitzer, 1995; Zimmerman & Rappaport, 1988; Zimmerman, 1995)
	SD2	I have independence and freedom in how I use the CS apps for coastal environment monitoring.	
	SD3	I can decide how to use CS apps for coastal environment monitoring on my own.	
Green self-identity (GSI)	GSI1	I consider myself to be concerned about environmental issues.	(Barbarossa et al., 2017; Sparks & Shepherd, 1992)
	GSI2	I consider myself to be a green consumer.	
	GSI3	The effect that marine pollution/overexploitation has on the environment concerns me.	
Collectivism (CI)	CI1	Group success is more important than individual success.	(Srite & Karahanna, 2006)
	CI2	Being loyal to a group is more important than individual gain.	
Long-term orientation (LTO)	LTO1	Respect for tradition is important for me.	(Hassan et al., 2011)
	LTO2	I will work hard for success in the future.	
	LTO3	Traditional values are important for me.	

(*continued on next page*)

Table A1 (*continued*)

Construct	#	Item	Source
	LTO4	I plan for the long-term.	
Behavioral Intention (BI)	BI1	I intend to continue using CS apps for coastal environment monitoring in the future.	(Venkatesh *et al.*, 2003; Venkatesh et al., 2012)
	BI2	I will always try to use CS apps for coastal environment monitoring in my daily life.	
	BI3	I plan to continue to use CS apps for coastal environment monitoring frequently.	
	BI4	I plan to use CS apps for coastal environment monitoring regularly.	

Table B1
Loadings and cross-loadings.

Item	EPE	EE	SI	FC	HM	HA	CO	ME	IM	SD	CI	LTO	GSI	BI
EPE_1	**0.86**	0.34	0.29	0.37	0.53	0.21	0.26	0.44	0.46	0.29	0.14	0.09	0.26	0.42
EPE_2	**0.88**	0.31	0.32	0.40	0.52	0.24	0.23	0.44	0.43	0.28	0.10	0.09	0.29	0.45
EPE_3	**0.84**	0.31	0.25	0.38	0.48	0.20	0.25	0.41	0.35	0.23	0.05	0.04	0.30	0.39
EPE_4	**0.82**	0.38	0.34	0.34	0.49	0.27	0.29	0.45	0.44	0.27	0.07	0.03	0.24	0.42
EE_1	0.35	**0.91**	0.29	0.58	0.39	0.28	0.56	0.33	0.26	0.50	0.12	0.06	0.20	0.36
EE_2	0.36	**0.92**	0.32	0.57	0.38	0.26	0.58	0.34	0.29	0.48	0.08	0.07	0.20	0.35
EE_3	0.37	**0.91**	0.32	0.56	0.44	0.33	0.54	0.36	0.30	0.42	0.07	0.05	0.21	0.35
EE_4	0.33	**0.84**	0.23	0.51	0.38	0.22	0.50	0.31	0.21	0.44	0.11	0.04	0.12	0.28
SI_1	0.33	0.33	**0.91**	0.26	0.42	0.52	0.24	0.46	0.39	0.18	0.18	0.15	0.20	0.42
SI_2	0.35	0.36	**0.94**	0.28	0.49	0.56	0.27	0.50	0.38	0.24	0.21	0.10	0.22	0.46
SI_3	0.21	0.15	**0.75**	0.10	0.33	0.48	0.11	0.36	0.30	0.04	0.11	0.11	0.08	0.29
SI_4	0.34	0.26	**0.91**	0.23	0.45	0.56	0.21	0.49	0.34	0.21	0.19	0.06	0.17	0.42
FC_1	0.30	0.52	0.10	**0.79**	0.28	0.08	0.46	0.25	0.20	0.44	0.08	0.02	0.18	0.25
FC_2	0.36	0.48	0.10	**0.79**	0.35	0.03	0.43	0.27	0.29	0.43	0.01	0.01	0.20	0.25
FC_3	0.33	0.43	0.13	**0.74**	0.37	0.06	0.38	0.27	0.30	0.45	0.10	0.11	0.25	0.29
FC_4	0.33	0.57	0.20	**0.81**	0.35	0.20	0.58	0.27	0.20	0.44	0.06	0.08	0.25	0.38
FC_5	0.37	0.44	0.35	**0.78**	0.43	0.30	0.40	0.48	0.28	0.37	0.10	0.10	0.43	0.54
HM_1	0.54	0.43	0.45	0.45	**0.91**	0.46	0.37	0.54	0.45	0.38	0.15	0.20	0.34	0.58
HM_2	0.49	0.39	0.44	0.39	**0.89**	0.41	0.32	0.54	0.43	0.38	0.14	0.14	0.27	0.49
HM_3	0.52	0.39	0.43	0.40	**0.89**	0.45	0.37	0.53	0.42	0.34	0.08	0.11	0.30	0.50
HM_4	0.55	0.37	0.33	0.47	**0.80**	0.28	0.36	0.50	0.40	0.41	0.12	0.14	0.39	0.48
HM_5	0.43	0.31	0.43	0.26	**0.77**	0.42	0.27	0.48	0.50	0.28	0.11	0.08	0.12	0.40
HA_1	0.23	0.30	0.57	0.22	0.45	**0.93**	0.34	0.57	0.36	0.25	0.12	0.20	0.24	0.58
HA_2	0.33	0.28	0.49	0.20	0.43	**0.78**	0.26	0.46	0.37	0.19	0.11	0.06	0.16	0.47
HA_3	0.24	0.31	0.52	0.22	0.42	**0.92**	0.38	0.57	0.38	0.25	0.12	0.14	0.20	0.58
HA_4	0.09	0.11	0.45	0.03	0.28	**0.77**	0.17	0.41	0.29	0.10	0.11	0.11	0.07	0.34
CO_1	0.18	0.51	0.35	0.36	0.35	0.52	**0.76**	0.47	0.32	0.45	0.08	0.13	0.21	0.45
CO_2	0.29	0.56	0.15	0.57	0.34	0.20	**0.94**	0.40	0.32	0.59	0.07	0.01	0.23	0.34
CO_3	0.31	0.53	0.16	0.57	0.36	0.23	**0.92**	0.38	0.34	0.58	0.06	0.03	0.21	0.36
ME_1	0.49	0.37	0.52	0.40	0.57	0.59	0.48	**0.95**	0.55	0.48	0.23	0.17	0.42	0.67
ME_2	0.51	0.35	0.46	0.41	0.58	0.53	0.41	**0.95**	0.55	0.47	0.18	0.13	0.43	0.65
ME_3	0.44	0.33	0.48	0.40	0.55	0.58	0.45	**0.93**	0.53	0.44	0.12	0.15	0.45	0.67
IM_1	0.50	0.29	0.36	0.32	0.48	0.37	0.36	0.58	**0.95**	0.41	0.16	0.18	0.31	0.50
IM_2	0.48	0.32	0.35	0.34	0.52	0.38	0.39	0.55	**0.94**	0.42	0.13	0.16	0.25	0.49
IM_3	0.37	0.20	0.39	0.22	0.39	0.39	0.26	0.45	**0.85**	0.28	0.11	0.18	0.17	0.44
SD_1	0.32	0.51	0.18	0.52	0.36	0.22	0.64	0.47	0.35	**0.92**	0.06	0.13	0.24	0.39
SD_2	0.29	0.46	0.19	0.49	0.41	0.24	0.56	0.46	0.39	**0.95**	0.05	0.10	0.23	0.43
SD_3	0.27	0.44	0.18	0.45	0.38	0.22	0.50	0.43	0.38	**0.88**	0.02	0.12	0.21	0.36
CI_1	0.10	0.08	0.17	0.09	0.14	0.11	0.07	0.20	0.14	0.05	**0.94**	0.23	0.21	0.25
CI_2	0.09	0.12	0.20	0.08	0.12	0.13	0.06	0.13	0.12	0.04	**0.87**	0.17	0.08	0.18
LTO_1	0.07	0.01	0.05	0.05	0.14	0.12	0.05	0.12	0.14	0.05	0.22	**0.81**	0.12	0.18
LTO_2	0.06	0.05	0.10	0.09	0.12	0.10	0.05	0.14	0.18	0.14	0.15	**0.70**	0.20	0.20
LTO_3	0.02	0.00	0.09	0.00	0.10	0.15	0.05	0.09	0.11	0.02	0.19	**0.81**	0.05	0.15
LTO_4	0.06	0.14	0.10	0.14	0.13	0.07	0.06	0.11	0.10	0.17	0.07	**0.62**	0.17	0.12
GSI_1	0.30	0.18	0.16	0.34	0.31	0.16	0.22	0.41	0.24	0.22	0.13	0.18	**0.90**	0.45
GSI_2	0.26	0.16	0.21	0.31	0.31	0.26	0.21	0.39	0.25	0.21	0.16	0.15	**0.83**	0.45
GSI_3	0.28	0.19	0.15	0.31	0.26	0.13	0.22	0.39	0.22	0.21	0.16	0.15	**0.87**	0.43
BI_1	0.51	0.39	0.36	0.52	0.56	0.46	0.42	0.62	0.46	0.42	0.22	0.23	0.55	**0.90**
BI_2	0.45	0.35	0.44	0.42	0.54	0.61	0.38	0.68	0.53	0.39	0.24	0.22	0.48	**0.94**
BI_3	0.49	0.34	0.47	0.45	0.55	0.58	0.41	0.69	0.50	0.40	0.24	0.19	0.46	**0.96**
BI_4	0.42	0.34	0.44	0.44	0.53	0.59	0.42	0.66	0.47	0.40	0.23	0.21	0.44	**0.95**

References

Aitkenhead, M.J., Donnelly, D., Coull, M.C., Hastings, E., 2014. Innovations in environmental monitoring using mobile phone technology -A review. Int. J. Interact. Mobile Technol. 8 (2), 42–50. Available at: 10.3991/ijim.v8i2.3645.

Alender, B., 2016. Understanding volunteer motivations to participate in citizen science projects: A Deeper look at water quality monitoring. J. Sci. Commun. 15 (3), A04. Available at: 10.22323/2.15030204.

Ashraf, A.R., Thongpapanl Tek, N., Anwar, A., Lapa, L., Venkatesh, V., 2021. Perceived values and motivations influencing m-commerce use: A nine-country comparative study. Int. J. Inf. Manage. 59, 102318. Available at: 10.1016/j.ijinfomgt.2021.102318.

Assumpcao, T.H., Jonoski, A., Theona, I., Tsiakos, C., Krommyda, M., Tamascelli, S., Kallioras, A., Mierla, M., Georgiou, H., Miska, M., Pouliaris, C., Trifanov, C., Cimpan, K.T., Tsertou, A., Marin, E., Diakakis, M., Nichersu, I., Amditis, A.J., Popescu, I., 2019. 'Citizens' campaigns for environmental water monitoring: Lessons from field experiments'. IEEE Access 7, 134601–134620. Available at: 10.1109/ACCESS.2019.2939471.

Balázs, B., Mooney, P., Nováková, E., Bastin, L., Jokar Arsanjani, J., 2021. In: Data Quality in Citizen Science BT - The Science of Citizen Science. Springer International Publishing, Cham, pp. 139–157. Available at: 10.1007/978-3-030-58278-4_8.

Barbarossa, C., De Pelsmacker, P., Moons, I., 2017. Personal Values, Green Self-identity and Electric Car Adoption. Ecol. Econ. 140, 190–200. Available at: 10.1016/j.ecolecon.2017.05.015.

Beza, E., Steinke, J., van Etten, J., Reidsma, P., Fadda, C., Mittra, S., Mathur, P., Kooistra, L., 2017. What are the prospects for citizen science in agriculture? Evidence from three continents on motivation and mobile telephone use of resource-poor farmers. PLoS ONE 12 (5), e0175700. Available at: 10.1371/journal.pone.0175700.

Blut, M., Chong, A.Y.L., Tsiga, Z., Venkatesh, V., 2022. Meta-Analysis of the Unified Theory of Acceptance and Usage of Technology (UTAUT): Challenging its Validity and Charting a Research Agenda in the Red Ocean. J. Associat. Informat. Syst. 23 (1), 13–95. Available at: 10.17705/1jais.00719.

Bohensky, E., Butler, J.R.A., Costanza, R., Bohnet, I., Delisle, A., Fabricius, K., Gooch, M., Kubiszewski, I., Lukacs, G., Pert, P., Wolanski, E., 2011. Future makers or future takers? A scenario analysis of climate change and the Great Barrier Reef. Global Environ. Change 21 (3), 876–893. Available at: 10.1016/j.gloenvcha.2011.03.009.

Bojovic, D., Clair, A.L., Christel, I., Terrado, M., Stanzel, P., Gonzalez, P., Palin, E.J., 2021. Engagement, involvement and empowerment: Three realms of a coproduction framework for climate services. Global Environ. Change 68, 102271. Available at: 10.1016/j.gloenvcha.2021.102271.

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., and Wilderman, C. C. (2009) 'Public participation in scientific research: Defining the field and assessing its potential for informal science education. A CAISE Inquiry Group Report.', *Online submission*.

Bouman, T., Steg, L., Zawadzki, S.J., 2020. The value of what others value: When perceived biospheric group values influence individuals' pro-environmental engagement. J. Environ. Psychol. 71, 101470. Available at: 10.1016/j.jenvp.2020.101470.

Bruyere, B., Rappe, S., 2007. Identifying the motivations of environmental volunteers. J. Environ. Plann. Manage. 50 (4), 503–516. Available at: 10.1080/09640560701402034.

Camins, E., de Haan, W.P., Salvo, V.S., Canals, M., Raffard, A., Sanchez-Vidal, A., 2020. Paddle surfing for science on microplastic pollution. Sci. Total Environ. 709, 136178. Available at: 10.1016/j.scitotenv.2019.136178.

Chan, F.K.Y., Thong, J.Y.L., Brown, S.A., Venkatesh, V., 2021. Service Design and Citizen Satisfaction with E-Government Services: A Multidimensional Perspective. Public Administr. Rev. 81 (5), 874–894. Available at: 10.1111/puar.13308.

Chao, S.H., Jiang, J.Z., Wei, K.C., Ng, E., Hsu, C.H., Chiang, Y., Fang, W.T., 2021. Understanding pro-environmental behavior of citizen science: an exploratory study of the bird survey in Taoyuan's farm ponds project. Sustainability (Switzerland) 13 (9), 5126. Available at: 10.3390/su13095126.

Clary, E.G., Snyder, M., 1999. The motivations to volunteer: Theoretical and practical considerations. Curr. Direct. Psychol. Sci. 8 (5), 156–159. Available at: 10.1111/1467-8721.00037.

Cox, J., Oh, E.Y., Simmons, B., Graham, G., Greenhill, A., Lintott, C., Masters, K., Woodcock, J., 2018. Doing Good Online: The Changing Relationships Between Motivations, Activity, and Retention Among Online Volunteers. Nonprofit Voluntary Sect. Quart. 47 (5), 1031–1056. Available at: 10.1177/0899764018783066.

Dangelico, R.M., Fraccascia, L., Nastasi, A., 2020. National culture's influence on environmental performance of countries: A study of direct and indirect effects. Sustain. Dev. 28 (6), 1773–1786. Available at: 10.1002/sd.2123.

Datta, A., Maharaj, S., Prabhu, G.N., Bhowmik, D., Marino, A., Akbari, V., Rupavatharam, S., Sujeetha, J.A.R.P., Anantrao, G.G., Poduvattil, V.K., Kumar, S., Kleczkowski, A., 2021. Monitoring the Spread of Water Hyacinth (Pontederia crassipes): Challenges and Future Developments. Front. Ecol. Evolut. 9, 6. Available at: 10.3389/fevo.2021.631338.

De Rijck, K., Schade, S., Rubio, J-M., Van Meerloo, M., 2020. Best Practices in Citizen Science for Environmental Monitoring: Commission Staff Working Document.. European Commission, Brussels. https://ec.europa.eu/jrc/communities/en/community/examining-use-and-practices-citizen-science-eu-policies/page/best-practices-citizen.

Dean, A.J., Church, E.K., Loder, J., Fielding, K.S., Wilson, K.A., 2018. How do marine and coastal citizen science experiences foster environmental engagement? J. Environ. Manage. 213, 409–416. Available at: 10.1016/j.jenvman.2018.02.080.

ECSA (2015) *Ten Principles of Citizen Science*. Berlin. Available at: http://doi.org/10.17605/OSF.IO/XPR2N.

Eitzel, M. V, Cappadonna, J.L., Santos-Lang, C., Duerr, R.E., Virapongse, A., West, S.E., Kyba, C.C.M., Bowser, A., Cooper, C.B., Sforzi, A., Metcalfe, A.N., Harris, E.S., Thiel, M., Haklay, M., Ponciano, L., Roche, J., Ceccaroni, L., Shilling, F.M., Dörler, D., Heigl, F., Kiessling, T., Davis, B.Y., and Jiang, Q. (2017) 'Citizen Science Terminology Matters: Exploring Key Terms', Citizen Sci.: Theory Pract., 2(1). Available at: 10.5334/cstp.96.

El-Kholei, A.O., 2020. 'The reliability of citizen science in plan formulation: evidence from Askar, the Kingdom of Bahrain'. Open House Int. 45 (1/2), 209–222. Available at: 10.1108/OHI-04-2020-0017.

Estrada, M., Schultz, P.W., Silva-Send, N., Boudrias, M.A., 2017. The Role of Social Influences on Pro-Environment Behaviors in the San Diego Region. J. Urban Health 94 (2), 170–179. Available at: 10.1007/s11524-017-0139-0.

European Commission, 2021. *Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change COM(2021) 82 final*. Brussels. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN.

Fajardo, P., Beauchesne, D., Carbajal-López, A., Daigle, R.M., Denisse Fierro-Arcos, L., Goldsmit, J., Zajderman, S., Valdez-Hernández, J.I., Maigua, M.Y.T., Christofoletti, R.A., 2021. Aichi Target 18 beyond 2020: mainstreaming Traditional Biodiversity Knowledge in the conservation and sustainable use of marine and coastal ecosystems. PeerJ 9, e9616. Available at: 10.7717/peerj.9616.

Fan, F., Chen, S.L., 2019. Citizen, Science, and Citizen Science. East Asian Sci., Technol. Soc.: Int. J. 13 (2), 181–193. Available at: 10.1215/18752160-7542643.

Fornell, C., Larcker, D.F., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. J. Mark. Res. 18 (1), 39–50. Available at: 10.2307/3151312.

Frensley, T., Crall, A., Stern, M., Jordan, R., Gray, S., Prysby, M., Newman, G., Hmelo-Silver, C., Mellor, D., Huang, J., 2017. Bridging the Benefits of Online and Community Supported Citizen Science: A Case Study on Motivation and Retention with Conservation-Oriented Volunteers, Citizen Sci.: Theory. Practice 2 (1). Available at: 10.5334/cstp.84.

Fritz, S., See, L., Carlson, T., Haklay, M. (Muki), Oliver, J.L., Fraisl, D., Mondardini, R., Brocklehurst, M., Shanley, L.A., Schade, S., Wehn, U., Abrate, T., Anstee, J., Arnold, S., Billot, M., Campbell, J., Espey, J., Gold, M., Hager, G., He, S., Hepburn, L., Hsu, A., Long, D., Masó, J., McCallum, I., Muniafu, M., Moorthy, I., Obersteiner, M., Parker, A.J., Weissplug, M., West, S., 2019. Citizen science and the United Nations Sustainable Development Goals. Nature Sustainability 2 (10), 922–930. Available at: 10.1038/s41893-019-0390-3.

Froeling, F., Gignac, F., Hoek, G., Vermeulen, R., Nieuwenhuijsen, M., Ficorilli, A., de Marchi, B., Biggeri, A., Kocman, D., Robinson, J.A., Grazuleviciene, R., Andrusaityte, S., Righi, V., Basagaña, X., 2021. Narrative review of citizen science in environmental epidemiology: Setting the stage for co-created research projects in environmental epidemiology. Environ. Int., 106470. Available at: 10.1016/j.envint.2021.106470.

Garcia-Soto, C., van der Meeren, G.I., Busch, J.A., Delany, J., Domegan, C., Dubsky, K., Fauville, G., Gorsky, G., Von, Juterzenka, K., Malfatti, F., Mannaerts, G., McHugh, P., Monestiez, P., Seys, J., Węsławski, J.M., and Zielinski, O. (2017) *Advancing Citizen Science for Coastal and Ocean Research. Position Paper 23 of the European Marine Board.* Edited by V. French, P. Kellett, J. Delany, and N. McDonough. Ostend, Belgium.

Garcia-Soto, C., Seys, J.J.C., Zielinski, O., Busch, J.A., Luna, S.I., Baez, J.C., Domegan, C., Dubsky, K., Kotynska-Zielinska, I., Loubat, P., Malfatti, F., Mannaerts, G., McHugh, P., Monestiez, P., van der Meeren, G.I., Gorsky, G., 2021. 'Marine Citizen Science: Current State in Europe and New Technological Developments'. Front. Marine Sci., 621472. Available at: 10.3389/fmars.2021.621472.

Gardner, B., Rebar, A.L., 2019. Habit Formation and Behavior Change, in *Oxford Research Encyclopedia of Psychology*. Available at: 10.1093/acrefore/9780190236557.013.129.

Geoghegan, H., Dyke, A., Pateman, R., West, S., Everett, G., 2016. Understanding motivations for citizen science. *Final report on behalf of UKEOF*. University of Reading, Stockholm Environment Institute (University of York) and University of the West of England.

Göckeritz, S., Schultz, P.W., Rendón, T., Cialdini, R.B., Goldstein, N.J., Griskevicius, V., 2010. Descriptive normative beliefs and conservation behavior: The moderating roles of personal involvement and injunctive normative beliefs. Europ. J. Soc. Psychol. 40 (3), 514–523. Available at: 10.1002/ejsp.643.

Golumbic, Y., Baram-Tsabari, A., Fishbain, B., 2020. Engagement styles in an environmental citizen science project. J. Sci. Commun. 19 (06), A03. Available at: 10.22323/2.19060203.

Gonçalves, J., Kostakos, V., Karapanos, E., Barreto, M., Camacho, T., Tomasic, A., Zimmerman, J., 2014. Citizen motivation on the go: The role of psychological empowerment. Interact. Comput. 26 (3), 196–207. Available at: 10.1093/iwc/iwt035.

Götz, O., Liehr-Gobbers, K., and Krafft, M. (2010) 'Evaluation of Structural Equation Models Using the Partial Least Squares (PLS) Approach', in *Handbook of Partial Least Squares*, pp. 691–711. Available at: 10.1007/978-3-540-32827-8_30.

Gunnell, J.L., Golumbic, Y.N., Hayes, T., Cooper, M., 2021. Co-created citizen science: Challenging cultures and practice in scientific research. J. Sci. Commun. 20 (5), Y01. Available at: 10.22323/2.20050401.

Hair, J.F., Hult, G.T.M., Ringle, C.M., Sarstedt, M., 2017. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM), Second Edition. Sage, California.

Haklay, M., Dörler, D., Heigl, F., Manzoni, M., Hecker, S., Vohland, K., 2021. What Is Citizen Science? The Challenges of Definition, in *The Science of Citizen Science*. Available at: 10.1007/978-3-030-58278-4_2.

Haklay, M., 2013. Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In: Sui, D., Elwood, S., Goodchild, M. (Eds.), Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice. Springer, Netherlands, Dordrecht, pp. 105–122. Available at: 10.1007/978-94-007-4587-2_7.

Hart, P.S., Nisbet, E.C., Shanahan, J.E., 2011. Environmental Values and the Social Amplification of Risk: An Examination of How Environmental Values and Media Use Influence Predispositions for Public Engagement in Wildlife Management Decision Making. Soc. Natl. Resour. 24 (3), 276–291. Available at: 10.1080/08941920802676464.

Hassan, L.M., Shiu, E., Walsh, G., 2011. A multi-country assessment of the long-term orientation scale. Int. Market. Rev. 28 (1) https://doi.org/10.1108/02651331111107116.

He, Q., Silliman, B.R., 2019. Climate Change, Human Impacts, and Coastal Ecosystems in the Anthropocene. Curr. Biol. 29 (19), R1021–R1035. Available at: 10.1016/j.cub.2019.08.042.

He, Y., Parrish, J.K., Rowe, S., Jones, T., 2019. Evolving interest and sense of self in an environmental citizen science program. Ecol. Soc. 24 (2). Available at: 10.5751/ES-10956-240233.

Hecker, S., Bonney, R., Haklay, M., Hölker, F., Hofer, H., Goebel, C., Gold, M., Makuch, Z., Ponti, M., Richter, A., Robinson, L., Iglesias, J.R., Owen, R., Peltola, T., Sforzi, A., Shirk, J., Vogel, J., Vohland, K., Witt, T., Bonn, A., 2018. Innovation in Citizen Science – Perspectives on Science-Policy Advances. Citiz. Sci.: Theory Pract. 3 (1). Available at: 10.5334/cstp.114.

Hecker, S., Garbe, L., and Bonn, A., 2019. The European citizen science landscape – a snapshot, in *Citizen Science*, pp. 190–200. Available at: 10.2307/j.ctv550cf2.20.

Hofstede, G.J., 2001. Adoption of communication technologies and national culture. Systèmes d'Information et Management 6 (3), 55–74.

Irwin, A., 1995. Citizen science: a study of people, expertise, and sustainable development. Routledge (Environment and society.), London.

Jakučionytė-Skodienė, M., Liobikienė, G., 2021. Climate change concern, personal responsibility and actions related to climate change mitigation in EU countries: Cross-cultural analysis. J. Cleaner Prod. 281, 125189. Available at: 10.1016/j.jclepro.2020.125189.

Johnson, M.F., Hannah, C., Acton, L., Popovici, R., Karanth, K.K., Weinthal, E., 2014. Network environmentalism: Citizen scientists as agents for environmental advocacy. Global Environ. Change 29, 235–245. Available at: 10.1016/j.gloenvcha.2014.10.006.

Johnson, J.E., Hooper, E., Welch, D.J., 2020. Community Marine Monitoring Toolkit: A tool developed in the Pacific to inform community-based marine resource management. Mar. Pollut. Bull. 159, 111498. Available at: 10.1016/j.marpolbul.2020.111498.

Johnson, R.E., Rosen, C.C., Djurdjevic, E., 2011. Assessing the Impact of Common Method Variance on Higher Order Multidimensional Constructs. J. Appl. Psychol. 96 (4), 744. Available at: 10.1037/a0021504.

Juaneda-Ayensa, E., Clavel San Emeterio, M., Cirilo-Jordan, S., González-Menorca, L., 2020. Unified Theory of Acceptance and Use of Social Apps (UTAU-SA): The Role of Technology in the Promotion of Recycling Behavior. In: International Scientific Conference on Innovations in Digital Economy. Springer, pp. 3–22. Available at: 10.1007/978-3-030-84845-3_1.

Kaasa, A., Andriani, L., 2021. 'Determinants of institutional trust: The role of cultural context'. J Institut. Econom. 18 (1), 45–65. Available at: 10.1017/S1744137421000199.

Kasten, P., Jenkins, S.R., Christofoletti, R.A., 2021. Participatory Monitoring—A Citizen Science Approach for Coastal Environments. Front. Marine Sci. 8, 992. Available at: 10.3389/fmars.2021.681969.

Kennedy, C., Hatley, N., Lau, A., Mercer, A., Keeter, S., Ferno, J., Asare-Marfo, D., 2022. Strategies for Detecting Insincere Respondents in Online Polling. Public Opinion Quar. 85 (4), 1050–1075. Available at: 10.1093/poq/nfab057.

Kim, H.W., Gupta, S., 2014. A user empowerment approach to information systems infusion. IEEE Trans. Eng. Manage. 61 (4), 656–668. Available at: 10.1109/TEM.2014.2354693.

Kloetzer, L., Lorke, J., Roche, J., Golumbic, Y., Winter, S., Jõgeva, A., 2021. Learning in Citizen Science. In: The Science of Citizen Science, p. 283. Available at: 10.1007/978-3-030-58278-4_15.

Kosmala, M., Wiggins, A., Swanson, A., Simmons, B., 2016. Assessing data quality in citizen science. Front. Ecol. Environ. 14 (10), 551–560. Available at: 10.1002/fee.1436.

Kullenberg, C., Kasperowski, D., 2016. What is citizen science? - A scientometric meta-analysis. PLoS ONE 11 (1), e0147152. Available at: 10.1371/journal.pone.0147152.

Kumar, S., Giridhar, V., Sadarangani, P., 2019. A Cross-national Study of Environmental Performance and Culture: Implications of the Findings and Strategies. Global Busin. Rev. 20 (4), 1051–1068. Available at: 10.1177/0972150919845260.

Land-Zandstra, A., Agnello, G., and Gültekin, Y.S., 2021. Participants in Citizen Science, in *The Science of Citizen Science*, p. 243. Available at: 10.1007/978-3-030-58278-4_13.

LaRue, M.A., Ainley, D.G., Pennycook, J., Stamatiou, K., Salas, L., Nur, N., Stammerjohn, S., Barrington, L., 2020. Engaging "the crowd" in remote sensing to learn about habitat affinity of the Weddell seal in Antarctica. Remote Sens. Ecol. Conserv. 6 (1), 70–78. Available at: 10.1002/rse2.124.

Lee, T.K., Crowston, K., Harandi, M., Østerlund, C., Miller, G., 2018. Appealing to different motivations in a message to recruit citizen scientists: Results of a field experiment. J. Sci. Commun. 17 (1), A02. Available at: 10.22323/2.17010202.

Lee, G., Xia, W., 2010. 'Toward agile: An integrated analysis of quantitative and qualitative field data on software development agility'. MIS Quart. Manage. Informat. Syst. 34 (1), 87–114. Available at: 10.2307/20721416.

Lemmens, R., Antoniou, V., Hummer, P., Potsiou, C., 2021. Citizen Science in the Digital World of Apps. In: The Science of Citizen Science, p. 461. Available at: 10.1007/978-3-030-58278-4_23.

Li, W., 2021. The role of trust and risk in Citizens' E-Government services adoption: A perspective of the extended UTAUT model. Sustainability (Switzerland) 13 (14), 7671. Available at: 10.3390/su13147671.

Limayem, M., Hirt, S.G., Cheung, C.M.K., 2007. 'How habit limits the predictive power of intention: The case of information systems continuance'. MIS Quart. Manage. Informat. Syst. 31 (4), 705–737. Available at: 10.2307/25148817.

Linder, N., Giusti, M., Samuelsson, K., Barthel, S., 2022. Pro-environmental habits: An underexplored research agenda in sustainability science. Ambio 51 (3), 546–556. Available at: 10.1007/s13280-021-01619-6.

Luna, S., Gold, M., Albert, A., Ceccaroni, L., Claramunt, B., Danylo, O., Haklay, M., Kottmann, R., Kyba, C., Piera, J., Radicchi, A., Schade, S., Sturm, U., 2018. Developing Mobile Applications for Environmental and Biodiversity Citizen Science: Considerations and Recommendations. Multimedia Tool. Appl. Environ. Biodivers. Informat. 9–30. Available at: 10.1007/978-3-319-76445-0_2.

MacKenzie, S.B., Podsakoff, P.M., 2012. Common Method Bias in Marketing: Causes, Mechanisms, and Procedural Remedies. J. Retail. 88 (4), 542–555. Available at: 10.1016/j.jretai.2012.08.001.

MacKenzie, S.B., Podsakoff, P.M., Podsakoff, N.P., 2011. Construct Measurement and Validation Procedures in MIS and Behavioral Research: Integrating New and Existing Techniques. MIS Quarterly 35 (2), 293–334. Available at: 10.2307/23044045.

Malthus, T.J., Ohmsen, R., van der Woerd, H.J., 2020. An Evaluation of Citizen Science Smartphone Apps for Inland Water Quality Assessment. Remote Sensing 1578. Available at: 10.3390/rs12101578.

Mantovani, A., Vergari, C., 2017. Environmental vs hedonic quality: Which policy can help in lowering pollution emissions? Environ. Dev. Econ. 22 (3), 274–304. Available at: 10.1017/S1355770X16000371.

Marlowe, C., Hyder, K., Sayer, M.D.J., Kaiser, J., 2021. Divers as Citizen Scientists: Response Time, Accuracy and Precision of Water Temperature Measurement Using Dive Computers. Front. Mar. Sci. 8, 114. Available at: 10.3389/fmars.2021.617691.

McMichael, A.J., Lindgren, E., 2011. Climate change: present and future risks to health, and necessary responses. J. Intern. Med. 270 (5), 401–413. Available at: 10.1111/j.1365-2796.2011.02415.x.

Measham, T.G., Barnett, G.B., 2008. Environmental Volunteering: Motivations, modes and outcomes. Aust. Geogr. 39 (4), 537–552. Available at: 10.1080/00049180802419237.

Menon, N., George, G., Ranith, R., Sajin, V., Murali, S., Abdulaziz, A., Brewin, R.J.W., Sathyendranath, S., 2021. Citizen Science Tools Reveal Changes in Estuarine Water Quality Following Demolition of Buildings. Remote Sens. 1683. Available at: 10.3390/rs13091683.

Mi, L., Qiao, L., Xu, T., Gan, X., Yang, H., Zhao, J., Qiao, Y., Hou, J., 2020. Promoting sustainable development: The impact of differences in cultural values on residents' pro-environmental behaviors. Sustain. Dev. 28 (6), 1539–1553. Available at: 10.1002/sd.2103.

Nagy, S., Molnárné, C.K., 2018. The Effects of Hofstede's Cultural Dimensions on Pro-Environmental Behaviour: How Culture Influences Environmentally Conscious Behaviour. Theory Methodol. Pract. (TMP) 14 (01), 27–36.

Naranjo-Zolotov, M., Oliveira, T., Casteleyn, S., 2019. Citizens' intention to use and recommend e-participation: Drawing upon UTAUT and citizen empowerment. Informat. Technol. People 32 (2), 364–386. Available at: 10.1108/ITP-08-2017-0257.

Figueiredo Do Nascimento, S., Martinho Guimaraes Pires Pereira, A., and Ghezzi, A. (2014) *From Citizen Science to Do It Yourself Science An annotated account of an on-going movement . EUR 27095.* Luxembourg: Publications Office of the European Union. Available at: 10.2788/12246.

Newman, G., Wiggins, A., Crall, A., Graham, E., Newman, S., Crowston, K., 2012. The future of Citizen science: Emerging technologies and shifting paradigms. Front. Ecol. Environ. 298–304. Available at: 10.1890/110294.

O'Hara, C., Frazier, M., Halpern, B., 2021. At-risk marine biodiversity faces extensive, expanding, and intensifying human impacts. Science 372, 84–87. Available at: 10.1126/science.abe6731.

Papakonstantinou, A., Batsaris, M., Spondylidis, S., Topouzelis, K., 2021. A Citizen Science Unmanned Aerial System Data Acquisition Protocol and Deep Learning Techniques for the Automatic Detection and Mapping of Marine Litter Concentrations in the Coastal Zone. Drones 5 (1), 6. Available at: 10.3390/drones5010006.

Parboteeah, K.P., Addae, H.M., Cullen, J.B., 2012. Propensity to Support Sustainability Initiatives: A Cross-National Model. J. Bus. Ethics 105 (3), 403–413. Available at: 10.1007/s10551-011-0979-6.

Paul, J.D., Cieslik, K., Sah, N., Shakya, P., Parajuli, B.P., Paudel, S., Dewulf, A., Buytaert, W., 2020. 'Applying Citizen Science for Sustainable Development: Rainfall Monitoring in Western Nepal'. Front. Water 2, 62. Available at: 10.3389/frwa.2020.581375.

Perra, M., Brinkman, T., 2021. Seeing science: using graphics to communicate research. Ecosphere 12 (10), e03786. Available at: 10.1002/ecs2.3786.

Perry, G.L.W., Richardson, S.J., Harré, N., Hodges, D., Lyver, P.O.B., Maseyk, F.J.F., Taylor, R., Todd, J.H., Tylianakis, J.M., Yletyinen, J., Brower, A., 2021. Evaluating the Role of Social Norms in Fostering Pro-Environmental Behaviors. Front. Environ. Sci. 9, 160. Available at: 10.3389/fenvs.2021.620125.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P., 2003. Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. J. Appl. Psychol. 879. Available at: 10.1037/0021-9010.88.5.879.

Pucino, N., Kennedy, D.M., Carvalho, R.C., Allan, B., Ierodiaconou, D., 2021. Citizen science for monitoring seasonal-scale beach erosion and behaviour with aerial drones. Sci. Rep. 11 (1), 3935. Available at: 10.1038/s41598-021-83477-6.

Rappaport, J., 1987. Terms of empowerment/exemplars of prevention: Toward a theory for community psychology. Am. J. Community Psychol. 15 (2), 121–148. Available at: 10.1007/BF00919275.

Ringle, C., Wende, S., Becker, J., 2015. SmartPLS 3. SmartPLS GmbH, Bönningstedt. Available at: http://www.smartpls.com.

Robinson, L.D., Cawthray, J.L., West, S.E., Bonn, A., Ansine, J., 2019. Ten principles of citizen science. In: Citizen Science: Innovation in Open Science, Society and Policy, pp. 27–40. Available at: 10.2307/j.ctv550cf2.9.

Robinson, J.A., Kocman, D., Speyer, O., Gerasopoulos, E., 2021. Meeting volunteer expectations — a review of volunteer motivations in citizen science and best practices for their retention through implementation of functional features in CS tools. J. Environ. Plann. Manage. 64 (12), 2089–2113. Available at: 10.1080/09640568.2020.1853507.

Rotman, D., Hammock, J., Preece, J., Hansen, D., Boston, C., Bowser, A., He, Y., 2014. Motivations Affecting Initial and Long-Term Participation in Citizen Science Projects in Three Countries, in, pp. 110–124. Available at: 10.9776/14054.

Ryan, R.M., Deci, E.L., 2000. Self-Determination Theory and the Facilitation of Instrinsic Motivation, Social Development, and Well-Being. Am. Psychol. 55 (1), 68–78. Available at: 10.1037110003-066X.55.1.68.

Ryan, R.M., Deci, E.L., 2020. Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contempor. Educat. Psychol. 61, 101860. Available at: 10.1016/j.cedpsych.2020.101860.

San Llorente Capdevila, A., Kokimova, A., Sinha Ray, S., Avellán, T., Kim, J., Kirschke, S., 2020. Success factors for citizen science projects in water quality monitoring. Sci. Total Environ. 728, 137843. Available at: 10.1016/j.scitotenv.2020.137843.

Sauermann, H., Vohland, K., Antoniou, V., Balázs, B., Göbel, C., Karatzas, K., Mooney, P., Perelló, J., Ponti, M., Samson, R., Winter, S., 2020. Citizen science and sustainability transitions. Res. Policy 49 (5), 103978. Available at: 10.1016/j.respol.2020.103978.

Schade, S., Manzoni, M., Tsinaraki, C., Kotsev, A., Fullerton, K.T., Sgnaolin, R., Spinelli, F., and Mitton, I., 2017. *Using new data sources for policymaking*. Luxembourg: EUR 28940 EN, Publications Office of the European Union, JRC109472. Available at: 10.2760/739266.

Schaefer, T., Kieslinger, B., Brandt, M., van den Bogaert, V., 2021. Evaluation in Citizen Science: The Art of Tracing a Moving Target. In: The Science of Citizen Science, p. 495. Available at: 10.1007/978-3-030-58278-4_25.

Secretariat of the Convention on Biological Diversity, 2020. Global Biodiversity Outlook 5. Secretariat of the Convention on Biological Diversity, Montreal, Canada: Montreal, Canada, p. 208.

Senabre Hidalgo, E., Perelló, J., Becker, F., Bonhoure, I., Legris, M., Cigarini, A., 2021. Participation and Co-creation in Citizen Science. In: The Science of Citizen Science, pp. 199–218. Available at: 10.1007/978-3-030-58278-4_11.

Sharma, N., Greaves, S., Siddharthan, A., Anderson, H.B., Robinson, A., Colucci-Gray, L., Wibowo, A.T., Bostock, H., Salisbury, A., Roberts, S., Slawson, D., van der Wal, R., 2019. From citizen science to citizen action: Analysing the potential for a digital platform to cultivate attachments to nature. J. Sci. Commun. 18 (1), 1–35. Available at: 10.22323/2.18010207.

Shevchuk, N., Oinas-Kukkonen, H., 2020. 'Aiding Users in Green IS Adoption with Persuasive Systems Design'. Urban Science 4 (4), 52. Available at: 10.3390/urbansci4040052.

Shirk, J.L., Ballard, H.L., Wilderman, C.C., Phillips, T., Wiggins, A., Jordan, R., McCallie, E., Minarchek, M., Lewenstein, B.V., Krasny, M.E., Bonney, R., 2012. Public participation in scientific research: A framework for deliberate design. Ecol. Soc. 17 (2). Available at: 10.5751/ES-04705-170229.

Siano, R., Chapelle, A., Antoine, V., Michel-Guillou, E., Rigaut-Jalabert, F., Guillou, L., Hégaret, H., Leynaert, A., Curd, A., 2020. Citizen participation in monitoring phytoplankton seawater discolorations. Marine Policy 117, 103039. Available at: 10.1016/j.marpol.2018.01.022.

Sparks, P., Shepherd, R., 1992. Self-Identity and the Theory of Planned Behavior: Assesing the Role of Identification with "Green Consumerism". Soc. Psychol. Quart. 55 (4), 388–399. Available at: 10.2307/2786955.

Spreitzer, G.M., 1995. Psychological Empowerment in the Workplace: Dimensions, Measurement, and Validation. Acad. Manage. J. 38 (5), 1442–1465. Available at: 10.2307/256865.

Sreelakshmi, G., 2016. Empowerment Constructs : An Implementation Model-A Case Study. J. Business Manage. 18 (6), 37–42.

Sreen, N., Purbey, S., Sadarangani, P., 2018. Impact of culture, behavior and gender on green purchase intention. J. Retail. Consum. Serv. 41, 177–189. Available at: 10.1016/j.jretconser.2017.12.002.

Srite, M., Karahanna, E., 2006. 'The role of espoused national cultural values in technology acceptance'. MIS Quart. Manage. Informat. Syst. 30 (3), 679–704. Available at: 10.2307/25148745.

Steg, L., Bolderdijk, J.W., Keizer, K., Perlaviciute, G., 2014a. An Integrated Framework for Encouraging Pro-environmental Behaviour: The role of values, situational factors and goals. J. Environ. Psychol. 38, 104–115. Available at: 10.1016/j.jenvp.2014.01.002.

Steg, L., Perlaviciute, G., van der Werff, E., Lurvink, J., 2014b. The Significance of Hedonic Values for Environmentally Relevant Attitudes, Preferences, and Actions. Environ. Behav. 46 (2), 163–192. Available at: 10.1177/0013916512454730.

Sullivan, A., York, A.M., 2021. Collective action for changing forests: A spatial, social-ecological approach to assessing participation in invasive plant management. Global Environ. Change 71, 102366. Available at: 10.1016/j.gloenvcha.2021.102366.

Taghizadeh, S.K., Rahman, S.A., Nikbin, D., Alam, M.M.D., Alexa, L., Ling Suan, C., Taghizadeh, S., 2021. Factors influencing students' continuance usage intention with online learning during the pandemic: a cross-country analysis. Behav. Informat. Technol. 41 (9), 1998–2017. Available at: 10.1080/0144929X.2021.1912181.

Tiago, P., Gouveia, M.J., Capinha, C., Santos-Reis, M., Pereira, H.M., 2017. The influence of motivational factors on the frequency of participation in citizen science activities. Nat. Conservat. 61–78. Available at: 10.3897/natureconservation.18.13429.

Tinati, R., Luczak-Roesch, M., Simperl, E., Hall, W., 2017. An investigation of player motivations in Eyewire, a gamified citizen science project. Comput. Hum. Behav. 73, 527–540. Available at: 10.1016/j.chb.2016.12.074.

Tsybulsky, D., 2020. Self-Reported Reasons for Participating in Pro-environmental Citizen Science Activities: A Case Study of Butterfly Monitoring in Israel, Front. Educat., 5. Available at: 10.3389/feduc.2020.00116.

Turicchia, E., Cerrano, C., Ghetta, M., Abbiati, M., Ponti, M., 2021. MedSens index: The bridge between marine citizen science and coastal management. Ecol. Ind. 122, 107296. Available at: 10.1016/j.ecolind.2020.107296.

Turrini, T., Dörler, D., Richter, A., Heigl, F., Bonn, A., 2018. The threefold potential of environmental citizen science - Generating knowledge, creating learning opportunities and enabling civic participation. Biol. Conserv. 225, 176–186. Available at: 10.1016/j.biocon.2018.03.024.

Uhrin, A.V., Lippiatt, S., Herring, C.E., Dettloff, K., Bimrose, K., Butler-Minor, C., 2020. 'Temporal Trends and Potential Drivers of Stranded Marine Debris on Beaches Within Two US National Marine Sanctuaries Using Citizen Science Data'. Front. Environ. Sci. 232.

United Nations, 2021. The Sustainable Development Goals Report 2021. United Nations, New York, USA.

United Nations, 2020. Leaders' pledge for nature: United to Reverse Biodiversity Loss by 2030 for Sustainable Development. United Nations Summit on Biodiversity [Preprint].

van Noordwijk, T., Bishop, I., Staunton-Lamb, S., Oldfield, A., Loiselle, S., Geoghegan, H., Ceccaroni, L., 2021. Creating Positive Environmental Impact Through Citizen Science. In: The Science of Citizen Science, pp. 373–395. Available at: 10.1007/978-3-030-58278-4_19.

Venkatesh, V., Thong, J.Y.L., Xu, X., 2012. Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Quart. Manage. Informat. Syst. 36 (1), 157–178. Available at: 10.2307/41410412.

Ward, P.J., de Ruiter, M.C., Mård, J., Schröter, K., van Loon, A., Veldkamp, T., von Uexkull, N., Wanders, N., AghaKouchak, A., Arnbjerg-Nielsen, K., Capewell, L., Carmen Llasat, M., Day, R., Dewals, B., di Baldassarre, G., Huning, L.S., Kreibich, H., Mazzoleni, M., Savelli, E., Teutschbein, C., van den Berg, H., van der Heijden, A., Vincken, J.M.R., Waterloo, M.J., Wens, M., 2020. 'The need to integrate flood and drought disaster risk reduction strategies. Water Security 11, 100070. Available at: 10.1016/j.wasec.2020.100070.

Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User acceptance of information technology: Toward a unified view, MIS Quart. Manage. Informat. Syst. 27 (3), 425–478. https://doi.org/10.2307/30036540.

Weber, K., Pallas, F., Ulbricht, M.R., 2019. Challenges of Citizen Science: Commons, Incentives, Organizations, and Regulations. Am. J. Bioeth. 52–54. Available at: 10.1080/15265161.2019.1619862.

Wehn, U., Almomani, A., 2019. Incentives and barriers for participation in community-based environmental monitoring and information systems: A critical analysis and integration of the literature. Environ. Sci. Policy 101, 341–357. Available at: 10.1016/j.envsci.2019.09.002.

West, S., Pateman, R., 2016. Recruiting and Retaining Participants in Citizen Science: What Can Be Learned from the Volunteering Literature? Citizen Sci.: Theory Pract. 1 (2). Available at: 10.5334/cstp.8.

White, K., Habib, R., Hardisty, D.J., 2019. How to SHIFT consumer behaviors to be more sustainable: A literature review and guiding framework. J. Market. 83 (3), 22–49. Available at: 10.1177/0022242919825649.

Wilmsen, C., Elmendorf, W.F., Fisher, L., Ross, J., Sarathy, B., and Wells, G., 2012. *Partnerships for empowerment: Participatory research for community-based natural resource management, Partnerships for Empowerment: Participatory Research for Community-Based Natural Resource Management*. Routledge. Available at: 10.4324/9781849772143.

Wittmann, M., Sircova, A., 2018. Dispositional orientation to the present and future and its role in pro-environmental behavior and sustainability. Heliyon e00882. Available at: 10.1016/j.heliyon.2018.e00882.

Zimmerman, M.A., 1995. Psychological empowerment: Issues and illustrations. Am. J. Community Psychol. 23 (5), 581–599. Available at: 10.1007/BF02506983.

Zimmerman, M.A., Rappaport, J., 1988. Citizen participation, perceived control, and psychological empowerment. Am. J. Community Psychol. 16 (5), 725–750. Available at: 10.1007/BF00930023.