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How socio-psychological drivers prompt the adoption of nature-based solutions: Evidence from Mediterranean dryland ecosystems

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Abstract
With global climate change and disruption in socio-ecological systems, the Mediterranean region is experiencing increased climatic pressures, depletion of natural resources and limited citizen participation in climate change adaptation actions. To address this issue, this study seeks to ascertain the socio-psychological attributes behind citizens' pro-environmental behaviour by engaging in the adoption of Nature-Based Solutions (NBSs) in Mediterranean drylands. Ajzen's Theory of Planned Behaviour (TPB) model served as the theoretical foundation for this study, and a quantitative survey with 3836 citizens was conducted in six Mediterranean countries: Greece, Italy, Spain, Tunisia, Morocco, and Egypt. Structural Equation Modelling (SEM) was used to evaluate the strength of relationships between citizens' socio-psychological constructs and to predict their intention to support the adoption of NBSs in the Mediterranean region. The reported results indicated that considering citizens' socio-demographic factors, their age, gender, educational level, family members, employment status, financial situation, and habitat had a significant influence on their intention to support the adoption of NBSs. Then, regarding socio-psychological predictors their behavioural attitudes, subjective norms, perceived behaviour control, environmental knowledge, environmental consciousness, emotional connection, environmental identity, environmental opinions, and awareness of consequences significantly influence their intention to support the adoption of NBSs. The findings also implied that the inclusion of additional constructs had improved the predictive power of the baseline TPB model in projecting citizens' intention to support the adoption of NBSs. Thus, implications drawn from this work outline potential socio-psychological attributes to promote the adoption of NBSs in practice to facilitate pro-environmental behaviour among a diverse audience. Knowledge from this work guides the transition of the nature-based adaptation narrative from theoretical discourse to practical implementation for reinforcing the resilience and sustainability of socio-ecological systems.

Keywords Nature-Based Solutions (NBSs) · Intention to support · Theory of Planned Behaviour (TPB) · Socio-psychological factors · Pro-environmental behaviour

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1 Introduction

Since the evolution of humans towards their transition into societies, they have depended on natural resources for their livelihood and survival (Vasseur et al., 2017). However, the ever-increasing population, rapid economic growth, industrialized market, unsustainable exploitation and rising consumption of natural resources have progressively impacted both the environment and human well-being (Melgar-Melgar & Hall, 2020; O'Sullivan, 2020). These factors conjointly have led to deforestation, land degradation, depletion of water resources, degradation of soil and water health, increased greenhouse gas emissions (GHGE) and ever-increasing pollution that have accelerated the risk of vegetation loss and extinction of genetic diversity (Everard, 2020; Muluneh, 2021; Ursino, 2019). These circumstances have also reduced the resilience of humans with regard to natural calamities and unforeseen environmental consequences (Maja & Ayano, 2021). The most alarming fact is that the current demands for natural resources and the irreversible damage resulting from human activities have pushed us close to the dangerous thresholds that some have called the 'planetary boundary' (Richardson et al., 2023; Steffen et al., 2015). A sustainable socio-ecological system with environmental balance and conservation is needed to ensure the existence of human life and well-being (Leviston et al., 2018; Vasseur et al., 2017). Hence, failure to acknowledge the risk and uncertainty surrounding sustainable natural resource management and protection of the ecosystem would worsen the adverse effects of human activities and climate change scenarios on our survival in the long run.

In terms of the global concern regarding sustainability and resilience of the natural environment and human beings, nature-based solutions (NBSs) are emerging as pivotal responses in mitigating disruptions in the socio-ecological systems (Baptiste et al., 2024; Vanbergen et al., 2020) and are endorsed as a potential solution in facilitating sustainability under heterogeneous environmental, economic and social conditions (Davies et al., 2021; Mohanty, 2023). According to definitions provided by the International Union for Conservation of Nature (IUCN) and the European Commission, NBSs are actions or practices that are inspired by nature and address the societal and economic challenges of protecting ecosystems and sustainably managing biodiversity (Bauduceau et al., 2015; Cohen, 2013). Thus, the NBSs respect the three dimensions of sustainable development – societal, economic, and environmental, and are also linked to human well-being (Hanson et al., 2020). Consequently, NBSs provide a common conceptual ground to align policies in such a way as to protect nature and the ecosystem while attaining the targets of Sustainable Development Goals (SDGs) (Hanson et al., 2020; Martín et al., 2020). Researchers and policy makers are, therefore, mass promoting the NBSs in mainstream policy planning (Piotr & Ilona, 2023) and persuading active participation of citizens in the adoption process to facilitate the transition towards a more resilient socio-ecological system (Baldwin-Cantello et al., 2023; Davies et al., 2021).

It is well established that the current sustainability challenges are deeply rooted in changes in the global system and human behaviour, such as a lack of governance and policy to protect ecological balance, lack of public participation in preserving ecological systems and failure to engage in pro-environmental behaviour (Maund et al., 2020; Schröter et al., 2017). Because, for any socio-ecological system to flourish and sustain itself, it is necessary to ensure citizen participation (Melgar-Melgar & Hall, 2020). The significance of the involvement of all stakeholders through a participatory approach is also emphasized in the

concept of NBSs by both the IUCN (International Union for Conservation of Nature) and the EU (European Union) to co-design and co-implement the solutions (Faivre et al., 2017; Hanson et al., 2020). Besides, with recent advances in understanding the nexus between society and the environment, and how environmental and climatic changes increasingly complicate adaptation strategies, emerging paradigms in natural resource management are beginning to recognize the importance of public participation through co-creation and co-implementation of solutions (Dushkova & Kuhlicke, 2024; Ernst, 2019). Therefore, our study also followed this emerging paradigm of public engagement through co-creation and co-governance schemes to transform sustainability ambition into practical actions. Because as it is advocated before, participatory action of stakeholders facilitates recognizing who is affected by the decisions and actions they take, and who has the power to influence their outcome and will, thus, lead to the enforcement of pro-environmental behaviour at the individual and/or societal level (Davis et al., 2024; Freeman, 2010; Reed et al., 2009).

The Mediterranean region is characterized by the presence of rich biodiversity, the abundance of natural resources and unusual geographical and topographical variability with distinct environmental features. These features make it one of the most captivating but also one of the most vulnerable regions in the world not only from an ecological perspective but also in terms of social and cultural aspects (Gauquelin et al., 2018; Scarascia-Mugnozza et al., 2000). However, the Mediterranean region has been facing substantial challenges in maintaining sustainability and the natural balance of the ecosystem because of the rapid depletion of vegetation, land and water resources in the last few decades (Cramer et al., 2018). In particular, the over-exploitation of natural resources, socio-economic pressure and climatic vulnerabilities are resulting in severe land and water resource degradation and desertification in this region, mostly in the dryland areas (Becerril-Piña & Mastachi-Loza, 2021; Ferreira et al., 2022). As NBSs are being promoted as an integrated, cost-effective and innovative way of creating a greener, more sustainable, and more resilient system that optimises the synergies between nature, society and economy, the adoption of NBSs in restoring land, water resources and vegetation thereby has relevance and practical implications for the Mediterranean dryland ecosystem (Grace et al., 2021). Some examples of such NBSs that are being promoted and adopted in Mediterranean regions are integrated olive orchard management through reduced/no-tillage and cover crop (Kavvadias & Koubouris, 2019), the adoption of agro-slivo-pastoral systems (Keesstra et al., 2018), water provisioning and rainwater harvesting (Licciardello et al., 2021), afforestation and adaptive vegetation management (Nadal-Romero et al., 2023), microbiome-assisted restoration (Corinaldesi et al., 2023), the identification and adoption of suitable agroforestry plant genotypes (Aurelle et al., 2022), biodiversity-based agriculture and crop diversification (Di Bene et al., 2022), hydrological ecosystem service (Unguendoli et al., 2023), etc. Such nature-based practices have the potential to restore degraded and endangered ecosystems and will enhance the resilience of local stakeholders under the growing threats of climatic and geo-hydrological risks in the Mediterranean region (Boix-Fayos et al., 2020). Moreover, the heterogeneity of environmental, economic and social conditions in this region has led to strong regional differences in water and land use (Gauquelin et al., 2018; Jiménez-Olivencia et al., 2021). As a result, the Mediterranean region requires a tailored and practical ecosystem-based approach in association with participatory action on the part of all stakeholders to prevent or mediate environmental conflicts and to promote pro-environmental behaviour among the citizens (Di Franco et al., 2020; Ison & Schlindwein, 2015).

However, despite the potential of NBSs as a practical solution to address climate change risks and biodiversity crises in the Mediterranean region, the mass adoption of NBSs at the citizen level is very limited at this present time (Grace et al., 2021). There also exists a significant knowledge gap regarding citizens' intention to support the adoption of such NBSs and engaging in such transformative pro-environmental actions (Davies et al., 2021; Grace et al., 2021). Besides, when setting goals for achieving SDGs and transitioning NBSs from theoretical discourse to practical actions, it is crucial to understand the socio-psychological factors that motivate individual participation and intention to support the adoption of certain practices, i.e., NBSs for ecosystem conservation or to adopt pro-environmental behaviour (Delaroche, 2020; Scopelliti et al., 2018). On the other hand, although the relevance of individual socio-psychological factors in promoting and predicting public participation in co-creation and co-implementation of environmentally-friendly behaviour or nature conservation practices to tackle habitat fragmentation, depletion of natural resources, biodiversity loss, climate change and environmental pollution has been extensively advocated (Bechtoldt et al., 2021), the estimation of substantiating impact of these factors are often overlooked in literature (Agnello et al., 2022; Otto et al., 2021). Besides, considering the plethora of indexes and indicators introduced for the evaluation of citizens' pro-environmental decision-making behaviour (Bechtoldt et al., 2021; Lange, 2023; Lange & Dewitte, 2019), there exist significant drawbacks in incorporating different dimensions of individuals' decision-making processes into one behavioural model to evaluate their intention to support and participate in pro-environmental behaviour (Srisathan et al., 2024; van Valkengoed et al., 2022). Particularly in the case of the Mediterranean region, the relevant evidence and factual narratives on citizens' intention to support the adoption of such environmentally-friendly practices, and the contributing factors behind their adoption decision are scarce and call for immediate attention in the current situation (Intonti et al., 2024; Kifaya, 2023). Particularly, no significant work has been done so far regarding citizens' intention to support the adoption of NBSs in the Mediterranean region.

Hence, this work seeks to assess citizens' intention to support the adoption of NBSs to restore sustainability and enhance the resilience of endangered dryland socio-ecological systems in hyper-arid lands in six Mediterranean countries. We also considered looking into whether the socio-psychological attributes are better in explaining their intention to support compared to their socio-demographic factors. To achieve this aim, this work adapted Ajzen's Theory of Planned Behaviour (TPB) model (1991, 2011) to explore the influencing socio-psychological factors behind citizens' intention to support NBSs adoption for the conservation and restoration of dryland ecosystems. The Structural Equation Model (SEM) approach was employed to evaluate the validity and reliability of an extended TPB model designed to predict citizens' pro-environmental behaviour. In addition, while exploring the complex mechanism among these socio-psychological variables with an individual's intention to support NBSs adoption, the mediating role of individuals' environmental knowledge was also considered.

The methodological design followed in this study is novel and pioneering in the sense that it followed a participatory approach and integrated additional variables into the TPB model to improve the prediction of citizens' intention to support the adoption of NBSs. This study examines the relationships between citizens' intentions to support the adoption of NBSs and their socio-demographic factors on the one hand and their socio-psychological attributes on the other. So, this study is one of its kind because no similar study has been

done before with Mediterranean citizens. In addition, this work contributes to generating in-depth transformative knowledge for supporting the restoration of degraded ecosystems following action-oriented measures to promote the adoption of pro-environmental practices. Besides, such a structured and replicable methodological approach can potentially be adapted in other similar contexts to support the sustainable management of natural resources and ecosystems and to motivate public participation in the climate change adaptation process. Subsequently, this work facilitates the implementation of SDGs in the Mediterranean region in the long run, particularly SDG Target 15.1 aimed at ensuring the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, SDG Target 15.3 by contributing to combat desertification and restoring degraded land and soil, and SDG Target 13.1 by strengthening resilience and adaptive capacity to climate-related hazards in the Mediterranean region. Consequently, this work sought to propose ways of engaging citizens in adopting pro-environmental actions and in supporting the transition of the current scenario towards an inclusive, just, sustainable and resilient socio-ecological system in climate-vulnerable regions.

2 Theoretical framework and hypotheses

2.1 The Theory of Planned Behaviour (TPB)

To interpret Mediterranean citizens' pro-environmental adaptation behaviour in terms of conserving the ecosystem, the study is grounded on the theoretical perspective of the Theory of Planned Behaviour (TPB) developed by Ajzen (Ajzen, 1991, 2011). The TPB model is a socio-psychological model based on the personal interest and rational choices of an individual in the decision-making process and can predict their behavioural intention leading to actual behaviour (Ajzen, 1991). In the TPB model, behavioural intention is the proximal component advocated as the best predictor of the behaviour of an individual and originates from their attitudes, subjective norms and perceived behavioural control (Ajzen, 1991). The model explores the intention to support the adoption of a certain behaviour or intention to contribute to a certain practice on the part of an individual, under the assumption that their acceptance of this certain behaviour is rational (Ajzen, 2011).

Researchers have consistently used the TPB model to foresee and predict the behavioural intentions of an individual to ascertain their intention to engage in pro-environmental behaviour (Delaroche, 2020; Gansser & Reich, 2023; Maleknia & ChamCham, 2024; Xu et al., 2024), particularly their intention to support the adoption of ecosystem restoration activities and the adoption of nature-based practices (Maleknia, 2024; Viti et al., 223; Xu et al., 2024). Now, in our study, citizens' intention to support the adoption of NBSs was presumed as a reasoned action and planned decision-making process. Here, in the case of TPB variables, attitude gives an estimation of individuals' positive view about certain practices, and has been established to have a significant impact on individuals' intention to support the adoption of environmentally-friendly practices (Ajzen & Driver, 1992; Dienes, 2015; Luzar & Cosse, 1998). On the other hand, subjective norms measure the social pressure behind adopting a particular behaviour and the social acceptance of the execution of this behaviour by individuals. This in turn is associated with a greater intention to support the

adoption of an ecological product or practice (Harjadi & Gunardi, 2022; Luzar & Cosse, 1998; Van Tonder et al., 2023). Moreover, perceived behavioural control stipulates a comprehensive assessment of one's ability to govern action and achieve intended targets, and has a substantial influence on one's intention to support the adoption of environmentally friendly practices (Cao et al., 2022; Deng et al., 2016; Grilli & Notaro, 2019). Consequently, due to the multi-disciplinary application, robustness, and appropriateness of the TPB model, this study adopted this model in assessing the causal relationship between citizens' socio-psychological factors and their intention to support the adoption of NBSs for supporting ecosystem restoration and mitigating land and water degradation and desertification in the Mediterranean region.

2.2 Proposed extended TPB model

It is advocated that the TPB model can be made more rigorous and applicable by introducing new variables in the explanation of human behaviour if the extensions could explain a significant proportion of variation in the behavioural intentions of an individual (Ajzen, 1991; Nketiah et al., 2022). Several scholars have employed extensions to the original TPB model to construct a more rational model aimed at explaining individuals' pro-environmental behaviour and their acceptance of nature-based practices (Goh et al., 2017; Yuriev et al., 2020; Zulkepeli et al., 2024). So, instead of focusing on only three original TPB constructs, this study incorporated six additional predictors to the original TPB model to facilitate better prediction of citizens' intention to support the adoption of NBSs. The additional constructs are environmental knowledge, environmental consciousness, emotional connection, environmental identity, environmental opinions, and awareness of consequences. Here, environmental knowledge refers to individuals' know-how about the environment and ecosystem and the prevailing impact of human activities and climate change on the socio-ecological systems that have proven to have a significant impact on individuals' pro-environmental behaviour (Braun & Dierkes, 2019; Topf & Speekenbrink, 2022). Besides, the environmental consciousness of an individual guides them to participate or accept only those practices that have less or no impact on the environment (Chen & Tung, 2014; Emekci, 2019), while, the awareness of the consequences characterises individuals' conscious choice of activities and their resultant impact with the time that prompt their engagement in activities (Fornara et al., 2020). Moreover, emotional connections are the psychological attachment of the individual to the state of the environment, while environmental identity is the individuals' connection with nature and the extent of their nature-sensitivity that influences their engagement in pro-environmental activities (Baena-Morales & Fröberg, 2023). On the other hand, environmental opinions facilitate place attachment on the parts of individuals and generate a perceived understanding among them that certain environmental protection events are controlled by their behaviour (Whitmarsh & O'Neill, 2010; Zhang et al., 2020). These additional factors were shown in some previous studies to be significant in predicting individuals' intention to support the adoption of environmental protection actions (Ge et al., 2023; Reichl et al., 2021; Taye et al., 2018), but had never been incorporated into a single model. Therefore, these six additional variables were integrated with the three original TPB variables to enhance the predictive power of the theoretical model when it comes to investigating citizens' decision-making processes related to supporting the sustainability of socio-ecological systems. The hypothesized relationships considered for this

research were presumed to be positive and one-directional, and all nine constructs cumulatively predicted an assured intention of the citizens to support the adoption of nature-based technologies, management practices and monitoring solutions that can effectively improve soil-plant-water interactions across Mediterranean dryland ecosystems. So, the extended TPB model was built to incorporate the propositions that attitude (H_1), subjective norms (H_2), perceived behavioural control (H_3), environmental knowledge (H_4), environmental consciousness (H_5), emotional connection (H_6), environmental identity (H_7), environmental opinions (H_8), and awareness of consequences (H_9) are positively associated with citizens' intention to support NBSs adoption. The proposed Extended TPB model incorporating nine exogenous variables and their hypothesized relationships with the endogenous variable are presented in Fig. 1.

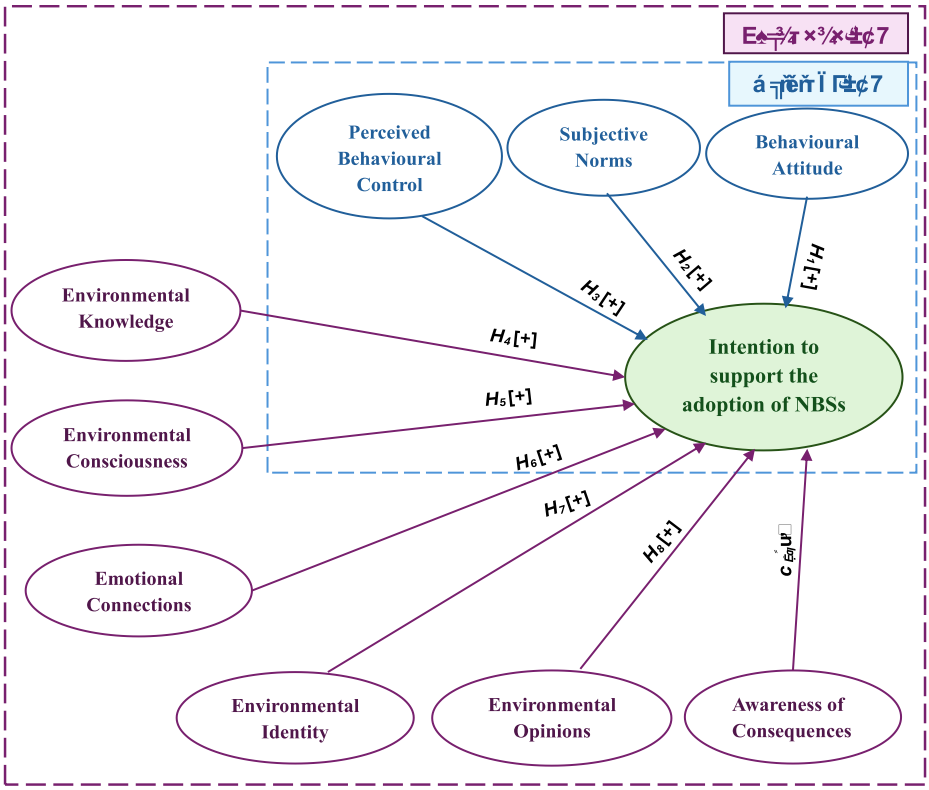

Fig. 1 The extended TPB model denotes the research framework for predicting the decision-making processes of citizens' regarding their intention to support adoption of nature-based solutions for mitigating socio-ecosystem degradation in the Mediterranean region; solid ➜ line showing possible one-tailed causal relationships and respective hypotheses of nine exogenous variables with the endogenous variable – citizens' intention to support adoption of NBSs

3 Materials and methods

3.1 Selection of the study area

The research was carried out in the Mediterranean region to address the complexity of ensuring public participation in attaining sustainability in terms of ecological and socio-economic processes. The Mediterranean region hosts exceptional biological and ecosystem diversity and socio-cultural richness and is characterized by a unique climate consisting of wet winters and hot, dry summers (Bonada & Resh, 2013). Because of the favourable weather conditions and the availability of natural resources, the Mediterranean region has also been favoured for human settlements and agricultural activities for decades. However, this region is now marked as a "hotspot" concerning the risks to the sustainability of ecosystems and societies due to rapid climatic and environmental changes aggravated by socio-economic and political tensions, misleading governance structures and power imbalances (Balzan et al., 2019; Rick et al., 2020). The rapid increase in population over the last century, the intensive exploitation of natural resources for agriculture and other economic purposes, people's dependence on natural resources, and a changing climate have resulted in a continuous loss of natural areas and soil and water resources in this region (Vafeidis et al., 2020). This ongoing process of land and water degradation, the increasing occurrence of forest fires and the loss of natural areas and vegetation are threatening the sustainability of the existing socio-ecological systems (Cramer & Guiot, 2022; Gudka et al., 2014). In addition, these events are placing increased stress on the access to and the utilization of natural resources, leading to conflict between stakeholders. The risk factors are most noticeable, particularly in areas with dryland ecosystems in southern and northern Mediterranean regions that are already facing a high degree of spatial and temporal variability in climate and an increase in demand for natural resources in the context where availability is already limited (Cramer et al., 2018; Gauquelin et al., 2018). To address the questions of climate change risks and human impact on dryland ecosystems, it is necessary to determine citizens' intentions to support the adoption of nature-based practices to restore and conserve the natural environment. So, six Mediterranean countries i.e., Greece, Spain, Italy, Morocco, Tunisia, and Egypt were selected as the study area (see Fig. 2) to assess citizens' intention to support the adoption of potential NBSs in this region.

3.2 Data collection

Prior to conducting the survey, a comprehensive literature review was conducted to identify potential NBSs for the Mediterranean region and to prioritize the real needs and understanding of the stakeholders regarding the adoption of NBSs in the Mediterranean region. In addition, the Living Lab (LL) approach was implemented for co-creating, assessing, and refining potential solutions in real-time by organizing several focus group discussions with different stakeholders, such as farmers, citizens, and policymakers to ensure and facilitate public participation. These discussions were carried out in Living Labs in each region using a bottom-up approach so that the co-creation process ensures that identified NBSs are relevant, user-centred, and practically applicable in specific dryland ecosystems in the Mediterranean region. Moreover, involving citizens directly in the co-creation and evaluation process of potential NBSs through the LL approach facilitates participatory action among

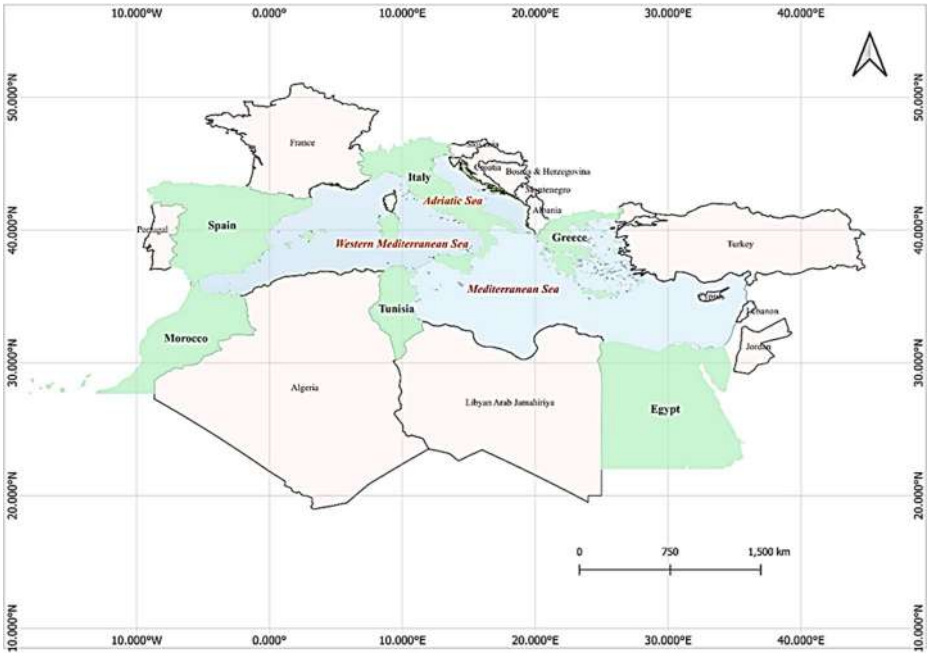

Fig. 2 Map of the Mediterranean region showing Mediterranean countries. The green colour identifies the six countries Greece, Spain, Italy, Morocco, Tunisia, and Egypt in the Mediterranean region considered as study locations for this study

the citizens, prompt reiteration and mass adoption of the proposed solution. Through these co-creating, co-learning sessions we selected a few specific potential NBSs for the Mediterranean region and certain NBSs were considered for certain countries - (i) subsurface water retention technology (SWRT) for Morocco, (ii) water harvesting for Egypt, (iii) Managed Aquifer Recharge (MAR) for Tunisia, (iv) cover crops and phenology-based irrigation for Greece, (v) microbial-based solution (mycorrhiza and biofertilizers)for Egypt, (vi) legume seeds inoculation with elite N-fixing rhizobia, innovative grazing management (GPS collars), and multi-scale remote sensing for the evaluation of soil-vegetation water dynamics for Italy, and (vii) adaptive vegetation management (CAFE DSS) for Spain. Respondents from each country were asked what was their intention to support the adoption of certain NBSs in their country.

In the second step, a semi-structured questionnaire was disseminated using the Qualtrics citizens panels and platform from 6th February to 27th February 2024 to collect data to better understand the mindset of the local communities regarding the adoption of NBSs. For selecting our study sample, we paid thoughtful attention to incorporating the citizens directly affected by negative externalities of the degraded ecosystem who are living in the Mediterranean drylands as they are most likely to engage with or be impacted by specific NBS interventions. The survey covered the six Mediterranean countries - Greece, Spain, Italy, Morocco, Tunisia, and Egypt using a random sampling method to collect data. This ensures a diverse selection of participants and the reliability of the collected data. In addition, to ensure the representativeness of the sample, a large sample size was targeted for data col-

lection considering certain pre-specified quotas i.e., ensuring gender balance in the sample and considering specific age groups (only respondents above 18 years of age). These quotes were adopted to obtain a balanced and representative composition of the study population from the six Mediterranean countries in such a way as to reflect the socio-demographic variances in the population and ensure the validity and generalizability of the study outcomes.

The survey questionnaire was originally developed in English based on previous research and was subsequently translated into other languages to meet the needs of the local population of the six Mediterranean countries. The questionnaire was divided into two sections, the first section dealt with the socio-demographic aspects of the respondents while the second section was based on the extended TPB model variables. Before going for the final data collection, a pre-test of the questionnaire was done through the use of a pilot survey covering approximately 20% of the sample size to verify and validate the items and the measurement scales.

During the survey, ethical considerations were respected, and the respondents' identity was kept anonymous. The participants were required to sign a consent form and receive an explanation of the aim and purpose of the study. After cleaning incomplete and faulty entries, the final sample consisted of 3836 respondents, of these, 726 respondents were from Greece, and 603, 475, 688, 497, and 847 respondents were from Spain, Italy, Morocco, Tunisia, and Egypt, respectively. The cumulative sample size (3836) is considered adequate for employing Structural Equation Modelling (SEM) and meets the general criteria of ensuring the validity and reliability of the outcomes in predicting citizens' intention to support the adoption of NBSs in Mediterranean countries.

3.3 Measurement of items

The latent constructs of the proposed extended TPB model are multifaceted and cannot be measured through a single observed variable. Consequently, they were measured using multi-item measurement scales adopted from previous studies. These were adjusted and re-specified hypothetically considering the context under consideration. In addition, to estimate the association between the constructs, a reflective measurement approach was followed whereby the latent construct is reflective and independent of the measurement items, and the items can be used interchangeably (Hair et al., 2013). Then, as the constructs of the extended TPB framework were unobservable, a total of thirty-five (35) items were proposed and estimated using seven-point Likert scales that were adopted and modified from previous publications based on similar contexts. The source and estimation of the items and the measurement scales for all constructs are presented in Table 1.

3.4 Analytical approach

To predict citizens' intention to support the adoption of NBSs in the Mediterranean region, the Structural Equation Model (SEM) approach was used to estimate the direct impact of their socio-psychological attributes on their behavioural intention. The demographic variables were not included in the SEM analysis as we followed the approach adopted in some previous works in predicting individuals' behavioural intention (see, for instance, Nguyen & Drakou, 2021; Shalender & Sharma, 2021; Wong et al., 2024). This approach allowed us to examine potential variations in citizens' behavioural intentions as a direct effect of

Table 1 Measurement of constructs to predict citizens' intention to support the adoption of nature-based solutions

Construct & Item	Statements	Measurement Scale	Reference
Behavioural attitude (AT)			
AT_1	For me, adopting nature-based solutions over the next years is	Extremely unnecessary (1) to Extremely necessary (7)	Chen and Tung (2014)
AT_2	For me, adopting nature-based solutions over the next years is	Extremely unimportant (1) to Extremely important (7)	
AT_3	For me, adopting nature-based solutions over the next years is	Extremely disadvantageous (1) to Extremely advantageous (7)	
AT_4	For me, adopting nature-based solutions over the next years is	Extremely damaging (1) to Extremely beneficial (7)	
Subjective norms (SN)			
SN_1	Most people who are important to me would prefer that I support nature-based solutions.	Strongly disagree (1) to Strongly agree (7)	Shalender and Sharma (2021)
SN_2	Most people who are important to me influence my actions to adopt nature-based solutions.		
SN_3	Most people who are important to me influence me to save natural resources because they are limited.		
Perceived behaviour control (PBC)			
PCB_1	I am confident that if I want, I support nature-based solutions	Strongly disagree (1) to Strongly agree (7)	Yadav and Pathak (2017)
PCB_2	Adopting nature-based solutions requires time, resources and effort.		
PCB_3	I am confident in adopting a nature-based solution in your region over the next few years.		
Environmental Knowledge (KNW)			
KNW_1	I know the advantages of supporting nature-based solutions.	Strongly disagree (1) to Strongly agree (7)	Nketiah et al. (2022)
KNW_2	I know adopting nature-based solutions can enhance biodiversity.		
KNW_3	I know adopting nature-bases solutions can enhance soil resilience.		
Environmental consciousness (ENV)			
ENV_1	Make strong environmental protection laws for business and industry.	Strongly disagree (1) to Strongly agree (7)	Nketiah et al. (2022)
ENV_2	Make laws requiring that all citizens conserve resources and reduce pollution.		
ENV_3	Support scientific research to help find new ways to save the environment.		
Emotional connection (EMO)			
EMO_P_1	Strong	Strongly disagree (1) to Strongly agree (7)	Dietrich (2013); Klonsky et al. (2019)
EMO_P_2	Enthusiastic		
EMO_P_3	Proud		
EMO_P_4	Elated		

Table 1 (continued)

Construct & Item	Statements	Measurement Scale	Reference
Environmental identity (IDENT)			
IDENT_1	Engaging in environmental behaviours is important to me.	Strongly disagree (1) to Strongly agree (7)	Dietrich (2013)
IDENT_2	I think of myself as a part of nature, not separate from it.		
IDENT_3	Being a part of the ecosystem is an important part of who I am.		
IDENT_4	Behaving responsibly toward the earth-living a sustainable lifestyle- is a part of my moral code.		
IDENT_5	In general, being a part of the natural world is an important part of my self-image.		
Environmental opinions (OPN)			
OP_1	For me, conserving the forest ecological system would provide us with a good environment.	Strongly disagree (1) to Strongly agree (7)	Dietrich (2013)
OP_2	For me, I support the behaviour of ensuring sustainable water management schemes.		
OP_3	I would like to adopt new natural solutions to enhance soil health.		
Awareness of Consequences (ACT)			
TIME_1	I consider how things might be in the future and try to influence those things with my day-to-day behaviour.	Not at all like me (1) to At all like me (7)	De Marchi et al. (2016)
TIME_2	I think it is important to take warnings about negative outcomes seriously, even if the negative outcome will not occur for many years.		
TIME_3	When I make a decision, I think about how it might affect me in the future.		
TIME_4	Often, I engage in a particular behaviour in order to achieve outcomes that may not result for many years.		
Intention to support (INT)			
INTEN_1	I am willing to pay for nature-based solutions if my current income increases.	Strongly disagree (1) to Strongly agree (7)	Nketiah et al. (2022)
INTEN_2	I am willing to pay for nature-based solutions if I currently have enough income.		
INTEN_3	I am willing to pay for nature-based solutions to ensure ecosystem restoration achievement.		

their socio-psychological attributes i.e., attitude, subjective norms, perceived behavioural control, environmental knowledge, environmental consciousness, emotional connection, environmental identity, environmental opinions, and awareness of consequences.

The SEM approach consisted of a two-phase analytical process i.e., a measurement model (reliability and validity analysis) and a structural model (path analysis) (Hair et al., 2019). The Partial Least Square (PLS-SEM) approach was specifically adopted for this work because it is reliable, accurate, and adaptable when it comes to predicting individuals' intention to support the adoption of a certain practice or behaviour and is widely advocated and used over the CB-SEM approach for this kind of work (Hair et al., 2019).

Before estimating the PLS-SEM model, an EFA (Exploratory Factor Analysis) was performed to identify the underlying factor structures, as per the guidelines proposed by Anderson and Gerbing (1988). A *KMO* value >0.50 was set to check for sampling adequacy and the Bartlett test of sphericity was validated to check the correlation matrix (p value <0.05) (Williams et al., 2010).

To estimate the measurement model through CFA (Confirmatory Factor Analysis) (Hair et al., 2020), the Kaiser criterion was utilized, where factors with eigenvalues greater than or equal to 1, and with factor loadings above 0.5 were retained to assess the item's (indicators) reliability. The internal consistency (reliability) of the items was evaluated using Cronbach's Alpha and Composite Reliability (*CR*) where items with a value $\geq$6 were retained (Cronbach & Gleser, 1957; Taber, 2018). The convergent validity of each construct was checked using the Average Variance Extracted (*AVE*) statistics where the threshold of 0.5 was accepted for each construct (Fornell & Larcker, 1981). Besides, discriminant validity was evaluated by utilizing the Fornell & Larcker Criterion and Heterotrait-Monotrait (*HTMT*) Ratio value above 0.90 (Hair et al., 2017a, b). Variance Inflation Factor (*VIF*) statistics were also employed to check the potential collinearity issues of the measurement items where *VIF* values less than 5 were preferable (Hair et al., 2021). Finally, overall model estimation was done considering a threshold value less than 0.10 or 0.08 for *SRMR* statistics and values above 0.9 as an acceptable fit for the Normed Fit Index (*NFI*) (Hair et al., 2017a, b; Henseler et al., 2014; Lohmöller & Lohmöller, 1989).

Consecutively, the significance and relevance of the relationships in the structural model were assessed by checking the path coefficient values, where values higher than 1.64 (one-tail test) indicate statistical significance at a 5% level (Hair et al., 2021). The null hypotheses need to be rejected with a *t*-statistics $>$1.96; and a *p*-value $<$0.05 at a 5% level of significance, so that the alternative hypothesis is sustained. In addition, the explanatory power and predictive power of the model were estimated where the coefficient of determination (R^2) value above 0.01 and the *Q*-square value above 0 was regarded as the threshold (Cohen, 1988, 2013; Hair et al., 2021). Here, the overall model fit was estimated for six countries separately. In addition, for cross-regional comparisons, Egypt, Morocco, and Tunisia were considered as the South Mediterranean region and Greece, Spain, and Italy as the North Mediterranean region. Then two separate model fits were evaluated for these two regions.

Besides, Multiple Regression Analysis was carried out to examine the explanatory power of the socio-demographic factors and their impact on citizens' intention to support the adoption of NBSs in the Mediterranean region.

3.5 Data analysis

The SPSS software (version 28) was used for descriptive analysis, regression analysis and for employing EFA (Exploratory Factor Analysis). To test the hypothesized relationships presented in the extended TPB model Smart-PLS software (version 4.1.0.3) was used. In the first stage of analysing the SEM model, CFA (Confirmatory Factor Analysis) was administered to evaluate the reliability and validity of the measurement model. Then, in the second stage, the goodness of fit of the model was evaluated and hypothesis testing was done to predict the dependence relationship between nine exogenous (predictor variables) and endogenous dependent variables (intention to support NBSs adoption) as the final part of structural analysis.

4 Results

4.1 Socio-demographic characteristics of the respondents

The socio-demographic profiles of the respondents are presented as designated groups in Table 2. Gender balance was highly satisfactory for all the countries except for Morocco. In terms of age, most of the respondents belonged to the 35–54 years old category and a majority of them were married. Education status varied between the countries where for Egypt, Greece and Morocco majority of the respondents had a university education, in Spain and Italy most of them had a secondary level of education (A level equivalent) and secondary education (below GC SE/O Level equivalent) in Tunisia. On the other hand, around half of the respondents were employed. However, the majority of them were reported to be in a bad financial situation, particularly in Greece, Spain and Italy while people from Egypt and Morocco comparatively had a good financial situation.

4.2 Socio-demographic effects on intentions to support the adoption of NBSs

The results of multiple linear regression output with citizens' overall mean intention to support score as the dependent variable and their socio-demographic predictors, like age, gender, educational level, family members, employment status, financial situation, and habitat are displayed in Table 3. Results indicate the model was statistically significant, $F(8,3700) = 17.028$, $p < 0.001$, Adjusted $R^2 = 0.033$ meaning weak correlation and only 3.3% of the variance in intention to support is explained by the model. All predictors were significant ($p < 0.05$; see Table 3). Respondent's age ($\beta = 0.069$, $p < 0.001$) indicated that older citizens had comparatively more favourable intention to support. Results for gender ($\beta = 0.071$, $p < 0.001$) showed that females had a higher intention to support than males. Educational level ($\beta = -0.035$, $p = 0.032$) suggested an interesting effect where higher education levels were associated with a slight decrease in intention to support. Then, results for family size ($\beta = -0.089$, $p < 0.001$) indicated larger families were likely to have less intention to support. A similar case was for employment status ($\beta = -0.064$, $p < 0.001$), where employed individuals had a higher intention to support than unemployed individuals. Financial situation ($\beta = -0.051$, $p = 0.003$) also had unique results suggesting that better financial situations were associated with a decrease in intention to support. Finally, results for citizens' habitat ($\beta = 0.093$, $p < 0.001$) indicated that residents from rural or forest areas had a higher intention to support adopting NBSs than urban residents.

Then two separate regression models were estimated to evaluate regional heterogeneity in citizens' intention to support adoption of NBSs in the North and South Mediterranean regions including age, gender, educational level, family members, employment status, financial situation, and habitat as predictors. Results are presented in Table 4. Both models were statistically significant, collectively explaining factors influencing citizens' intention to support, though with some regional variations.

In the case of respondents living in the North Mediterranean region, the model was significant ($F = 24.386$, $p < 0.001$), with an Adjusted R^2 of 0.082 meaning 8.2% of the cumulative variance in intention to support was explained by socio-demographic variables. Here, among the socio-demographic variables significant predictors were their educational level ($\beta = 0.059$, $p = 0.01$), financial situation ($\beta = 0.245$, $p < 0.001$), and employment status

Table 2 Socio-demographic categorization of the respondents

Socio-demographic Factors	Egypt	Greece	Spain	Italy	Morocco	Tunisia
	Sample Size					
	847	726	603	475	688	497
Gender						
Female	49.7%	44.5%	52.7%	45.9%	36.2%	50.3%
Male	50.3%	55.5%	47.3%	54.1%	63.8%	49.7%
Age						
18–34 years	37.8%	16.1%	19.7%	21.1%	31.8%	23.9%
35–54 years	47.1%	50.4%	33.0%	45.5%	51.2%	38.4%
>55 years	15.1%	33.5%	47.3%	33.5%	17.0%	37.6%
Family Size						
Mean	4.2	3.1	2.6	2.9	4.33	5.05
Std. dev.	1.5	1.6	1.28	1.25	2.74	3.48
Education						
Secondary education (Below GC SE/O Level)	0.7%	1.38%	4.83	6.33%	7.41%	43.46%
Secondary education (GCSE/O Level/ CSE or equivalent)	3.07%	1.10%	8.15%	14.98%	4.36%	6.04%
Secondary Education (A Level or equivalent)	4.72%	32.23%	33.44%	42.19%	10.90%	5.43%
University education	68.12%	36.50%	23.79%	9.07%	32.70%	22.33%
Vocational or Technical qualifications completed	4.84%	7.44%	5.82%	5.91%	9.16%	6.24%
Postgraduate degree or equivalent	16.65%	16.25%	10.82%	11.60%	24.71%	4.23%
Doctorate, post-doctorate or equivalent	1.06%	3.44%	8.82%	5.70%	4.94%	2.01%
Relationship Status						
Single	21.0%	29.9%	32.3%	6.8%	32.8%	34.4%
Married	76.0%	61.7%	57.4%	89.7%	60.8%	56.3%
Divorced	1.7%	8.4%	10.3%	3.6%	5.1%	3.6%
Widow(er)	0.4%	0.0%	0.0%	0.0%	0.3	5.6%
Other	0.9%	0.0%	0.0%	0.0%	1.0	0.0%
Employment status						
Employed	62.9%	56.3%	58.2%	46.5%	46.8%	28.6%
Self-employed	19.5%	16.0%	5.5%	15.6%	22.5%	26.6%
Retired	3.7%	9.1%	18.8%	9.7%	6.4%	8.7%
Stay-at-home parent	2.6%	2.8%	2.3%	9.5%	4.4%	20.3%
Student	7.7%	3.0%	2.3%	5.7%	9.0%	8.0%
Unemployed	3.7%	12.8%	12.8%	13.1%	10.9%	7.8%
Financial Situation						
Extremely bad	4.1%	7.0%	4.5%	4.4%	7.1%	12.5%
Bad	11.7%	86.0%	72.0%	72.4%	26.2%	47.7%
I don't know	5.4%	4.8%	20.6%	21.7%	11.9%	2.2%
Good	56.2%	2.2%	0.0%	0.0%	49.9%	35.0%
Extremely good	22.6%	7.0%	2.8%	1.5%	4.9%	2.6%

(β=−0.092, $p<0.001$) indicating respondents with higher education, employment and better financial situations were associated with higher intention to support the adoption of NBSs.

On the other hand, the model was also significant for respondents of the South Mediterranean region (F = 17.163, $p<0.001$), with an Adjusted R^2 of 0.056 indicating 5.6% of the vari-

Table 3 Summary of results of multiple regression analysis on effects of socio-demographic variables on intentions to support

Predictors	Unstandardized Coefficients	Coefficients Std. Error	Standardized Coefficients (β)	t-ratio	Sig.
(Constant)	4.213	0.116		36.312	<0.001
Age	0.098	0.025	0.069	3.913	<0.001
Gender	0.149	0.034	0.071	4.336	<0.001
Educational level	−0.022	0.01	−0.035	−2.149	0.032
Family size	−0.042	0.008	−0.089	−5.387	<0.001
Employment status	−0.04	0.01	−0.064	−3.811	<0.001
Financial situation	−0.048	0.016	−0.051	−2.979	0.003
Habitat	0.166	0.029	0.093	5.669	<0.001
Model summary: $R = 0.188^{a}$; Adjusted R Square = 0.033 Mean square = 18.299; F = 17.028; Sig < 0.001^{b}					

a. Dependent variable: Intention to support

b. Predictors: (Constant), Age, Gender, Educational level, Family members, Employment status, Financial situation, Habitat

Table 4 Summary of results of multiple regression analysis for North and South Mediterranean regions

Predictors	North Mediterranean Region			South Mediterranean Region		
	Standardized Coefficients (β)	t-ratio	Sig.	Standardized Coefficients (β)	t-ratio	Sig.
(Constant)		18.102	<0.001		20.497	<0.001
Age	−0.008	−0.355	0.723	−0.03	−1.299	0.194
Gender	−0.031	−1.379	0.168	−0.053	−2.348	0.019
Educational level	0.059	2.592	0.01	0.005	0.214	0.831
Family size	−0.013	−0.582	0.561	0.031	1.346	0.178
Employment status	−0.092	−3.979	<0.001	−0.093	−3.985	<0.001
Financial situation	0.245	10.29	<0.001	0.177	7.516	<0.001
Habitat	0.015	0.685	0.493	−0.048	−2.148	0.032
Model summary	$R = 0.292^{a}$; Adjusted R Square = 0.082 F = 24.386; Sig < 0.001^{b}			$R = 0.245^{a}$; Adjusted R Square = 0.056 F = 17.163; Sig < 0.001^{b}		

a. Dependent variable: Intention to support

b. Predictors: (Constant), Age, Gender, Educational level, Family members, Employment status, Financial situation, Habitat

ance in intention to support was explained by their socio-demographic variables. Significant predictors were their gender (β = −0.053, $p = 0.019$), financial situation (β = 0.177, $p < 0.001$), employment status (β = −0.093, $p < 0.001$) and habitat (β = −0.048, $p = 0.032$) suggesting that male respondents had comparatively higher intention to support and also who had employment and better financial situations and living in forest or rural areas.

These results highlight the financial situation and employment status consistently playing key roles in impacting respondents' intention to support, with education, gender, and habitat contributing variably by region. Particularly, a better financial situation strongly increased intention to support, with a larger effect in the North (β = 0.245) than in the South (β = 0.177). Besides, educational level significantly increased intention to support the adop-

tion of NBSs in the North region but not in the South region, while gender and habitat were significant only for respondents in the South region.

4.3 Assessment of the reflective measurement model

The EFA results showed that all factors are acceptable in terms of proceeding further with PLS-SEM model estimation, as the observed *KMO* value is 0.942 (>0.50), thus, indicating that the criteria of sampling adequacy are met. In addition, Bartlett's test of sphericity is statistically significant (p-value = 0.00), revealing that the correlation matrix is statistically different from an identity matrix as desired. Besides, all factors had Eigenvalues greater than "1" and are reported to extract 71.53% of the total variance in the model.

Regarding validity and reliability assessment, the fit indices were acceptable and well above the recommended criteria. All 35 items had a factor loading greater than the appropriate standard value of 0.6 satisfying indicator reliability, and, thus, were retained in the SEM model. In terms of construct reliability, Cronbach's Alpha and Composite Reliability (*CR*) statistics for all nine factors approximately reached the recommended threshold of 0.6 set by Cronbach and Gleser (1957), except for perceived behavioural control which has an α value of 0.57. However, in behavioural studies such values are acceptable as it is around the acceptable value of 0.6 and it might be because of the context of the study (Bonett & Wright, 2015; Vaske et al., 2017). The results of factor loading, Cronbach's α, and *CR* are presented in Table 5. In addition, the Variance Inflation Factor (*VIF*) value was less than the threshold value of 5, thereby, establishing the absence of any multicollinearity issue and results are also presented in Table 5. On the other hand, construct validity was established as all the constructs had an approximate *AVE* value of 0.5 as recommended by Fornell and Larcker (1981) and are presented in Table 5. For discriminant validity assessment, the recommendations for the Heterotrait-Monotrait (*HTMT*) Ratio and Fornell Larcker Criterion were also fulfilled (Hair et al., 2017a, b; Henseler et al., 2015) and the results are given in Table 6. To conclude, the validity and reliability of the ten constructs of the extended TPB model have been established.

4.4 Assessment of the structural model

4.4.1 Explanatory power of the extended TPB model

The explanatory power of the PLS-SEM model was estimated by adjusted R^2 value. In the structural model, the R^2 value is 0.320, hence, 32.0% of the variance or change in citizens' intention to support the adoption of NBSs can be explained by nine exogenous constructs cumulatively (see Table 7). Here, the R^2 value is above 0.26 indicating that the extended TPB model has substantial explanatory power in significantly explaining variance in citizens' intention to support the adoption of nature-based solutions (Cohen, 1988, 2013).

4.4.2 Predictive power of the extended TPB model

The *Q-square* value for the endogenous construct (intention to support the adoption) was above zero (0.312 > 0), hence, supporting the predictive relevance of the extended TPB model (Hair et al., 2013). In addition, the *Q-square* value for the three measurement items

Table 5 Assessment of reliability and convergent validity of the measurement model

Items	Factor Loading	Cronbach's α	CR	VIF	AVE
Behavioural Attitude (AT)					
AT_1	0.892	0.914	0.939	2.822	0.793
AT_2	0.871			2.644	
AT_3	0.909			3.248	
AT_4	0.89			2.767	
Subjective Norms (SN)					
SN_1	0.701	0.692	0.831	1.141	0.623
SN_2	0.825			1.757	
SN_3	0.834			1.775	
Perceived Behavioural Control (PBC)					
PBC_1	0.871	0.568	0.775	1.386	0.539
PBC_2	0.656			1.25	
PBC_3	0.653			1.128	
Environmental Consciousness (ENV)					
ENV_1	0.851	0.805	0.885	1.861	0.72
ENV_2	0.877			1.877	
ENV_3	0.816			1.586	
Awareness of Consequences (ACT)					
TIME_1	0.837	0.825	0.884	1.958	0.656
TIME_2	0.825			2.118	
TIME_3	0.815			2.012	
TIME_4	0.759			1.7	
Emotional Connection (EMO)					
EMO_1	0.773	0.682	0.806	1.417	0.511
EMO_2	0.691			1.388	
EMO_3	0.719			1.32	
EMO_4	0.67			1.158	
Environmental Identity (IDENT)					
IDENT_1	0.853	0.907	0.931	2.42	0.728
IDENT_2	0.83			2.336	
IDENT_3	0.881			2.817	
IDENT_4	0.847			2.455	
IDENT_5	0.855			2.399	
Environmental Knowledge (KNW)					
KNW_1	0.669	0.675	0.824	1.078	0.611
KNW_2	0.828			2.150	
KNW_3	0.837			2.164	
Environmental Opinion (OPN)					
OP_1	0.807	0.796	0.879	1.713	0.709
OP_2	0.884			1.892	
OP_3	0.832			1.576	
Intention to Support (INT)					
INT_1	0.898	0.905	0.934	2.471	0.841
INT_2	0.94			4.065	
INT_3	0.912			3.256	

Threshold values for Factor loading > 0.6; AVE = Average Variance Extracted > 0.5; CR = Composite Reliability > 0.6; α = Cronbach's Alpha > 0.3, VIF = Variance Inflation Factor < 5

Table 6 Assessment of discriminant validity of the measurement model

Heterotrait-Monotrait (HTMT) Ratio										
	AT	SN	PBC	ENV	ACT	EMO	IDENT	KNW	OPN	INT
AT										
SN	0.805									
PBC	0.825	0.999								
ENV	0.577	0.693	0.65							
ACT	0.505	0.657	0.691	0.516						
EMO	0.117	0.231	0.396	0.189	0.268					
IDENT	0.446	0.586	0.506	0.484	0.638	0.155				
KNW	0.832	0.977	0.889	0.663	0.545	0.266	0.528			
OPN	0.701	0.813	0.867	0.587	0.555	0.192	0.454	0.848		
INT	0.368	0.537	0.614	0.392	0.466	0.415	0.312	0.541	0.431	
Fornell Larcker Criterion										
	AT	SN	PBC	ENV	ACT	EMO	IDENT	KNW	OPN	INT
AT	0.891									
SN	−0.641	0.789								
PBC	−0.588	0.631	0.734							
ENV	−0.495	0.693	0.439	0.848						
ACT	−0.443	0.499	0.482	0.424	0.81					
EMO	−0.091	0.16	0.26	0.138	0.202	0.715				
IDENT	−0.406	0.466	0.37	0.416	0.465	0.046	0.853			
KNW	−0.649	0.665	0.677	0.483	0.479	0.191	0.412	0.782		
OPN	−0.595	0.605	0.59	0.472	0.455	0.146	0.39	0.617	0.842	
INT	−0.338	0.428	0.453	0.338	0.405	0.331	0.288	0.428	0.374	0.917

HTMT Ratio = HTMT values should be below 0.90, discriminant validity established

Fornell-Larcker criterion = Diagonal value should be larger than all values in the same row and column; constructs are distinct

Table 7 Assessment of explanatory power and predictive power of structural model

Items of endogenous construct	Adjusted R^2	Q^2 predict	
INTEN_1	0.320	0.290	0.315
INTEN_2		0.256	
INTEN_3		0.245	

INTEN_1, INTEN_2, and INTEN_3 are three measurement items of the endogenous construct, intention to support the adoption of NBSs

of the endogenous construct intention to support was also above zero, thereby, supporting the substantial predictive relevance of this extended TPB model in assessing citizens' intention to support the adoption of NBSs (Hair et al., 2013) (see Table 7).

4.4.3 Assessment of overall model fit

The *SRMR* value obtained for the model was 0.059 which is considered a good fit (*SRMR* < 0.08), while the NFI value of 0.84 was also an acceptable fit (*NFI* > 0.50) (Ding et al., 1995; Hair et al., 2017a, b). So, the validity and model fit indices were within acceptable limits for the PLS-SEM model based on the extended TPB framework and the results are presented in Table 8.

Table 8 Overall model fit for the proposed extended TPB model

Extended TPB model	SRMR	NFI
Intention to support the adoption of NBSs	0.059	0.84

$Q^2 > 0$; SRMR < 0.08; NFI > 0.50 threshold for model fit

4.4.4 Comparison of the original TPB model and the extended TPB model

The proposed extended TPB model with nine exogenous constructs in predicting citizens' intention to support the adoption of NBSs was compared with the original or baseline TPB model with three latent constructs to see if the proposed TPB model can explain variance in intention to support the adoption of NBSs more thoroughly than does the original model. Several studies compare the original TPB model with the extended TPB model using the R^2 statistic and Q-square values (Nketiah et al., 2022; Wang et al., 2016) and the results for this study are presented in Table 9. Here, the adjusted R^2 values imply that the original TPB model could significantly explain 24.0% of the total variance in citizens' intention to support the adoption of NBSs while the extended TPB model could significantly explain 32.0% of the total variance in citizens' intention to support NBSs adoption, indicating a better explanatory power on the part of the extended TPB model. So, the baseline TPB model has moderate explanatory power ($R^2 = 0.24 < 0.26$) while the extended TPB model has substantial explanatory power ($R^2 = 0.32 > 0.26$) (Cohen, 1988, 2013) implying that the extended TPB model is a better fit than the original TPB model when it comes to predicting citizens' pro-environmental behaviour and in explaining the variance in their intention to support NBSs adoption in the Mediterranean region.

On the other hand, the Q^2 predict values for all three items of our endogenous construct, and intention to support the adoption of NBSs are above 0 for both the original TPB model and the extended TPB model. However, the Q^2 values are greater for the extended TPB model ($Q^2 = 0.315$) than for the original TPB model ($Q^2 = 0.238$), and so is better than the original TPB model in predicting individuals' behavioural intentions. Hence, the addition of new factors to Ajzen's original TPB model has significantly ameliorated the explanatory power and predicting power of the extended TPB model for predicting citizens' intention to support the adoption of NBSs in the Mediterranean region.

4.5 Hypotheses testing

The significance and relevance of all the relationships covering the nine proposed hypotheses were established based on the t-values of the path coefficients at a 5% level of significance and the results are presented in Table 10. Here, all the hypothetical causal relationships of the nine exogenous constructs with their intention to support the adoption of NBSs were

Table 9 Comparison between the extended TPB model and baseline TPB model

Models	Predicting intention to support NBSs adoption				
	Adjusted R^2	Q^2 predict			
		INTEN_1	INTEN_2	INTEN_3	Overall Q^2
Baseline TPB model	0.240	0.239	0.181	0.174	0.238
Extended TPB model	0.320	0.290	0.256	0.245	0.315

R^2 statistic indicates the explanatory power of the structural model

Q-square statistic indicates the predictive power of the structural model

Table 10 Assessment of hypothesized direct relationships between the constructs

Hypothesis	Path Relation	Estimated β	t statistics	*p* values	Statement
H_1	AT ➜ INT	0.037	1.682	0.046**	H_1 supported
H_2	SN ➜ INT	0.116	4.876	0.00***	H_2 supported
H_3	PBC ➜ INT	0.149	6.215	0.00***	H_3 supported
H_4	KNW ➜ INT	0.096	4.004	0.00***	H_4 supported
H_5	ENV ➜ INT	0.061	3.063	0.001**	H_5 supported
H_6	EMO ➜ INT	0.214	11.959	0.00***	H_6 supported
H_7	IDENT ➜ INT	0.038	2.131	0.017**	H_7 supported
H_8	OPN ➜ INT	0.04	1.764	0.039**	H_8 supported
H_9	ACT ➜ INT	0.141	7.41	0.00***	H_9 supported

Path coefficients significant at ***p<0.01, **p<0.05; one-directional, positive relationships

found to have a direct, positive and significant impact on predicting citizens' intention to support (*p*-value<0.05; *t*-statics>1.64) for the adoption of nature-based, environmentally friendly actions for achieving a sustainable and resilient ecosystem in the Mediterranean region. The estimated structural model with path coefficients and associated *p*-value are also presented in Fig. 3.

Here, it can be seen that citizens' behavioural attitude positively influenced their intention to support the adoption of NBSs (β=0.037, *p*-value=0.046, *t*-statics=1.682), affirming hypothesis H_1 and explaining 3.7% of the variance in their intention to support the adoption of NBSs while considering all other constructs constant. Similarly, citizens subjective norms positively influenced their intention to support (β=0.116, *p*-value=0.00, *t*-statics=4.876), affirming hypothesis H_2 and explaining 11.6% of the cumulative variance in their intention to support NBSs adoption considering all other constructs constant. Their perceived behavioural control also positively influenced their intention to support (β=0.149, *p*-value=0.00, *t*-statics=6.215), affirming hypothesis H_3 and explaining 14.9% of the total variance in their intention to support the adoption of NBSs when other constructs remain constant. Similarly, citizens' environmental knowledge (β=0.096, *p*-value=0.00, *t*-statics=4.004, affirming hypothesis H_4), environmental consciousness (β=0.061, *p*-value=0.001, *t*-statics=3.063, affirming hypothesis H_5), emotional connection (β=0.214, *p*-value=0.00, *t*-statics=11.959, affirming hypothesis H_6), environmental identity (β=0.038, *p*-value=0.017, *t*-statics=2.131, affirming hypothesis H_7), environmental opinions (β=0.04, *p*-value=0.039, *t*-statics=1.764, affirming hypothesis H_8), and awareness of consequences (β=0.141, *p*-value=0.00, *t*-statics=7.41, affirming hypothesis H_9) had significantly explained 9.6%, 6.1%, 21.4%, 3.8%, 4.0% and 14.1% of the total variance in citizens' intention to support the adoption of NBSs in six Mediterranean countries while other variables remained constant, respectively. Besides, the adjusted R^2 value implied that the model containing all nine exogenous constructs together explained 32.0% of the overall

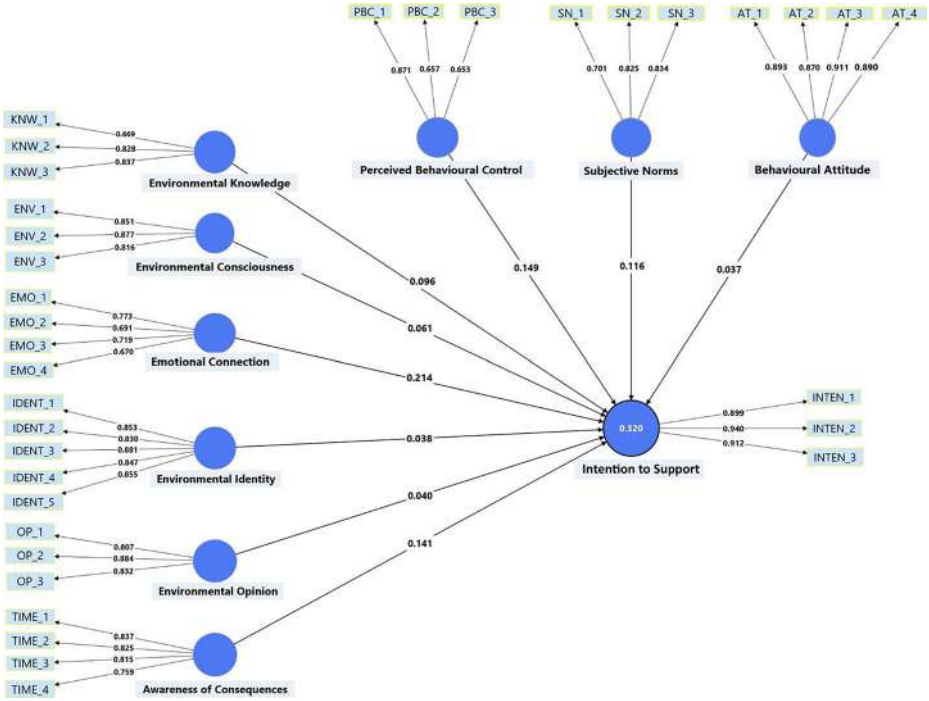

Fig. 3 The estimated structural model presents the direct relationships of nine exogenous constructs of the extended TPB model with endogenous construct, citizens' intention to support the adoption of NBSs; sign → indicates a direct, one-tailed relationship at a 5% level of significance; values showing factor loadings, β coefficients, adjusted R^2 values

variance in citizens' intention to support the adoption of NBSs for conserving and restoring the Mediterranean socio-ecosystems.

4.6 Mediating effect of environmental knowledge

It is crucial to identify variables whose significant effect is fully mediated by other variables. This study carried out a mediation analysis to explore the mediating mechanism of environmental knowledge on perceived behavioural control, environmental consciousness, environmental identity, environmental opinions, and awareness of consequences, as the environmental knowledge of an individual often shapes their awareness and ability to control a situation, and their perception about adopting environmentally-friendly practice or pro-environmental behaviour (Henseler et al., 2015). The results in Table 11 showed that the environmental knowledge of an individual had a substantial indirect effect on the intention to support the adoption of NBSs via perceived behavioural control ($\beta = 0.577$, p-value = 0.00), environmental consciousness ($\beta = 0.501$, p-value = 0.00), environmental identity ($\beta = 0.433$, p-value = 0.00), environmental opinions ($\beta = 0.628$, p-value = 0.00), and awareness of consequences ($\beta = 0.477$, p-value = 0.00). Therefore, individuals' environmental knowledge had and complementary partial mediation effect on the relationship between

Table 11 Assessment of mediation effect of environmental knowledge

Indirect Effect	Estimated β	t statistics	*p* values	Statement
KNW ➜ PBC ➜ INT	0.577	35.854	0.00***	Partial mediation
KNW ➜ ENV ➜ INT	0.501	28.244	0.00***	Partial mediation
KNW ➜ IDENT ➜ INT	0.433	30.892	0.00***	Partial mediation
KNW ➜ OPN ➜ INT	0.628	37.690	0.00***	Partial mediation
KNW ➜ ACT ➜ INT	0.477	31.451	0.00***	Partial mediation

Path coefficients significant at ***p < 0.01, **p < 0.05; mediating effect

these socio-psychological factors and the intention to support the adoption of NBSs among the Mediterranean citizens.

4.7 Heterogeneity among countries in predicting citizens' intention to support NBSs adoption

Citizen living in different countries are perceived to have significant heterogeneity in terms of their adaptive behaviour. To investigate the difference in their intention to support the adoption of NBSs, six separate extended TPB model fits were estimated for each of these six Mediterranean countries, and the model fits are presented in Table 12. The results reflected that the individual SEM model for all these six countries fulfilled the threshold conditions ($R^2 > 0.20$; $SRMR < 0.08$; $NFI > 0.50$) for model fit and were regarded as acceptable. Besides, in addition to the six models for six individual countries, two more models were estimated by dividing the countries into two groups – The North Mediterranean region (Greece, Spain, Italy) and the South Mediterranean region (Egypt, Morocco, Tunisia). The overall model fit estimation for these two separate models was also satisfactory ($R^2 > 0.20$; $SRMR < 0.08$; $NFI > 0.50$) and the results are presented in Table 12.

Then, when estimating citizens' intention to support the adoption of NBSs, the six countries exhibited varied outcomes concerning their intention to support the adoption of NBSs as illustrated in Table 13. Here, in the case of Greek citizens, subjective norms, environmental consciousness, environmental opinions, and awareness of consequences all positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors

Table 12 Overall models fit for six countries separately and for models on North and South mediterranean regions

Models	R^2	SRMR	NFI	Statement
Greece	0.389	0.069	0.753	Model acceptable
Spain	0.333	0.075	0.764	Model acceptable
Italy	0.397	0.080	0.721	Model acceptable
Egypt	0.426	0.074	0.741	Model acceptable
Morocco	0.357	0.055	0.815	Model acceptable
Tunisia	0.348	0.080	0.811	Model acceptable
North Region	0.343	0.074	0.780	Model acceptable
South Region	0.318	0.069	0.825	Model acceptable

$R^2 > 0.20$; $Q^2 > 0$; SRMR < 0.08; NFI > 0.50 were thresholds for model fit

Table 13 Heterogeneity among the countries in predicting citizens' intention to support the adoption of NBSs

Path Relation	Greece		Spain		Italy		Egypt		Morocco		Tunisia		North region		South region	
	p value	Result	*p* value	Result	*p* value	Result	*p* value	Result	*p* value	Result	*p* value	Result	*p* value	Result	*p* value	Result
AT ➜ INT	0.204	H_1 not supported	0.462	H_1 not supported	0.002	H_1 supported	0.111	H_1 not supported	0.133	H_1 not supported	0.014	H_1 supported	0.01	H_1 supported	0.301	H_1 not supported
SN ➜ INT	0.007	H_2 supported	0.023	H_2 supported	0.031	H_2 supported	0.166	H_2 not supported	0.00	H_2 supported	0.462	H_2 not supported	0.00	H_2 supported	0.015	H_2 supported
PBC ➜ INT	0.06	H_3 not supported	0.002	H_3 supported	0.00	H_3 supported	0.001	H_3 supported	0.116	H_3 not supported	0.171	H_3 not supported	0.00	H_3 supported	0.00	H_3 supported
KNW ➜ INT	0.065	H_4 not supported	0.113	H_4 not supported	0.005	H_4 supported	0.00	H_4 supported	0.004	H_4 supported	0.421	H_4 not supported	0.001	H_4 supported	0.019	H_4 supported
ENV ➜ INT	0.00	H_5 supported	0.171	H_5 not supported	0.145	H_5 not supported	0.261	H_5 not supported	0.363	H_5 not supported	0.00	H_5 supported	0.002	H_5 supported	0.096	H_5 not supported
EMO ➜ INT	0.134	H_6 not supported	0.382	H_6 not supported	0.002	H_6 supported	0.01	H_6 supported	0.41	H_6 not supported	0.00	H_6 supported	0.00	H_6 supported	0.00	H_6 supported
IDENT ➜ INT	0.47	H_7 not supported	0.00	H_7 supported	0.128	H_7 not supported	0.00	H_7 supported	0.00	H_7 supported	0.154	H_7 not supported	0.177	H_7 not supported	0.001	H_7 supported
OPN ➜ INT	0.001	H_8 supported	0.174	H_8 not supported	0.005	H_8 supported	0.00	H_8 supported	0.009	H_8 supported	0.349	H_8 not supported	0.00	H_8 supported	0.001	H_8 supported
ACT ➜ INT	0.001	H_9 supported	0.027	H_9 supported	0.022	H_9 supported	0.00	H_9 supported	0.018	H_9 supported	0.132	H_9 not supported	0.00	H_9 supported	0.00	H_9 supported
R^2	0.389		0.333		0.397		0.426		0.357		0.348		0.343		0.318	

Path coefficients significant at p value < 0.05; one-directional, positive relationships

The North Mediterranean region covers Greece, Spain, Italy and the South Mediterranean region covers Egypt, Morocco, Tunisia

cumulatively explained 38.9% of the total variance in their intention to support the adoption of NBSs. Then, Spanish citizens' subjective norms, perceived behavioural control, environmental identity, and awareness of consequences positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 33.3% of the total variance in their intention to support the adoption of NBSs. Similarly, in the case of Italian citizens', their behavioural attitude, subjective norms, perceived behavioural control, environmental knowledge, emotional connection, environmental opinions and awareness of consequences positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 39.7% of the total variance in their intention to support the adoption of NBSs. In Egypt, citizens perceived behavioural control, environmental knowledge, emotional connection, environmental identity, environmental opinions, and awareness of consequences all positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 42.6% of the total variance in their intention to support the adoption of NBSs. In the case of Moroccan citizens, subjective norms, environmental knowledge, environmental identity, environmental opinions, and awareness of consequences all had a positive impact on their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 35.7% of the total variance in their intention to support the adoption of NBSs. Finally, in the case of Tunisian citizens, behavioural attitude, environmental consciousness and emotional connection positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 34.8% of the total variance in their intention to support the adoption of NBSs in their country.

Furthermore, while considering the broader situation concerning the two Mediterranean regions (see Table 13), in the case of citizens in the North region, their behavioural attitude, subjective norms, perceived behavioural control, environmental knowledge, environmental consciousness, emotional connection, environmental opinions, and awareness of consequences positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 34.3% of the total variance in their intention to support the adoption of NBSs. In contrast, in the case of citizens in the South region, their subjective norms, perceived behavioural control, environmental knowledge, emotional connection, environmental identity, environmental opinions, and awareness of consequences positively influenced their intention to support (p-value < 0.05; t-statics > 1.64), and all nine factors cumulatively explained 31.8% of the total variance in their intention to support the adoption of NBSs in this particular region for conserving and restoring the declining socio-ecosystems.

5 Discussion and policy implications

5.1 Validating extension of the TPB model

This work was intended to improve the TPB model's explanatory power by introducing new dimensions into the original model. As reported in the outcomes, the baseline TPB containing the three original dimensions i.e., behavioural attitude, subjective norms, and perceived behavioural control, jointly explained 24.0% of the total variance in citizens' intention to support the adoption of NBSs. Through the incorporation of six additional dimensions i.e.,

environmental knowledge, environmental consciousness, emotional connection, environmental identity, environmental opinions, and awareness of consequences, the explanatory capacity of the model expanded to 32.0% from 24.0%. Hence, the incorporation of more factors into the baseline TPB model is necessary because the behavioural components of an individual are expected to differ across populations, contexts and situations (Schlüter et al., 2017). Ajzen (1991) also portrayed the TPB model as an open template for further elaboration if it improves the rationale and validity of the model. In line with our results, previous works also have seen a similar trend of improvement in prediction by extension of the TPB model (Grilli & Notaro, 2019; Savari & Khaleghi, 2023; Thuy et al., 2024). So, for predicting individuals' pro-environmental behaviour and intention to support the adoption of environmentally friendly practices, previous studies also employed an extended TPB model as their research framework in explaining individuals' behavioural intention (Goh et al., 2017; Yuriev et al., 2020; Zulkepeli et al., 2024). Hence, the incorporation of new variables in the TPB model has been justified and in the case of our study, has proven to improve the predictive power of our research framework. Thus, this study has proposed a new theoretical model that would significantly contribute to a more comprehensive understanding of individuals' behavioural intentions in terms of adopting nature-based ecosystem restoration practices. This outcome has significant administrative and strategic consequences, as the integration of new socio-psychological factors into the original TPB model might provide innovative and consequential assessments of the behavioural aspects of individuals' pro-environmental decision-making process. In this way, effective environmental conservation policies can be tailored based on citizens' preferences which will ensure the practical acceptance and rational participation of local communities in the conservation of nature.

5.2 Predicting intention to support by socio-demographic variables and socio-psychological attributes

The key purpose of this work was to understand the factors that have an impact on individuals' intention to support the adoption of NBSs which is critical for policy-makers to obtain a better understanding of individuals' pro-environmental decision-making process to promote environmentally friendly behaviour. Here we assessed the impact of socio-demographic factors and socio-psychological attributes separately to compare their influence on individuals' behavioural intention in contributing to the adoption of nature-based ecosystem restoration initiatives in Mediterranean drylands.

From the magnitude of R^2 values for socio-demographic factors, it is clear that the effect of these socio-demographic variables on the intention to support the adoption of NBSs is much smaller as the model explained only 3.3% of the variance (Adjusted R Square = 0.033) compared to the influence of socio-psychological variables that explained 32.0% of total variance. This suggests that while these factors contribute to their intention, socio-psychological variables likely play a more substantial role in explaining their behavioural intention. Notably, though all socio-demographic factors were significant, respondents' family size and habitat had the largest relative effects on their intention to support, suggesting that residency in rural and forest areas and smaller family sizes were associated with higher intention to support the adoption of NBSs.

5.3 Influence of socio-psychological attributes on behavioural intention

The assessment of the PLS-SEM model implied that citizens' behavioural attitude positively influences their intention to support the adoption of NBSs which is in line with the previous works done to predict intention to support the adoption actions to conserve natural resources (Bartczak & Metelska-Szaniawska, 2015; Gansser & Reich, 2023). Such verdicts indicate that individuals with a more positive attitude toward a given pro-environmental behaviour are more willing to participate and contribute to the adoption of nature-based initiatives. Therefore, efforts should be directed at facilitating positive attitudes among the public regarding the necessity and impact of NBSs to reinforce their intention to engage in pro-environmental behaviour. A similar result was found in the case of citizens' subjective norms that positively influences their intention to support the adoption of NBSs and explained 11.6% of the variance in their intention to support the adoption of nature-based initiatives. This result is in line with previous works (Harjadi & Gunardi, 2022; Li et al., 2020; Roh et al., 2022) and highlights that the more social pressure perceived, the higher their intention to support the adoption of NBSs in the Mediterranean region. The influence of perceived behavioural control on individuals' intention to support was also confirmed which is one of the most important predecessors among the nine factors in forming their actual behaviour (adoption of pro-environmental behaviour) (Ajzen, 1991). Various studies have confirmed the impact of this certain dimension on individuals' behavioural intention or environmentally friendly behaviour (Li et al., 2020; Mazhar et al., 2022; Roh et al., 2022). Besides, this factor was the second most important variable in explaining the variance in individuals' intentions as it alone explained 14.9% of the total variance in citizens' intention to support the adoption of NBSs. Therefore, perceived behaviour control holds greater significance in terms of individuals' intention to support NBSs adoption and supporting activities should be employed to nudge the socio-psychological dimensions that influence their pro-environmental behaviour.

Now, consistent with findings from previous studies (Elbarky et al., 2023; Liu et al., 2020; Saari et al., 2021), individuals' environmental knowledge was significant in predicting their intention to support the adoption of NBSs indicating individuals with a deeper knowledge and cognitive understanding of environmental issues are more inclined to participate in actions for the conservation of nature (Liu et al., 2020). Moreover, the mediation analysis results indicate that the environmental knowledge of an individual significantly mediates the relationship between perceived behavioural control, environmental consciousness, environmental identity, environmental opinions, and awareness of consequences with their intention to support the adoption of NBSs. Such an impact of environmental knowledge on refining one's pro-environmental behaviour has long been promoted in the available literature (Amoah & Addoah, 2021; Liu et al., 2020; Mansoor & Wijaksana, 2023). These facts imply that environmental knowledge is critical in facilitating the acceptance of environmentally friendly actions and adoption of pro-environmental behaviour at the public level since individuals with better knowledge have a better perception and awareness of environmental preservation and a desire to participate in avoiding the detrimental impact of human activities on nature. Such findings call for the development of educational programmes regarding the conservation of natural systems, the promotion of green products and the mass dissemination of information on environmental concerns by involving all stakeholders (Baena-Morales & Fröberg, 2023).

On the other hand, significant influences were also established in the case of individuals' environmental consciousness and the awareness of consequences that guide individuals' conscious choice of activities that have less or no impact on the environment (Fornara et al., 2020). This type of impact is also depicted in previous studies (Abrahamse & Matthies, 2018; Hansla et al., 2008; Kautish & Sharma, 2021; Lazaroiu et al., 2019). In addition, emotional connections are also proven to be significant in impacting citizens' intention to support the adoption of NBSs which aligns with previous research (Chang & Hung, 2022; Choi & Johnson, 2019; Lavuri, 2022). This variable was found to have the greatest influence in explaining the variance in citizens' intention to support (21.4%), thereby, emphasizing the role of the psychological attachment of an individual to the place and environment in prompting their pro-environmental decisions (Lee et al., 2019; Martin et al., 2020). Besides, the emotional or psychological attachment of an individual fosters a stronger commitment to participate in pro-environmental actions and interventions increasing both contact with, and connection to nature. Moreover, environmental identity also significantly influences citizens' behavioural intentions, and various studies (Jans, 2021; Klaniecki et al., 2018) have corroborated this result. These facts further emphasize the human-nature connection behind individuals' pro-environmental decision-making behaviour. Similarly, environmental opinions had a positive impact on individuals' intention to support the adoption of NBSs. The result is in line with previous research (Donmez-Turan & Kiliclar, 2021; Naalchi Kashi, 2020; Sockhill et al., 2022) and indicates perceived understanding of certain environmental events control individuals pro-environmental behaviour (Donmez-Turan & Kiliclar, 2021). The results regarding the impact of these socio-psychological factors on individuals' pro-environmental decision-making advocate for bottom-up pro-environmental initiatives to facilitate meaningful and conscious participation of citizens in ecosystem management practices. The facilitation of actions to nudge these factors in the desired direction should also be emphasized in environmental policy formation. Besides, close interaction among different stakeholders is also essential to promote the dissemination of environmental knowledge and to build citizens' environmental perception and sustainability narratives and their intention to participate in pro-environmental behaviour (Barth et al., 2021).

5.4 Cross-regional comparisons

The outcomes of this study also contextualized the alliances between citizens' pro-environmental behaviour and regional heterogeneity among individuals as depicted in some related studies (Alexis et al., 2024; Morren & Grinstein, 2016; Srisathan et al., 2024). Here, as reflected in our outcomes, the R^2 value was similar in both cases, ($R^2 = 0.343$ for the North region, $R^2 = 0.318$ for the South region). However, the impact of socio-psychological attributes was heterogeneous. Such differentiating impact of citizens' socio-psychological attributes on their intention to support the adoption of NBSs further emphasized the magnitude of regional heterogeneity and place-attachment of individuals on their involvement in environmental actions (Aral & López-Sintas, 2023). Though the North and South Mediterranean are very homogenous in traditions and cultures, our outcomes revealed financial situation and employment status as consistent predictors of intention to support the adoption of NBSs across the North and South Mediterranean regions, with educational level, gender, and habitat showing regional variations. These findings reflect underlying cultural and heritage differences that shape economic behaviours in these distinct Mediterranean

contexts. The stronger inclination towards financial situation, educational level in case of North Mediterranean region reflects its historical heritage of industrialization and trade. On contrast, the South Mediterranean more reliance on agriculture and rural social structure as reflected in our outcome as respondents gender and habitat was significant only for the respondents from the South Mediterranean region, suggesting cultural norms around gender roles and rural-urban divides.

5.5 Limitations and future scope of research

The interconnected relationships translated in the outcomes of this work reflect on individuals' behavioural intentions and how to drive them to engage in sustainable practices to protect their surrounding environment and socio-ecosystems. Hence, these interpretations from our study provided a deep dive into contextual heterogeneity in environmental psychology and regional-border-bounded social participation in pro-environmental behaviour (Kudryavtsev et al., 2012). However, there still remain areas unexplored in our study. Though the significance of extending the TPB model in explaining citizens' behavioural intention is established through our empirical results, however, the current study has not considered any other behavioural models to be incorporated with the original TPB model, which might reflect opportunities for future research. As we presented the significance of extending TPB model in predicting and explaining the behavioural intention of individual, it supports the potential of integrating other behavioural models i.e., the Norm Activation model (NAM), Value-Belief-Norms Theory (VBN), Theory of Reasoned Action (TRA), Theory of Environmentally Responsible Behaviour (ERB) etc. with the baseline TPB model to provide a better and more elaborate explanation of human intention and pro-environmental behaviour. This will provide a more comprehensive understanding of the acceptance of pro-environmental nature-based technologies among the citizens. In addition, it might add a clearer perspective and robust evidence on the behavioural perspectives of individuals in adopting such adaptive measures. We have witnessed a favourable and positive intention among the marginal communities to adopt or support such innovative and participatory approaches to mitigate climate change impacts. We anticipate the accumulation of more comprehensive findings considering other behavioural models, thus, enabling a deeper analysis of the pro-environmental behaviour of the citizens.

6 Conclusions

Nature-based initiatives as a strategic tool in the environmental management paradigm have been gaining relevance for policy makers, administrators and environmental activists. Intending to investigate citizens' intention to support the adoption of NBSs, this study predicted their intention to contribute to adopting NBSas for ecosystem restoration actions in Mediterranean drylands. The findings show that socio-demographic factors, including age, gender, education level, family size, employment status, financial situation, and place of residence, significantly influence citizens' intention to support the adoption of NBSs. The assessment of the PLS-SEM model indicates that incorporating additional socio-psychological factors within the original TPB model appeared to be a better fit for the assessment of data and had a stronger capacity for explaining citizens' intention to support the adoption of NBSs. Besides,

results implied that citizens are willing to pay for such nature-based initiatives when they have a positive attitude, positive subjective norms and better-perceived behaviour control, better knowledge of the environment and well-developed environmental consciousness, positive emotional connection, positive environmental identity and environmental opinions, a better awareness of consequences of human activities and impact of climate changes on both people and planet. These findings can be valuable for developing region-specific and need-based environmental policy and ecosystem management programmes based on the interests and preferences of citizens. The implications drawn from this study would also provide a better insight into the mindset and pro-environmental decision-making behaviour of the citizens. Therefore, these findings are not only applicable to citizens in the Mediterranean region but can also be replicated in similar nature-dependent regions where people are struggling with limited resources and capabilities to adapt to climatic shocks and the destruction of socio-ecosystems. However, to increase public acceptance of NBSs and the adoption of such climate actions, it is important to tailor communication and education efforts to increase awareness and risk perception of the citizens. On the other hand, the study has a few limitations which could be addressed in future works. This study would benefit from a larger sample with the participation of individuals from different socio-political sectors to better understand the profile of stakeholders in each segment. Besides, there are other socio-psychological constructs i.e., risk perception, risk attitude, perceived values, social identity, etc. used in other behavioural models which should be studied to ensure greater validity and reliability of predictions concerning citizens' intention to participate in or adopt pro-environmental behaviour. To conclude, since human behaviour varies based on differences in cultural norms and values, ecological dimensions, and governance systems, it is crucial to consider individuals' socio-psychological dimensions in understanding the acceptance and compatibility of nature-based initiatives in tackling climate change impacts that will align with the local needs and priorities.

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Data availability Data will be made available on request.

Declarations

Conflict of interest The corresponding author reports financial support was provided by the European Commission under the Horizon 2020, the framework programme of the European Union for research and innovation. The corresponding author reports a relationship with Polytechnic University of Catalonia that includes employment. The other co-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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