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ATTITUDES AND WILLINGNESS OF PUBLIC FOREST MANAGERS TO PRODUCE AND SELL GOODS AND SERVICES: THE CASE OF CARBON CREDIT MARKET IN EUROPEAN NATURAL PARKS

SUMMARY

Forests have an important role for climate change mitigation; indeed, they act as carbon sinks. So, a carbon-oriented management of forests should help to provide relevant environmental benefits but also can have economic spin-offs in enhancing one of the ecosystem services provided by forests, such as carbon storage. In this sense, the creation of a voluntary market for carbon credits in forestry, also recently regulated in Europe, can represent a good economic alternative especially in forests where the productive purpose is not among the main ones, such as in some publicly owned areas. This study aims to analyse the intentions and willingness of European Natural parks managers to apply a forest management system for carbon offset production and consequently to participate in the carbon market. For this propose the Theory of Planned Behaviour was applied. Results show that attitude and perceived behavioural control have a statistically significant influence on managers' intention to participate in voluntary carbon market. On the other hand, subjective norms do not have a statistically significant influence. Moreover, findings suggest that knowledge of the topic still needs to be deepened by respondents. This should offer valuable insights for policymakers and practitioners to diffuse and promote participation in voluntary carbon markets, intensifying dissemination and assistance towards the adoption of carbon-oriented forest practices

Keywords: Theory of Planned Behaviour; PLS-SEM; carbon sequestration; intentions; public forest areas

INTRODUCTION

It is commonly accepted that forests, especially when actively and well managed, provide lots of positive externalities, enhancing the liveability of local communities in rural areas, supporting local timber markets and ensuring the provision of several valuable ecosystem services, such as protection from natural

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hazards, recreation and biodiversity (Accastello *et al.*, 2018). To these positive externalities counterbalance some negative externalities generated by human activities. These include, in particular, climate change caused by the increase in the concentration of carbon in the atmosphere due to fossil fuel consumption (IPCC, 2018). In this context, forests on the one hand, act as carbon sinks, considered as climate change mitigation option (van der Gaast *et al.*, 2018), indeed forests are estimated to absorb an average of 2 billion metric tons of carbon from the atmosphere, on the other hand they are particularly sensitive to climate change, with different impacts depending on the geographic area considered. So, it is necessary to identify silvicultural strategies capable of considering and counteracting the effects of climate change (Blanc *et al.,* 2019 b). An example of this is sustainable forest management that plays a crucial role in climate change mitigation and adaptation, as well as the achievement of the 2030 Sustainable Development Goals (SDGs) (Que *et al.*, 2025).

In this sense, some market mechanisms to manage positive externalities represent appropriate instruments also suitable for combating climate change, for example Payments for Ecosystem Services (PES) (Paletto *et al.,* 2020), or forest carbon credit market. Indeed, as highlighted by Vacchiano *et al.* (2018), three types of forestry activities may generate carbon credits as afforestation on non-forested lands or reforestation (A/R), where offsets are generated through the creation or reestablishment of forest land use; avoiding emissions from deforestation and degradation, and improved forest management (IFM), i.e., forest management that increases the carbon stocked in the forest (by better logging practices, longer rotation, or other means) and/or in wood products (by producing more durable assortments), relative to business as usual. IFM credits are the most promising for the forest sector at local level, because they can provide income to public and private forest owners and increase the economic interest in carrying out sustainable forest management activities. In this sense, it can be said that forests now play a central role in global carbon markets (Suitor *et al.*, 2025), that are emerging as a central component of international climate change policies, so it becomes imperative to establish clear guidance on buying forest carbon credits, to develop standards and procedures to assess forest carbon sinks, and to strengthen cooperation from a purely legal and political point of view (Que *et al.*, 2025). Indeed, at international level, the commitment to combat climate change has been expressed for the first time, respectively in the Kyoto Protocol in 1997 and in Paris Agreements.

The Kyoto Protocol allowed countries to trade emission units or undertake emission reduction projects in other countries and created the framework for the development of carbon markets, by committing signatories to binding emission reduction targets (Suitor *et al.*, 2025). Instead, Paris Agreements introduced Nationally Determined Contributions (NDCs) in lieu of legally binding targets. Since the beginning of these international climate negotiations, forests have been considered as a climate change mitigation option (van der Gaast *et al.*, 2018). Indeed, various forestry projects were developed, for example Reducing

Emissions from Deforestation and Forest Degradation (REDD), formally recognized as a legitimate forestry carbon sink project, and later expanded as REDD-plus framework, that incorporates additional measures, including the forest conservation and sustainable forest management (Que *et al.,* 2025). Focusing on Europe, after the expiration of the first commitment period of the Kyoto Protocol, and given to the exclusion of forest sinks from the EU Emission Trading Scheme, voluntary markets have been of great importance for forestry as they have been the framework where international accounting methodologies for forest carbon credits, such as those for A/R, IFM, or REDD+, were developed and tested (van der Gaast *et al.*, 2018; Blanc *et al.*, 2019 a).

On the other hand, various forest carbon sink projects have been driven and managed by the government and a project developer. For instance, the "EU Biodiversity Strategy for 2030", released in 2020, commits to planting at least 3 billion new trees, prioritizing native species and those resilient to climate change. In 2024, the European Union formally adopted the Nature Restoration Law (NRL), to address the triple crisis of climate change, biodiversity loss, and environmental degradation, covering a wide range of ecosystems, including forests, with a focus on restoring those ecosystems that have the greatest potential for carbon removal and storage. In terms of specific action plans, the EU LIFE program promotes forest restoration through diverse projects in Europe. Moreover, also the EU Deforestation Free Regulation (EUDR) introduced in 2023 aims to reduce deforestation, forest degradation, or violations of local environmental and social laws, and consequently greenhouse gas emissions and conserve biodiversity. So, at present, direct remuneration for Carbon Farming activities in the agricultural/forest sector occurs through the voluntary carbon market, where farmers can generate and sell carbon credits. Certification is required to validate these credits, which must be obtained through accredited entities. In this context, in absence of stringent forest regulation, voluntary forest certification can aid in proving a base level of forest management that considers all forest values, not only timber production and revenue generation. Indeed, it represents a supporting tool for the ecosystem services, considering that compliance with forest certification provides practices that easily transfer to carbon sequestration and trading (e.g. forest inventory, management plans, etc.) (Paluš *et al.*, 2021).

In any case, this voluntary market is different from the EU-regulated carbon market, known as Emission Trading System (ETS) (Frascarelli *et al.*, 2025), that requires participants to trade allowances within a strictly regulated framework. Moreover, this voluntary market is more volatile and less attractive than a regulated market, so to standardize carbon sequestration quantification methodologies, the European Community has published, recently, Regulation No. 2024/3012, which outlines the minimum criteria for classifying farmers' activities as carbon sequestration practices, using the QU.A.L.ITY system (Quantification, Additionality, Long-term storage, and Sustainability) (Frascarelli *et al.*, 2025). This with the overall objective of reducing net greenhouse gas emissions by at

least 55% by 2030 with more effective and results-based support for carbon sequestration activities in agricultural and forest soils. Even at national level, some countries are active in this regard. This is the case of the Italian government, which with the regulation No. 41/2023, Article 45, c. 2-quater, at the Council for Agricultural Research and Economics (CREA), established the public register of carbon credits generated on a voluntary basis by the national agro-forestry sector. This regulation will be accompanied by the guidelines for the establishment of the 'Public Registry of Voluntarily Generated Carbon Credits from the National Agroforestry Sector - Forestry Section' being drafted. Currently, the management of the voluntary carbon credit market in the Italian forestry sector has been implemented through a number of projects (e.g. FORCREDIT Project, in the Piedmont region, together with the resolution DGR 24-4638 of 06/02/17 adopted by the region itself; the 'Sustainability credits' project of the Tuscan-Emilian Apennines National Park) (Blanchard and Molteni 2016; Petrella *et al.*, 2019; Ente Parco Nazionale Appennino Tosco Emiliano, 2025). Also in Romania, in the Macin Mountains National Park (MMNP), the calculations of the volume of carbon stored in trees inside of non - intervention areas (Strict protected area and Integral Protection Areas) are being finalized. In this context, several studies have analyzed the hierarchy of players involved in the demand-side of carbon market (e.g. government, firms, NGO's, etc.), but there is little extant work regarding supply-side dynamics; especially about public forestland managers and their intentions to develop forest carbon offsets (Jo *et al.*, 2020; Morales and Ovando 2025). Indeed, various research primarily focuses on the propensity of private forest owners to participate in carbon sequestration and trading (Fletcher *et al.*, 2009; Håbesland *et al.*, 2016; Khanal *et al.,* 2017; Tzemi *et al.,* 2025) especially in North America (Thompson and Hansen 2012; Miller *et al.*, 2012; Thompson and Hansen 2013; Kelly *et al.*, 2017). On the other hand, the point of view of public actors is little explored (Wu *et al.*, 2025), considering that, Protected Areas and more specifically Natural Parks, also thanks to a close-to-nature forest management, play a key role in addressing the provision of various ecosystem services (e.g., carbon sequestration, availability of mushrooms and truffles, opportunity for tourism and recreation, conservation of biodiversity and habitat integrity) (Vizzarri *et al.*, 2015).

Starting from these premises, the aim of this study is to understand the intentions and perceptions of European Natural Parks' managers to apply a forest management system for carbon offset production and consequently to participate in the carbon market. The research employs the Theory of Planned Behavior (TPB) as an investigatory framework in order to examine potential antecedents to these intentions. Indeed, in TPB, personal behavior is affected by attitude, norms, control, and intentions (Jo *et al.*, 2020). In addition, in order to have a general overview also of the external factors that may be connected to the production and related market of carbon credits, the knowledge of natural parks' managers about carbon sequestration and trading, the presence of any market and legislative instruments adopted (e.g. forest certification, adhesion to Rural Development

Plans) and the analysis of the most important ecosystem services provided by parks were considered. Recognition of the views of public forest owners/managers can help illuminate current administrative and/or policy needs, useful scientific products and tools, current obstacles in addressing climate change, and highest priority needs on national forests to increase the effectiveness of land management activities, indeed a large component of European forest areas, 40%, is in public ownership and about 24% are in protected areas (FOREST EUROPE 2020).

MATERIAL AND METHODS

Theoretical framework and survey design

Understanding the attitudes of a subject or focal group is important in any study that explores decision-making and willingness to adopt new practices, as in the case of those necessary to mitigate climate change through carbon sequestration or to improve resilience of forests to climate change (Laakkonen *et al.,* 2018). The attitudes can be understood through multiple theoretical frameworks from the fields of psychology and social science though some common themes are highlighted in each. The Theory of Planned Behavior (TPB) provides a framework to understand control mechanisms which influence a subject's actions. The TPB has been successfully used by the conservation and forest scientists to understand attitudes and behaviours of stakeholders regarding issues as climate change, carbon sequestration, reforestation methods and bioenergy, techniques for the conservation of biodiversity (karppinen, 2005; Bieling, 2004; Fielding *et al.*, 2005; Rasamoelina *et al.*, 2010; Ofoegbu and Speranza 2017; Thompson and Hansen 2012; Primmer and Karppinen 2010). TPB is an extension of the Theory of Reasoned Action (TRA) developed by Fishbein and Ajzen (1977). The TRA suggests that a given behavior is dependent upon the intentions to perform the behavior, and that these intentions are dependent upon individual attitudes towards the behavior and subjective norms. Indeed, attitudes signal the strength of convictions and the subjective evaluation of the outcomes of a performed behaviour and subjective norms are defined as perceived social pressure and motivation to comply with expectations (Ajzen, 2011). The TPB extended the TRA by including a perceived behavioral control construct which also acts as an antecedent to behavioral intentions (Jo *et al.*, 2020). Perceived Behavioural Control (PBC) refers to the perception of the ease or difficulty of performing a behaviour (Ajzen, 1991). In this study, the attention was focused on managers' behavior related to mitigation of climate change and to the interest to adopt specific silvicultural practices to generate and sell carbon credits. Based on the theoretical frame of reference (Ajzen, 1991; Thompson and Hansen 2013), some specific research hypotheses were formulated as follows:

H1: Personal attitudes directly influence intentions of forest managers to apply a forest management system for carbon sequestration and trading.

H2: Subjective norms directly influence the intentions.

H3: Perceived behavioural control positively influences the intentions towards carbon sequestration and trading in natural parks.

The survey was conducted using a structured questionnaire in Google Forms, translated in different language as English, German, Italian, Polish, Swedish, French, to more easily include various European nature parks. The questions were formulated according to a closed or hierarchical response scheme. Only in a few cases open-ended questions were used to better detail some closed answers and to get a more direct insight into the respondents' opinions, if any, on the carbon credit market. The questionnaire was structured in four sections. In the first section, “General information on the Park”, various aspects were considered such as: name; park headquarters; total park area; forest area within the park; year of establishment; number of employees working in the park; the respondent's role in the park; the main forest types according to Barbati *et al.* (2014); main forest management practices adopted; the presence of areas falling within Natura 2000 Network; the presence of an approved Park Plan and other forest management plans (considering that the presence of an approved forest planning instrument is necessary for the certification of carbon credits); the presence of an approved Park Regulation; the products sold in the park (wood products, non- wood products, services); the main ecosystem services provided by the park. For this general information was followed the structure proposed by Vizzarri *et al.* (2015). Specifically, according to the study by Paluš *et al.* (2021), in order to explore the main ecosystem services, sixteen items were identified using 5-point Likert scale (Likert, 1932) where a score of 1 corresponds to 'completely disagree' and a score of 5 to 'completely agree'. The second section " Legislative and market instruments", considered the presence of any forest certification, the interest in participating in forestry projects related to the production of ecosystem services, and joining rural development plan forestry interventions. In this case binary responses with two possible opposing options (Yes/No) were used. The third section “Knowledge in the field of storage and market of carbon credits” assessed the degree of knowledge of the respondents about practices related to the production and sale of carbon credits, using both a closed question with a Likert scale and an open question, in order to obtain general considerations on the topic. Finally, the fourth section, “Propensity towards management practices for the production and subsequent sale of carbon credits”, provided information on the intention of managers regarding the production of carbon credits. Indeed, intentions, subjective norms, perceived behavioural control, attitudes, i.e. the factors underlying TPB, were explored in 15 items. The items for the study constructs were again based on adapted versions of already validated scales (Thompson and Hansen 2012; Thompson and Hansen 2013; Karppinen, 2005; Kelly *et al.*, 2017). The scale used was set considering the same parameters as the one adopted in the previous section.

Data collection and analysis

The natural European parks involved in the survey were identified from the database proposed by Park.it- Federparchi (https://www.parks.it/). The

development of the survey was based on the methods recommended by Dillman (2007) which include an information telephone call (used only in the case of Italian parks) a pre-notification and a first and second email in order to maximize the response rate. Indeed, several countries participated in the survey and specifically Romania, Poland, Sweden, Germany, Italy, France and considering a sample of 123 parks, also selected in relation to the presence of forest areas within them (stratified sampling), 67 complete questionnaires were received, with a response rate of 54,47%. Data were collected in January- May 2025. The statistical analysis was developed using Stata (Version 17, 2021) and SmartPLS 4 software. In the first step, a univariate descriptive analysis of the surveyed variables was carried out, including averages and standard deviations, for Likert scale responses, to assess the main ecosystem services provided by the park or the analysis of knowledge in the field of storage and market of carbon credits. Regarding the application of TPB, data were analysed using SmartPLS 4, to validate the measurement model with the confirmatory factor analysis (CFA) and for the application of PLS SEM (Partial Least Square Structural Equation Modeling method), used to assess the relationships between the component latent constructs of the basic conceptual model. PLS SEM estimation is a powerful analytical tool that not only factorizes constructs through observations but also demonstrates the relationships between them. Moreover, it is free from sample size and advantageous for the verification of variables that follow the questionnaire structure, indeed it can be applied to small samples of about 30–100 (Jo *et al*., 2020; Cammarata *et al.*, 2024). Specifically, in order to assess the validity of the model, composite reliability with factor loading, Cronbach 's alpha, rho, correlations between constructs, AVE and Fornell- Larcker criterion, based on the comparison of the square root of AVE with the correlation of the latent constructs, are analysed (Gallagher *et al.*, 2022; Morales and Ovando 2025). In general, composite reliability, rho, and Cronbach's alpha values above 0.7 are considered to have adequate internal consistency while for AVE values the recommended level is of 0.5. The structural model was evaluated on the basis of path coefficient values and their statistical significance (Venturini and Mehmetoglu 2019; Cammarata *et al.*, 2024).

RESULTS AND DISCUSSION

Description of the characteristics of Natural Parks and external factors connected to the production and related market of carbon credits

The analysis of data shows that 67% of natural parks have a total area between 1001 and 50.000 ha, followed by 16% exceeding 100.000 ha, 9% between 50.001 and 100.000 ha, and only 8% with an area less than or equal to 1000 ha. For these values, there are some differences in relation to the forest area in the various parks. Indeed, 72% of natural parks have a forest area between 1001 and 50.000 ha, 21% less than or equal to 1000 ha, 4% between 50.001 and 100.000 ha, followed by only 3% with a forest area exceeding 100.000 ha. In relation to the year of establishment, 78% of parks were founded between 1923

and 2000, 19% between 2000 and 2011 and only 3% between 2011 and 2019. The majority of the parks have a number of employees between 1 and 45 (90%) and only 10% between 46 and 90. Specifically the majority of respondents is represented by technical office for 52.24% followed by "Directors" for 26.87% and "Other professional figures" (e.g. conservation specialist; science service; park ranger; manager of research and documentation department; nature center manager; climate and energy manager) for 20.89%. As shown in the Figure 1, the predominant forest type found in parks is "Beech forests" for 12%, followed by "Oak, downy oak and English oak forests", "Other coniferous forests, pure or mixed", "Other deciduous woods" for 10%.

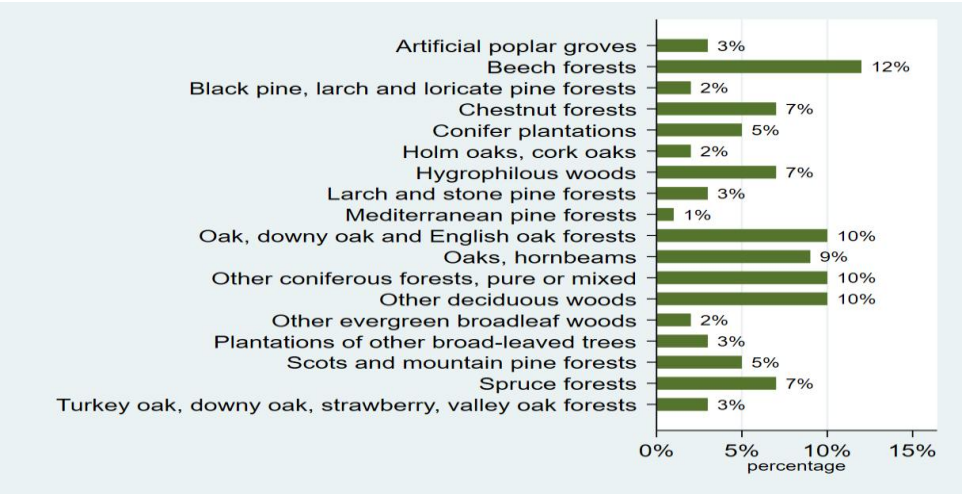

Figure 1. Main forest types in interviewed parks. Source: author

For these forest types, the main management practice is represented by "Tall-tree, mixed management, transitional high forest" for 26%, followed by "Uneven-aged high forest (occasional cutting)" for 23%, "Forestation, afforestation, reforestation" for 18%, "Coppice with matricinees" for 16%, "Even-aged high forest (clear cut, successive cuts)" for 11% and only 6% for "Other type of coppice (simple, stemmed, compound)". Moreover, the majority of parks (96%) has a territory falling within the Natura 2000 network. With regard to the main land and/or forest management plans, almost all parks (93%) have an approved park plan. This percentage is somewhat lower (75%) in relation to the presence of an approved park regulation. Forest management in parks is also mostly regulated (78%) through instruments such as conservation plans, nature conservation acts, forest management plans, forest policy plans, forest laws. Focusing on the main ecosystem services provided by parks, as shown in Figure 2., "the conservation of biodiversity" totals the highest average score. This is also in line with the results of the study by Vizzarri *et al.* (2015) who points out that biodiversity conservation is the primary objective of the Protected Areas establishment, taking into account its key role both in Italy and globally. On the

other hand, "the availability of non- timber forest products" and "the availability of woody biomass" are considered less relevant. Also, this finding is consistent with Vizzarri *et al.* (2015). Indeed, in some cases, most of the regulatory frameworks of natural parks strictly limit the use of forest resources for economic purposes (including timber extraction and transformation), at least in their core areas for biodiversity conservation (Schneiders *et al.,* 2012). In this sense, management can be better implemented by adopting an integrated approach that takes into account economic, socio-cultural, and ecological features (e.g., areas for commercial use vs. areas for nature conservation) (Vizzarri *et al.*, 2015).

Figure 2. Main ecosystem services provided by parks. Source: author

Also in this context, respondents were asked whether wood products (e.g. firewood) or non-wood products (e.g. mushrooms, truffles) or services (e.g. tourist-recreational services) are sold in the relevant parks, and if so, how much was the average revenue for five years. 61% of respondents state that products are sold within the park compared to 39%, but in terms of revenues almost no one can report a value, pointing out that this is difficult to estimate due to the heterogeneity of the forests, the lack of official data, and sales by other agencies operating in the area. Only three parks quantify a sales value of between 70,000 and 90,000 Euro related, in one case, to involvement in a project for the valorization and sale of ecosystem services. Regarding the analysis about the use of legislative and market instruments related to the production of ecosystem services, several questions were put to the interviewees, especially in the context of adherence to RDP interventions and forest certification. In particular, a good part of the parks (43% vs. 57%) participates in any RDP forestry interventions / or other public funding, and 88 % think that legislative instruments such as RDP forestry measures/interventions can foster the production of ecosystem services. This last aspect is very interesting, considering that currently, in the EU, the Common Agricultural Policy (CAP) provides payments to farmers for voluntarily adopting practices aimed at reducing emissions also with the promotion of forest and afforestation practices (Criscuoli *et al.*, 2024). Moreover, 67% of parks,

against 21%, would be interested in participating in forest projects concerning the adoption of practices to improve CO_2 storage in forests and ecosystem services in general, on the other hand, 12% already participate in similar projects. Also, with regard to adherence to PEFC and/or FSC sustainable forest management (SFM) and ecosystem services certification schemes, most respondents say it would be beneficial to adopt certification in the relevant parks (57%), while 17% of the parks surveyed have already adopted a forest certification system. In this sense, as also highlighted by Paluš *et al.* (2021), forest certification can represent a tool supporting SFM and ecosystem services such as climate regulation in terms of carbon storage. In relation to the level of knowledge declared by respondents on the functioning of the carbon credit market, as shown in figure 3., the highest average value is recorded for the item 'My knowledge in the area of carbon sequestration and trading is quite good'. In general, therefore, the degree of knowledge is not very high and as also highlighted in other studies (Cammarata *et al.*, 2024; Thompson and Hansen 2013) the knowledge gap on the topic and on the climate change mitigation potential, offered by participation in sequestration programs and Voluntary Carbon Market (VCM), should be addressed.

Figure 3. Knowledge level about sequestration and trading of carbon credits. Source: author

These results are partly confirmed and made explicit directly by the respondents through the open-ended question submitted to them concerning their thoughts on the topic under investigation. Indeed, one respondent states: "*Much uncertainty because of skepticism about the real political will to pursue the goal. Technical skepticism in that I don't know how much the practices to incentivize*

carbon sequestration need to increase cutting and encourage juvenile formations, and in the park, I am more in favor of maintaining aged or even old forests (Respondent 1)". Of the same opinion are other respondents: *"The topic is certainly of interest. The strength of the institution is sometimes insufficient to follow such arguments and topics, which are important and new, grasped with more interest by young staff (Respondent 2)"*; *"I know little or nothing about this topic, but I grasp its importance and potential for our organization (Respondent 3)"*; *"There is a lack of trust/information at the national level on obtaining certificates for sequestered CO_2. I proposed that at least for strictly protected (non-intervention) areas, forestry should study data processing and application to carbon trading (Respondent 4)"*.

On the other hand, other managers have a different view on the matter, as can be seen from the following answers: *"The application of such a system could be interesting for publicly owned forest formations, owned by agrarian communities or where there is civic use. This would make it possible to carry out "close-to-nature" forest management and, at the same time, to obtain revenue for the users of civic use. Such properties are those, among others, that fall in the most sensitive areas of the park and for which coppice cutting is required, with even substantial withdrawals. For private properties, which are significantly fragmented, I see the application of the system as more difficult, except for the possibility of creating consortia between private individuals (Respondent 5)*"; "*There should be alternatives for national parks that do not exploit forests. Where the forest is left free to manage itself or where the aim of management methods is to increase biodiversity. Carbon is stored in our forests by increasing biomass (wood and biocenosis), transferring it to the soil (roots and mycorrhizae) and increasing humus formation (Respondent 6)"*, and again "*I believe that in the Park the existence of sequestered carbon can be easily demonstrated (Respondent 7)"*. In particular, some respondents state that: "*The Park, in the past, has activated voluntary carbon offset projects by acting as a mediator and guarantor for the society concerned (Respondent 8)"*; "*The Park is investing in scientific research on this topic, precisely to fill knowledge gaps and improve the approach to project development. It would be very useful if a first step of joint work could be taken to provide the parks with information, technical assistance and useful models to be applied on a local scale (Respondent 9)"*.

Intentions towards the production and selling of carbon credits in Natural Parks

The results of the measurement model are presented in Tables 1-2, which includes mean scores and standard deviation of constructs, internal consistency (Cronbach's alpha), indicator reliability (rho A), and convergent validity (AVE). All indicators confirm the robustness of the measurement model for the constructs. Indeed, the measured constructs exhibited high mean scores. Particularly for Intentions, most respondents were "interested in exploring the opportunities that the production and sale of carbon credits can offer". Moreover,

all Cronbach's alpha values exceed the critical threshold of 0.7, indicating high internal consistency for the constructs, as well as rho A that exceeds the value of 0.7 and the AVE above 0.5.

Table 1. Mean and standard deviation of the items

Items	*Statement*	Mean*	SD
Intentions	**INT1- I plan to manage at least part of the park for the production of carbon credits in the future**	3.239	1.080
	INT2- I intend to participate in the carbon credit market	3.134	1.064
	INT3- I plan to follow (or have already followed) the necessary steps to improve the sequestration of carbon in the park	3.299	1.120
	INT4- I am interested in exploring the opportunities that the production and sale of carbon credits can offer	3.657	1.016
Attitudes	**ATT1- I welcome the opportunity to participate in the sequestration and sale of carbon credits in the park I manage**	3.567	1.109
	ATT2- For me, carbon sequestration could improve the value of forests (in relation to ecosystem and landscape services) and minimize climate change	3.478	1.070
	ATT3- In the short term, the sequestration and trading of carbon credits may increase the economic revenues generated by the park	2.910	1.018
Subject norms	**SN1- Forestry professionals and forestry associations influence the choice of park management for sequestration and the carbon credit market**	2.463	1.111
	SN2- The choice to adopt forest management for the production of carbon credits is influenced by government regulations and institutions	3.060	1.292
	SN3- Park employees, whose opinion is important to me, believe that there should be management for the storage and sale of carbon credits in the park	2.776	1.220
	SN4- Industry experts, whose opinion I value, believe that managing forests for the production and sale of carbon credits is a correct decision	2.985	1.152
	SN5- Public and private research organisations and universities influence the decision to operate the carbon credit storage park	2.970	1.159
Perceived behavioural control	**BC1- Our park has the economic resources, information and expertise needed to manage forests for the production of carbon credits**	2.448	1.249
	BC2- The characteristics of the park are suitable for management for the production of carbon credits	3.284	1.336
	BC3- I believe it is possible to make management decisions that promote the production and sale of carbon credits in the park where I work	3.164	1.253

* With 5-point Likert scale (1= completely disagree; 5= completely agree)

For what concerns the correlations between latent variables, as shown in Table 3. Attitudes were strongly correlated with Intentions, followed by perceived behavioural control.

Table 2. Construct reliability and validity.

Items	Cronbach's alpha	Composite reliability (rho_a)	Average variance extracted (AVE)
ATT	0.821	0.841	0.737
BC	0.834	0.851	0.754
INT	0.879	0.900	0.736
SN	0.857	0.877	0.635

Table 3. Latent variables- Correlations

Latent variables- Correlations				
Items	ATT	BC	INT	SN
ATT	1.000	0.608	0.757	0.522
BC	0.608	1.000	0.636	0.650
INT	0.757	0.636	1.000	0.394
SN	0.522	0.650	0.394	1.000

For discriminant validity, the Fornell-Larcker criterion results show that the square root of the AVE for each construct is greater than the correlations with other latent constructs, thus providing adequate output (Table 4). Furthermore, the analysis of variance inflation factors confirmed the absence of multicollinearity issues among the measured constructs, indeed all values are below the acceptable level of 3.3 (Cammarata *et al.,* 2024) (Table 5).

Table 4. Discriminant validity- Fornell- Larcker criterion

Discriminant validity- Fornell- Larcker criterion				
Items	ATT	BC	INT	SN
ATT	**0.858**			
BC	0.608	**0.868**		
INT	0.757	0.636	**0.858**	
SN	0.522	0.650	0.394	**0.797**

Table 5. Collinearity statistics (VIF)

Items	VIF
ATT->BC	1.375
ATT->INT	1.659
ATT->SN	1.000
BC->INT	2.092
SN->BC	1.375
SN->INT	1.813

Figure 4. shows the PLS- SEM model. The yellow rectangles represent the outer loadings, that measure the strength of relationship between an indicator and its latent variable. Their value is much higher than the recommended level of 0.7

(Jo *et al.*, 2020). On the other hand, path coefficients are represented by arrows joining the blue circles and measure the strength of the relationship between the latent variables.

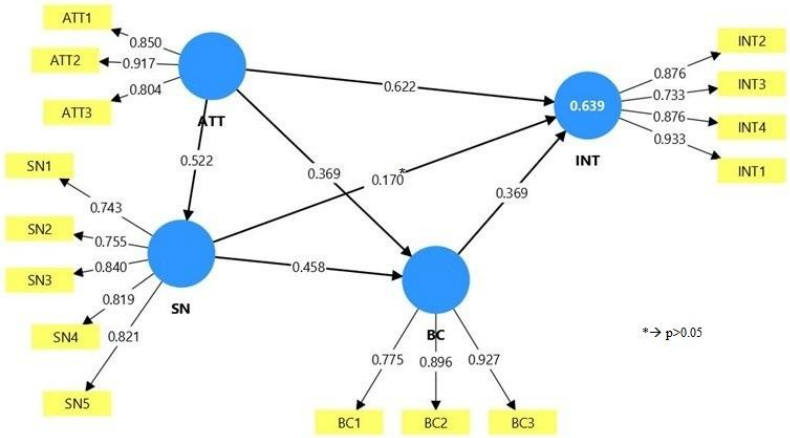

Figure. 4 PLS- SEM model

Specifically, in this study attitudes are considered as the perception (by parks' managers) of positive or negative outcomes of forest carbon offsetting practices. Subjective norms are represented by the influence of external subjects, instead, behavioral perceived control reflects managers perceived ability to participate in carbon sequestration and trading, considering the availability of natural and economic, resources and capacity to make independent decisions regarding carbon offsetting. The analysis revealed that attitude towards voluntary carbon market has a positive and significant effect on the intention to participate (β =0.622, p <0.001). This confirms hypothesis H1. Indeed, the more positively the carbon sequestration and trading is evaluated, the stronger the intention to adopt these practices. This result is in line with other work on the subject, that has shown as attitude has the highest positive and significant effects on intention (Thompson and Hansen 2012; Thompson and Hansen 2013; Tao *et al.*, 2021).

Conversely, subjective norms do not show a significant effect on the intention to participate (β =0.170, p >0.05), suggesting that the perception of approval from government institutions, park employees, industry experts and public and private research organizations or universities does not significantly influence park managers' intention to participate in voluntary carbon market, leading to the rejection of hypothesis H2. Also, some studies found similar results (Thompson and Hansen 2012; Cammarata *et al.*, 2024; Leduc and Hansson 2024). This lack of social pressure may still indicate a lack of awareness or popularity of the voluntary forest carbon credit market and its potential for both public and private sector participants. Finally, perceived behavioral control has a positive and significant effect on the intention to participate (β =0.396, p <0.001), indicating that park managers who have adequate access to necessary resources, information, and expertise exhibit a strong intention to participate, supporting

hypothesis H3. Furthermore, there is a good influence of the latent variables on each other (e.g. ATT->SN, β =0.522, p <0.001). In general, the model explained a significant amount of the variance related to behavioral intentions of park managers to apply a forest management system for carbon offset production and consequently to participate in the carbon market (R^2 = .639).

CONCLUSIONS

This study aimed to analyze the intentions of natural parks managers towards the adoption of carbon-oriented management of forests in order to participate in VCM. For this propose the Theory of Planned Behaviour was used, a much-applied model in this field of research. The results, however, only partially confirmed the usefulness of this model to explain the psychological factors that drive public forest managers towards VCM. Indeed, while perceived behavioural control and attitudes had a significant effect on intentions, subjective norms had little impact. In any case, these aspects highlight that, given the strong impact of perceived behavioral control on managers' intentions, ensuring access to necessary resources and support is crucial, starting with an improvement in forest management, considering that carbon credits can only be certified in the presence of a forest planning document, which, if it exists, must be implemented with carbon accounting, including through the support of guidelines. Moreover, the low impact of subjective norms on suggests that the existing communal support for adopting these practices is currently insufficient. In this context, especially by institutions and research organizations could aim at promoting successful case studies involved in pilot projects on the topic, highlighting the achievements of early adopters.

In addition, also thanks to the open-ended question used in the survey, some perplexities emerged, especially the lack of information and knowledge on the part of the respondents on this topic. This is of relevant importance, especially for policymakers and practitioners, also considering the introduction of the new European regulation on VCM and sequestration practices in agroforestry. In fact, compliance and voluntary carbon markets are growing worldwide, boosting supply of and demand for carbon credits from protecting, managing, and restoring forests. Despite ongoing debates concerning the actual contribution of carbon offsetting to climate mitigation strategies, these projects continue to attract buyers due to their perceived cost-effectiveness and additional co-benefits, such as biodiversity conservation. So, especially for the forest sector, the need to consolidate a voluntary market for carbon credit at international level, with a growing number of players and projects, and with transactions between buyers (companies, individuals, public and private entities, etc.) and sellers (both public and private owners or operators) is becoming more and more preponderant. In particular, in those areas where the production purpose is not the main, such natural parks, or where the forest produces average- to low quality assortments, the carbon-oriented management could represent a viable alternative to business-as-usual management activities and the sale of carbon credits an important source

of funding for forest conservation. However, there is still a lack of a stable market with appropriate rules and regulations even at the national level that would allow forest landowners/managers to implement the necessary strategies to participate. Therefore, in the absence of such a market or regulatory framework, it is only possible to speculate on the intentions of forest landowners/managers to enter a carbon market. In this sense, this can represent a limitation of this study, that analyses the prediction of intentional rather than actual behaviour. Indeed, studying managers' intentions regarding participation in ongoing projects (which is only possible for some parks) would provide a better understanding of behaviour. Other limitations presented by the study relate to small sample size, (67 natural parks), which was nevertheless taken into account given the great heterogeneity of European parks. Moreover, the Extended Theory of Planned Behaviour, which could have evaluated other variables in the model, was not applied. These limits can pave the way for future research opportunities. In fact, one could focus on a single European state, also in order to assess the state of the art at the national regulatory level on VCM by analyzing how intentions and behaviour vary in different regions and contexts. Furthermore, analyzing the influence of other external variables or factors within the model such as perceived environmental risk, knowledge, policy changes, could also contribute to a more comprehensive explanation of the dynamics influencing managers' decision-making toward VCM.

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