


Case Study

Stepping on invisible land: on the importance of communicating the value of soils

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Abstract

Soils play fundamental roles in the functioning of the Earth's ecosystems. Despite numerous initiatives to protect soils, it continues to be generally perceived as dirt or, at best, the surface we walk on. To better understand soil perception by the public, we conducted a survey with 99 participants from Poland and Brazil. We applied opportunity sampling and conducted semi-structured interviews with 40 respondents from Poland and 30 from Brazil, and 29 unstructured interviews in Brazil. Most of the respondents (53%) of the semi-structured interviews associated soil with the surface where plants grow, while 27% said that it is the ground we step on. When asked about pro-environmental campaigns, none of the respondents pointed to soil-related initiatives. Most of the respondents (99%) claimed that there is a need to increase their knowledge about the importance of soils, mostly through education (30%). The majority of the respondents of the unstructured interviews in Brazil indicated provision services provided by soils and pointed to the need for youth engagement in soil communication, corroborating the results from the semi-structured interviews. To address this, we present the results on artistic workshops as an experimental model for teaching and dissemination. We present two short documentary movies reporting the results from unstructured interviews and artistic workshops that can be used as data gathering tools, teaching tools and for dissemination purposes. This is a novel approach to communicating with the relevant stakeholders to promote more sustainable resource management.

Keywords Soil ecosystem services · Dissemination · Movies · Artists · Science-practice interface

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1 Introduction

Soils provide several ecosystem functions and services, such as food provision, climate regulation, waste recycling, water purification and recreation [1–3]. Soils host the cultural legacies of ancient people, have spiritual value and are artifacts for paintings and handicrafts [4, 5]. Soils relate to several sustainable development goals (SDGs) (SDG 2—Zero Hunger, SDG 6—Clean Water and Sanitation, SDG 13—Climate Action and SDG 15—Life on Land) [6], and their effective contribution to the 2030 agenda will only occur with efforts involving different decision-makers and society [7].

Various initiatives around the world aim to curb land degradation. The ‘4 per 1000’ Initiative, launched in 2015 at the United Nations Conference on Climate Change (COP 21), aims to increase global soil organic carbon stocks from 4 to 1000 (0.4%) per year to offset global emissions of carbon [8]. The Global Soil Partnership, which aims to promote the sustainable management of soil and improve global governance for its protection and sustainable productivity, encourages investment, and technical cooperation and promotes research in soil science. In addition, there are some commemorative soil dates, such as April 15th as “National Soil Conservation Day” and December 5th as “World Soil Day”. These initiatives represent a concerted effort to bring attention to the importance of soil and prevent further soil degradation.

Notwithstanding the fundamental role of soils in nature, their importance is often not recognised beyond academia and among non-scientists [9]. For example, in a survey-based study on environmental problems in Poland and Brazil, soil degradation was recognised as the least important problem compared to deforestation, water pollution and climate change [10]. Soil, which is often perceived as an inexhaustible resource, undergoes degradation worldwide. Currently, approximately one-third of the world’s soils are degraded, and more than 90% can be degraded by 2050 [11, 12]. Decreasing or eliminating land degradation is essential to maintaining ecosystem functions and services and is more cost-effective than rehabilitating land after degradation [11].

Lack of recognition of the value and functions of soil by different stakeholders has historically fostered widespread land degradation [13]. The solutions indicated by the stakeholders may provide effective measures to improve sustainable land management [14]. Although increased awareness does not imply immediate behavioural change, understanding stakeholders’ perception is a step toward social engagement [15]. Social engagement, in turn, is paramount in the context of land conservation and restoration, an increasingly popular approach to protect biodiversity [16, 17].

Given the vital role of soil in global resource management and the decline in the provision of soil ecosystem services, it is paramount to develop mechanisms for communicating scientific knowledge about the value of soils to a wider audience [7, 18]. However, with the abundance of fake news available online, there is a gap between scientists’ work and accessibility to potential readers [19]. Visual content in scientific papers is gaining more importance to address these efforts [20]. The recent TikTok boom among so-called Gen-Z shows how visual content is crucial for the dissemination of information to youth. For example, Basch et al. [21] presented research based on a sample of 100 TikTok videos with hashtag #climatechange, which they already totalled over 205.5 million views.

To this end, this paper has two principal objectives: (i) to investigate, using a survey, the perception of soil importance via opportunity research in Poland and Brazil and (ii) to report results on a creative dissemination method we used to show soil importance to a wider audience. We produced two videos, which may be applied not only as a tool to understand perceptions about soils but also for dissemination and teaching purposes. To achieve these objectives, we used a mixed-method research approach that involves interdisciplinary team. This is a standard robust approach to aid addressing a complex problem [17, 22, 23].

Finally, we discuss the need to publicise the importance of soil to society and discuss other awareness-raising practices. We believe this paper will contribute to encouraging soil scientists to engage with a broader audience about the importance of soil and its functions. Through a transdisciplinary approach performed throughout this study, we believe the article can reach the wider public.

2 Materials and methods

2.1 Survey

The survey aimed to collect and investigate different perceptions and information about the meaning of soil, its importance, and ways to increase awareness about soil value. We applied a semi-structured anonymous questionnaire to conduct personal interviews and video-recorded unstructured interviews.

2.1.1 Semi-structured questionnaire

The semi-structured personal interviews were performed over June and July 2021 in Poland and Brazil using accidental (opportunity) and voluntary sampling [24]. In accidental sampling, the respondents are selected based on availability and willingness to participate. It is a non-probabilistic and therefore non-representative sampling. The interviews were performed in Polish and Portuguese, were anonymous, and consisted of 10 questions:

1. Which recent pro-environmental campaign do you remember?
2. What was the source of it?
3. Where did you encounter it?
4. What is the soil?
5. Do you think soil is important?
6. Why?
7. Do you think it is important to do awareness campaigns about the importance of soil?
8. How can we increase awareness about the importance of soil?
9. What do you think about the app 'What can you do for the earth'?
10. Would you take part in this app?

The list of the original questions in Polish and Portuguese is included in Appendix 1. While asking question 9, we explained our idea to develop a mobile application, which in principle could encourage users to be more 'soil friendly' by explaining how everyday activities link to either damaging or improving soil. For each activity that could contribute to soil degradation but is replaced and reported by the user with soil-improving activity, the user would gain a point. When reaching a certain threshold, there would be a reward.

A monitoring system was also applied to verify compliance. The responses were transcribed to Excel and analysed using content analysis and descriptive statistics.

2.1.2 Video-recorded unstructured interviews

In September 2021, we performed unstructured interviews in different ecosystems within the Atlantic Forest biome, in the state of Rio de Janeiro, Brazil (Fig. 1): (i) coastal ecosystem in Cabo Frio municipality (22° 52' 55" S, 42° 0' 36" W) with a distinct presence of a 'Sambaqui' (see below)); (ii) Atlantic Forest 'sensu stricto' vegetation-in the "Serra dos Órgãos" National Park (PARNASO; 22° 29' 35" S, 43° 4' 24" W) and in Araras, both in Petrópolis municipality; (iii) coastal tropical moist broadleaf forest—'Restinga'- in Grumari Environmental Protection Area (APA Grumari) in Rio de Janeiro municipality (23° 2' 32" S, 43° 32' 10" W); and (iv) mangrove forest in the Guapimirim Environmental Protected Area (APA Guapi-Mirim) in the Itaboraí municipality (22° 39' 30" S, 42° 57' 0" W). Sambaquis, which in the indigenous Tupi language means "assembled of shells", are categorized as a rounded hill that can reach over 30 m high. They are composed of food residues such as seeds, shells, animal bones (mostly fish), and other artefacts demonstrating their use for burial rituals. They represent one of the major and more diverse archaeological heritage of the Brazilian territory.

At each site, we approached local visitors, including residents, tourists, tourist guides, conservation unit employees and scientists. The questions asked were "What soil means for you? ", "Do you consider the soil important? ", "Why?". Considering the particular importance and the specific term of 'sambaquis', we asked the additional question 'Do you know what sambaqui is?' during the field visit in Cabo Frio.

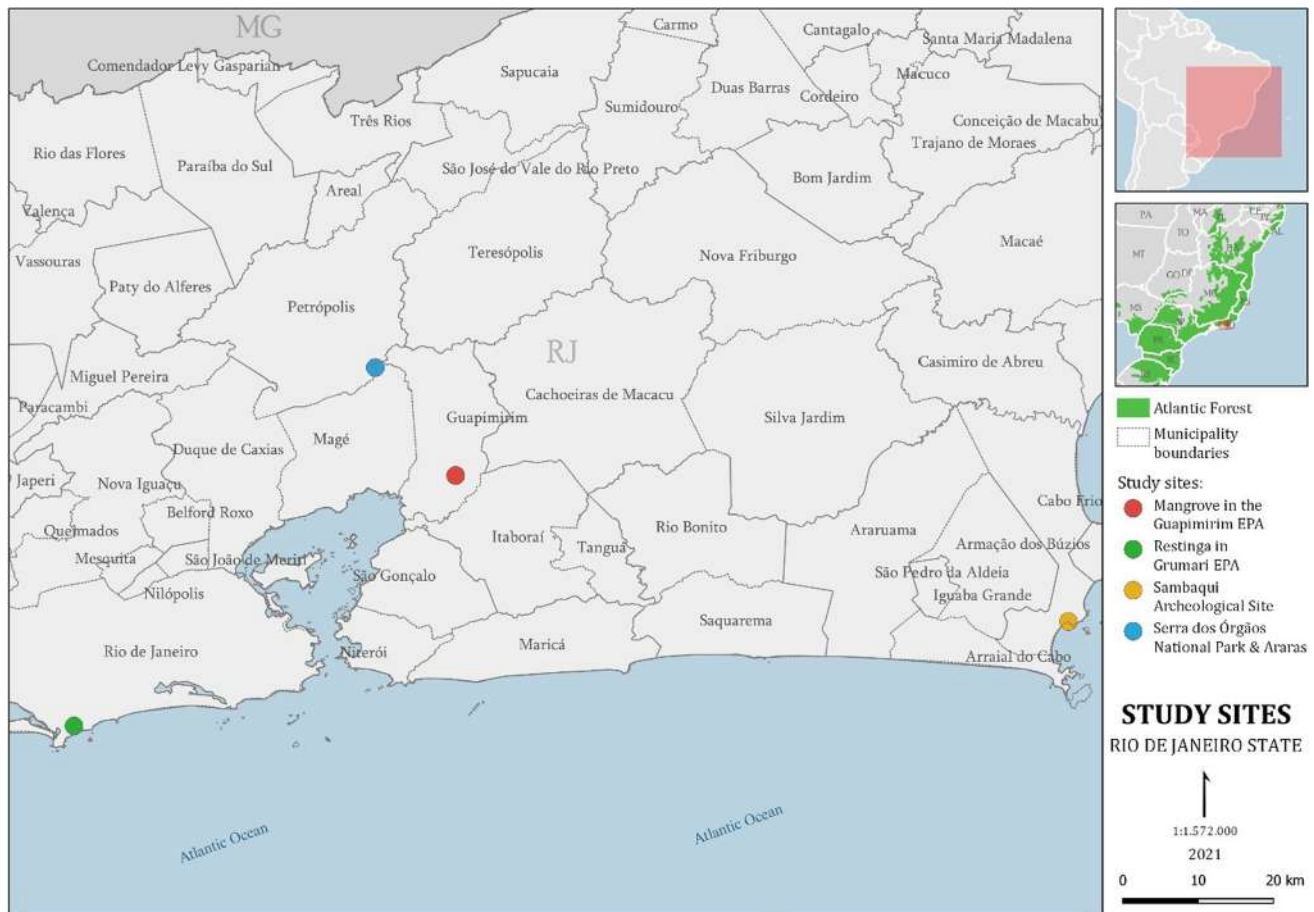


Fig. 1 Field work sites—state of Rio de Janeiro in the Atlantic Forest biome region

We also conducted two artistic workshops, one in Cabo Frio and the second in Petrópolis, with diverse audiences: collaborators of this project, tourists and local residents, including children. The participants were asked to express their perceptions about the soil through painting with soils. The participants also collected leaves, petals, stones, shells, plants and other elements that represent the meaning of soil. At the end of the workshop, we collected and filmed the testimonials from each participant about soil perception.

We used the soil ecosystem services framework from [25] to categorise the perceptions from unstructured interviews. This framework defines soil ecosystem services as the benefits people demand from soils for their quality of life. Furthermore, it differentiates this concept from others associated with soil science, such as soil properties, soil processes and soil functions, which have sometimes been used synonymously with soil ecosystem services. In this framework, soil ecosystem services are classified into regulation, provision and cultural.

2.1.3 Video capture and editing settings

The video interviews and the artistic workshops were compiled in two short documentary movies regarding the importance of soil for teaching and dissemination purposes. These videos were recorded using a SONY ALPHA 6500 camera, a CANON 80D camera, a CANON 5D MK3 camera, a MAVIC PRO 2 drone, and a Boya By-m1 microphone. This resulted in more than 12 h of raw filming. The most representative answers were added to the script. The final videos were edited with Adobe software: Premiere, After Effects, Lightroom and Photoshop.

3 Results

3.1 Survey

3.1.1 Semi-structured interviews

We interviewed 70 respondents: 40 from Poland (57%) and 30 from Brazil (43%). Of these, 61% (N = 43) were women, 38% were men (N = 26) and one respondent was identified as other (Fig. 2). Regarding the age of respondents: 46% (N = 32) were between 19 and 29 years old, 34% (N = 24) were between 30 and 39 years old, 9% (N = 7) were between 40 and 49 years old, and seven respondents were above 50 years old. Regarding the level of educational background of interviewees: 51% (N = 36) had higher education—meaning bachelor's or master's degree—or were still at the university, 13% (N = 9) completed high school, 7% (N = 5) completed PhD or were coursing PhD studies, and 4% (N = 3) completed primary school. Seventeen respondents did not disclose their education level. All respondents were living in urban areas.

In response to the question 'Which recent pro-environmental campaign do you remember?', 16% (N = 11) were familiar with campaigns about pollution with plastic, especially related to the use of plastic straws, 11% (N = 8) of respondents were not able to recall any, 7% (N = 5) were about the Amazon rainforest, 7% (N = 5) about campaigns for garbage treatment; 4% (N = 3) recalled a "Clean Air" campaign; 4% (N = 3) pointed to "Earth Hour", and 4% (N = 3) "On the side of nature" campaigns. The remaining 46% (N = 32) of answers were categorized as miscellaneous and are listed in Appendix 2. One Polish and seven Brazilian respondents did not remember any campaign.

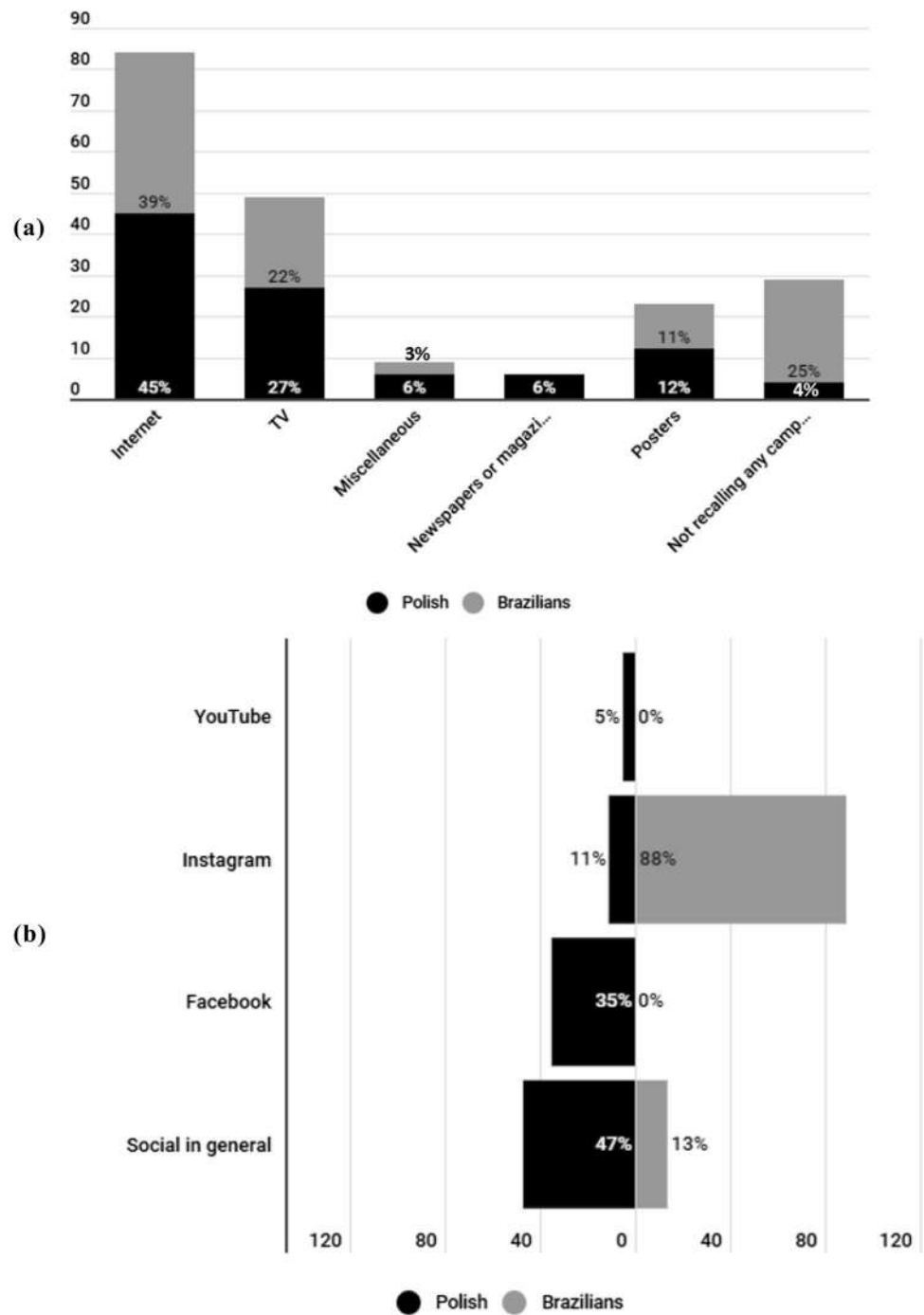
Regarding organisations responsible for the campaigns, government units, for example, the Ministry of Climate and Environment, were pointed out by seven respondents, WWF was pointed out by five respondents, and Greenpeace was pointed out by four. The rest of the interviewees did not remember the name of the organization or recall what type it was, did not remember any campaign or did not provide an answer. In the response to the question where the campaign was encountered, the respondents could indicate more than one source, therefore, the total number of answers is 85.

The most recurrent answers of Polish and Brazilian interviewees were internet (45% for Polish, 39% for Brazilians) and TV (27% of Polish respondents and 22% of Brazilians). Twelve percent of Polish interviewees and 11% of Brazilians encountered campaigns on posters. While six percent of Polish respondents cited newspapers or magazines, none of the Brazilian respondents indicated this source. Likewise, 6% of Polish interviewees cited other sources. News from the members of the family, university, and scientific papers were among them. For Brazilian interviewees it was 3% of answers, and church was one of the examples. Miscellaneous answers are in Appendix 3 (N = 10; 12%). Differences in responses between Polish and Brazilian interviewees are presented in Fig. 3a.

Fig. 2 Distribution of nationality and gender of respondents of semi-structured personal interviews



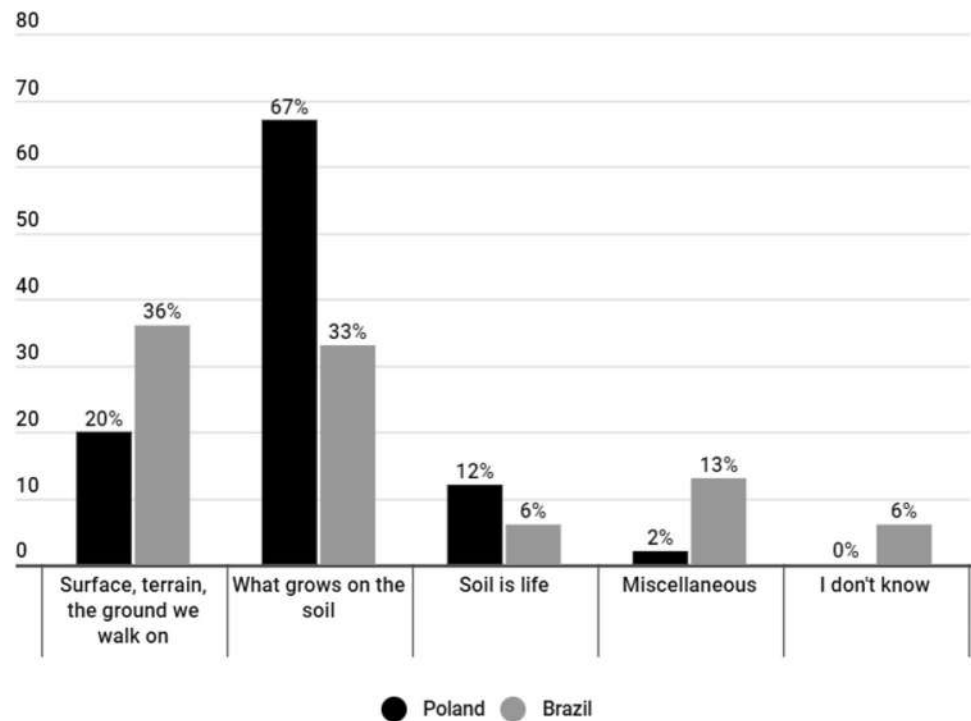
Fig. 3 Distribution of answers for sources where campaign has been encountered (a) and differences between social media where the respondents from Poland and Brazil encountered the campaign (b)



For both Brazilian and Polish respondents, the most recurring answer was the internet, which also included social media. For Polish interviewees, the most common answer was social media in general, Facebook and Instagram (Fig. 3b). Brazilian respondents indicated Instagram as the most recurring answer, while there were no answers either for Facebook, or YouTube.

Regarding the question ‘What is soil’, the respondents were asked to describe in their own words the perceptions they had about what the soil is without being tied to predefined concepts. Most of the respondents (N = 37, 53%) associated it with the surface where plants grow and develop, 27% (N = 19) believed that the soil is the ground we step on, seven respondents (10%) said that soil is life, 7% mentioned several different aspects related to the soil, and 3% did not answer (N = 2). Figure 4 presents the distribution of the answers between the two nationalities.

Fig. 4 Distribution of leading themes from answers of respondents of semi-structured personal interviews to the question ‘What is soil?’



All participants responded that the soil is important. The majority (N = 45; 64%) reported that the soil was important because of food provision and water regulation. For 27% (N = 19) soil is life and a survival resource for the planet. If the respondent included a mixture of these aspects in the response, the response was categorised as ‘miscellaneous—many aspects’. For example:

“Soil generates life in several aspects; if we don’t protect the soil, we won’t have its products. There is also what we consume directly and not directly, sometimes it is a raw material used for something, or there is water, which can only be filtered because it has passed through the ground. Soil is much more than what we don’t see than what we see.”

In relation to the participants’ opinion regarding increasing awareness about soil, one respondent replied that she/he did not think it was important. In response to the question ‘why we should raise awareness about the value of soils’, the most recurring answer was that it is needed for education (37%, N = 26) and because of pollution (16%, N = 11). Four respondents indicated that awareness campaigns are important for future generations, and one respondent claimed that our lives depend on soil. Selected citations:

“I think it should be done more for people who are connected to the soil, farmers or families who live in rural areas. Also educate people who work in government or work indirectly. It is also important so that the public is interested and can demand actions from politicians in case of violation of nature-protection laws.”

“To inform and raise awareness among the population.”

“To make the public aware that soil and caring for its quality is important for the natural environment and for the life of fauna and flora.”

Regarding the question of how to raise awareness about the importance of soil, education was the most recurring answer (N = 21; 30%). This should be done through lectures, workshops, and videos to address the youth. Campaigns were also indicated to increase awareness (N = 15; 21%) and 17% (N = 12) replied that there should be a mixture of campaigns with education in schools or TV commercials with dissemination in social media.

“Webinars, lectures with scientists/biologists/farmers, scientific articles.”

“(…) school education is very important, but it would also be good to focus on open communication channels such as TV or social media.”

“Influencers should increasingly take a stance on environmental issues, as their voice is of particular importance to the young generation, who must be properly educated to be able to prevent soil destruction from an early age.”

Regarding the question about the app, 76% (N=53) of interviewees found it an interesting or a good idea. For example:

‘it’s best to start with the youngest, they will be interested in it, something like Pokémon and there is a reward that can motivate people in the younger age.’

or

‘I think this type of application would be more intended for children and this is good, because from an early age you have to learn how to care about our environment.’

Among the limitations regarding the application, interviewees questioned for which group of society it would be destined and how to choose the targeted group. Additionally, interviewees had concerns about how to promote the app and get to the broader public, and how to monitor the activities registered in the app. Three respondents stated that a different approach, such as events, and campaigns, would be more beneficial than a new mobile application. Regarding interest in using the app, 51% (N=36) of the respondents indicated that they would use the app, while 30% (N=21) answered ‘no’. Twelve respondents were not sure, as they had concerns about whether they would be in the targeted group or because of lack of time, lack of space on mobile phone, or what would be the prize for using the app. One respondent did not answer the question.

3.1.2 Video-recorded unstructured interviews

We interviewed four respondents in the Cabo Frio area, four in the PARNASO Forest, five in the APA Grumari ‘restinga’ and two in the APA Guapi-Mirim mangrove. Furthermore, we recorded perceptions about soil from the participants of both artistic workshops conducted in Cabo Frio (N=9) and Petrópolis (N=5). This resulted in 29 unstructured interviews and registered 69 comments considering soil ecosystem services. Most of the comments (N=34) related to provision services, cultural (N=31) and four indicated regulation services following classification of [25], Table 1. Notably, in Cabo Frio, only one interviewee was aware of the existence of sambaqui and described it as an indigenous cemetery.

A total of 11 participants (collaborators of this project and local residents), including three children (3 years old, 4 years old and 9 years old), took part in the artistic workshop conducted in Cabo Frio (Fig. 5). Participants painted on canvas with soil and raw materials collected in the area—roots, litter, grass, and flowers, as well as with acrylic coloured paint. The artwork produced expressed the meaning of soils and participants’ relationship with soil. We repeated this activity in Petrópolis with five participants.

3.1.3 Video recordings and communication products

We recorded two videos. The first video is a 15’ short documentary called “Soil and society” (Additional file 1) featuring testimonials of local residents (workers, students and youth), tourists and visiting scientists about their perception of what is soil and their personal relation with soil in four different ecosystems in Rio de Janeiro. The second video is a 13’ short documentary called “Artistic Activity with Soils” based on the two artistic workshops (Additional file 2). It explains how the artistic workshop with soil paints was conceived and conducted, how the soil and other natural materials were collected and how the paints were prepared. The videos also show the testimonials of the participants about the value of soil. The paintings are also used for exhibitions at universities, botanical gardens, schools, and research institutions related to soil education in Rio de Janeiro.

4 Discussion

The quality of soil resources affects human well-being in multiple ways [25, 26]. Soil has, however, historically received less attention than other natural resources, such as water, in the context of conservation. It is important to acknowledge this gap and address it to incentivise and inform better soil use and adoption of better land management practices [17, 22, 23].

Given the increasing environmental impacts generated by soil degradation, it is necessary to raise awareness in society about the importance of conserving global soils [13]: the soil must be considered an integral part of the human-nature relationship and as indispensable to the natural processes that allow life on Earth. However, soil degradation is

Table 1 Categorisation of soil ecosystem services according to the framework of [25]

Soil ecosystem services classification	Type of service	Number of indications	Site	Example
Provision	Water	5	Petrópolis (Atlantic Forest)	Youths and a scientist recognised the importance of soil for water
	Wood	5	Petrópolis (Atlantic Forest)	Youths and a scientist indicated the importance of soil for forests
	Physical support	2	Grumari (Restinga)	Restoration employees recognised the importance of soil for seedlings to grow
	Physical support	1	Grumari (Restinga)	Local worker mentioned that animals depend on soil to survive
	Physical support / Food / Water / Fibre / Wood	6	Cabo Frio (Artistic workshop)	Scientists associate the soil with life
	Physical support	4	Petrópolis (Atlantic Forest)	Youths listed animals that live in the park
Regulation	Minerals	1	Petrópolis (Atlantic Forest)	Tourist associated soil as a mineral source (gold)
	Food	2	Grumari (Restinga)	A surfer and a local worker associated soil with plantation and food provision
	Food	5	Petrópolis (Atlantic Forest)	Youths and a tourist associated soil with plantation and food
	Wood	1	Guapimirim (Mangroove)	Local guide mentioned firewood extraction in the 70–60's to feed bakery ovens in the city
	Food	2	Guapimirim (Mangroove)	Crab's hunting is a source of food and income for hundreds of local residents
	Water purification	2	Guapimirim (Mangrove)	Tourist guides mentioned that mangroves 'filter' water
	Water purification	1	Petrópolis (Atlantic Forest)	Tourist associated soil with water quality
	Carbon stock	1	Petrópolis (Atlantic Forest)	Tourist associated soil with air quality
	Aesthetic/Recreational/Spiritual	4	Petropolis (Atlantic Forest)	Tourists explained why they search for natural sites to feel relaxed and alleviate from stress
		3	Grumari (Restinga)	Local workers mentioned how their work of restoring native vegetation, removing invasive species, and collecting garbage enhances the natural beauty of the place
Cultural		4	Petrópolis (Atlantic Forest)	Young local residents related how they feel energised and relaxed after visiting the park and its waterfalls, that is the only recreational option in their neighbourhood
		1	Cabo Frio (Sambaqui)	"Every time I come here (to the Sambaqui) to collect garbage, the next day the pitangua's (fruit) tree is loaded! It feel like that the nature is thanking me for taking care of her"—by local resident
		1	Cabo Frio (Artistic workshop)	Artist expresses in painting that soil is a "portal and everything in the universe is connected and shares energy through soil"
		1	Petrópolis (Artistic workshop)	Tourist associated the soil with human essence
		1	Cabo Frio (Sambaqui)	Local resident uses Sambaqui for recreational purposes
		1	Petrópolis (Atlantic Forest)	A tourist related soil with faith
		1	Petrópolis (Atlantic Forest)	A tourist mentioned that living in the city, the contact with soil and nature is missed
		1	Cabo Frio (Sambaqui)	Local resident related the importance of that archaeological site to preserve history and the feeling of connection with ancestors
		2	Grumari (Restinga)	Surfer and local worker associate the soil to the connection with nature and with their life itself, in a relationship of interdependence: "if we take care of the soil, we are taking care of ourselves. [...] We are a link in the chain [...]"

Table 1 (continued)

Soil ecosystem services classification	Type of service	Number of Site indications	Example
		1	Surfer related the use of the region's natural trails
		1	Restoration worker said he loves the contact with soil and planting, this is one way that he can express himself
Education and Knowledge		1	Restoration worker mentioned he was invited to visit a primary school to teach students about conservation and restoration
		2	Scientists talk about soil analysis and its elements
		2	Scientists associates life cycles with soil cycles and other philosophical insights
		4	Scientists explained that Sambaquis are pre-historical cultural deposits encompassing accumulations with a range of functions and origins

Fig. 5 Going clockwise: “Sambaqui” archaeological site in Cabo Frio; paintings from the artistic workshop in Cabo Frio; participants of the artistic workshop in Petrópolis; painting with soils



perceived as least important of current environmental problems [18], and the concept of ecosystem services related to soil quality has received less attention than biodiversity [27]. There are also gaps in the implementation of soil science in restoration studies [25, 28].

Our results confirmed the need to increase awareness about a variety of ecosystem services that soils provide. In our survey, soil was mostly perceived in the context of food provision and water regulation. Furthermore, although all respondents claimed that soil is important, none of the environmental campaigns that the respondents were familiar with considered soils. Similarly, the study from Brazil by [29] with children from the 5th year in elementary school shows that the majority (97%) of 29 participants stated that the soil is important for the conservation of the planet. Additionally, although all participating children affirmed the relationship of the soil with nature and the environment, 48% said that there is no life in the soil. When asked if they would like to learn more and if it was important to study the soil, 93% agreed. In a recent paper, [30] calls for improved dialogue between soil scientists and different stakeholders to shape the future soil research agenda. Based on surveys, they demonstrate that research priorities in soil science are generally not in line with the needs of key environmental and industrial sectors.

Regarding the evaluation of soil ecosystem services, we found that the majority of the respondents from field visits in Brazil recognised soil through the perspective of provision services ($N=34$), which corroborates the results from our semi-structured interviews. Importantly, cultural services were mentioned 31 times, which can be explained by the fact that the interviews were conducted in touristic places that are used for recreational or spiritual purposes. Indeed, cultural and social valuation that considers values of nature and its benefits that are rooted in individuals and at the same time are shaped by the social and cultural context in which they are embedded [31]. However, in the case of sambaquis, which are often based in touristic places in Brazil, sambaquis areas are not well preserved and overlooked despite their cultural and historical importance (Additional file 1). We also noticed that the site was neglected, with broken fences, trespassing, and no surveillance.

Our research confirms that a wide-ranging educational policy is needed regarding the importance of the natural environment. It is important to use new communication channels to reach wide social groups. The use of communication tools that employ methodologies with participatory activities and playful materials, both in urban and rural areas, is needed [32]. Indeed, many innovative methodologies in soil education such as theatre plays, games, videos, environmental tracks, soil painting workshops and papier mache, increasingly represent educational tools of research institutions [33]. For example, The Brazilian Agricultural Research Corporation (Embrapa) & School Program performs workshops with soil painting with teachers and students and the Soil Quality Indicators methodology addresses adults (farmers, students, teachers, and indigenous people; for more information and to watch the institutional videos about these activities consult Appendix 4 and 5). The integration of research and communication increases the chances that science will become useful to society [34].

Information technology (IT) and web-based multimedia have opened new paths to offer motivating learning alternatives as opposed to traditional passive learning. It improves motivation to learn, as students are generally interested in having multimedia resources online at hand. However, due to the daily multitude of information, more dynamic and interactive teaching formats are needed to attract the interest of broader audiences, especially younger generations [35]. Furthermore, considering that the learning process is related not only to contact with information but also to cognitive and motivational aspects, it is necessary to consider methods that lead to the internalization of knowledge [36]. Scientific articles, lectures and books are being translated into blogs, lives, and videos [37]. In particular, videos are increasingly popular, which opens a new opportunity for researchers to carry out efficient scientific dissemination outside the academy [38]. YouTube, one of the main online video networks in the world, is the preferred platform of Brazilians. This platform has more than 2 billion monthly users in more than 100 countries around the world, which represents a great potential for dissemination. Due to its visual characteristics, video content allows contextualizing the most diverse themes with the necessary nuances, details, and emotional appeals while maintaining an immersive dynamic [38]. This leads to much greater engagement: video is twice as likely to be commented on, shared, and discussed with friends and family than other formats [39]. Furthermore, emotional appeals—i.e. using real people talking about their feelings with pride, hope and joy -; and social influence—i.e. publicly broadcasting who have engaged in desirable behaviour such as restoration or conservation—are powerful leverages to drive behaviour [40]. Therefore, we believe that our videos contribute to the scientific dissemination of the value of soils to a broader and non-scientific audience and will attract wider interest, especially among the younger generation.

5 Conclusions

The results of this paper highlight the need for more engagement with broader public on soil importance. Even though soil resources are being depleted at unprecedented speed, there are few initiatives targeting wider audience on how to better manage better our soils. Creative tools should be promoted to facilitate communication between different stakeholders on appropriate soil management, contributing to achieving the Sustainable Development Goals. We hope that the results presented here will encourage other soil specialists to disseminate and communicate the importance of conserving soils in an effective and innovative manner.

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Author contributions AEL designed the research. All authors wrote the main manuscript text. AFR, MSM and M.E.M. prepared figures. F.G; B.D.V and V.M prepared figures and videos. AEL, MEM, BM, MSM, AFR, FG, BDV, VM, KF, performed the field research; AEL, MEM, MSM, FG, BDV analysed the data. All authors reviewed the manuscript.

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Data availability All materials developed and presented in this study are available in the manuscript, appendices and additional material.

Declarations

Competing interests The authors declare no competing interests.

Ethics approval and consent to participate This is a pre-project with anonymous respondents. The Committee of Faculty of Social Sciences of Opole has confirmed that no ethical approval is required.

Consent for publication All participants in the recorded interviews, as well as in the photographs, signed an image consent document with an explanation of the research proposal and image use.

Appendix 1

Questions in Polish

1. Jaką ostatnią kampanię proekologiczną pamiętasz?
2. Jakie było jej źródło?
3. Gdzie się z nią spotkałaś/eś?
4. Co to jest gleba?
5. Czy jest ważna? Tak/nie
6. Dlaczego?
7. Myślisz, że ważne jest robić podobne kampanie dla gleby? Dlaczego?
8. Jak inaczej można zwiększyć świadomość o funkcjach gleby?
9. Co myślisz o aplikacji 'co możesz zrobić dla ziemi'?
10. Brałbyś w tym udział?

Questions in Portuguese

1. Qual campanha pró-ambiental recente você lembra? Quando foi isso?
2. Qual foi a fonte dela?
3. Onde você a encontrou?
4. O que é o solo?
5. Acha que é importante? Sim/Não.
6. Por quê?
7. Acha que é importante fazer as campanhas similares sobre o solo?
8. Quais são as outras possibilidades de conscientizar o público sobre a importância do solo?
9. O que você acha sobre o aplicativo 'o que você pode fazer pela terra'?
10. Faria parte dessa iniciativa?

Appendix 2

- Clean Poland Program.
- Clean Poland Program.
- Demonstration in the Ministries' Esplanade in favour of Indigenous Rights.
- Don't get stuck in a bottle, about drinking tap water.
- Don't suck the life from our oceans.
- Drying up of Masurian lakes.
- Environment Day.
- Environment minister's departure from Brazil.
- Flower Meadows.
- Gisele Bündchen's birthday action.
- Hedgehogs instead of mosquitoes.
- Hedgehogs instead of mosquitoes.
- Importance of biodiversity.
- Jeżyki for hedgehogs.
- Patagonia.
- Poland 2050.
- Protection of the environment.
- Reduction of pollution at Tom Jobim airport.
- Rio92.
- Save Ralph.
- Sea turtle sanctuary on the Praia Vermelha.
- Something about tourism.

- Stop the invasion.
- Stop the invasion.
- Urban Gardens.
- Using cracks in the walls for vegetation growth.
- Vegan food and cosmetics.
- We turn off the electricity, we turn on saving.
- We turn off the electricity, we turn on saving.
- Wear clothes longer, leave the water to nature.
- Wear clothes longer, leave the water to nature.
- YES to climate education.

Appendix 3

- I found out from my son.
- In restaurants.
- From my family.
- During one of my classes at university.
- Research articles.
- Publicly available information in various online newsletters.
- Was widely promoted on media.
- Visiting a community garden in Favela dos Prazeres.
- Former college newsletter email.
- In Church.

Appendix 4

Embrapa & School Program

Since 1997, Embrapa—Brazilian Agricultural Research Corporation has been developing the Institutional Embrapa & School Program, which aims to promote and popularize, among the school community (teachers, students and their families and other school employees), the contribution of research by Embrapa and its partners, both for the development of Brazilian and world agriculture and for the importance of environmental conservation, thus awakening interest in technical-scientific activities in the target audience. Through its environmental education actions throughout the country, the program serves in rural and urban areas, and public and private elementary and high schools.

Embrapa Soils, one of Embrapa's Agricultural Research Thematic Centers, is headquartered in the Jardim Botânico neighborhood, in Rio de Janeiro. In Recife-PE, Northeast Research Execution Unit (UEP Nordeste) is installed. In its Soil Education actions are addressed topics related to the origin and diversity of soils, environmental degradation, conservation practices aimed at the sustainable management of soil, water and biodiversity, actions to recover degraded areas and education in soils.

The soil education actions developed by Embrapa Soils employ non-formal education activities such as lectures and guided visits in its facilities, schools and Embrapa Demonstration Units. In school events and in agricultural science and technology fairs and exhibitions, Embrapa Soils participates with an institutional stand, disseminating its research and conducting workshops on painting with soil paint. Another activity is to guide the implementation of school, community, and urban gardens in small spaces.

More information about the Embrapa & School Program at the Website <https://www.embrapa.br/embrapa-escola>

PronaSolos University

The creation of the PronaSolos University is in progress, a partnership initiative of the Brazilian Society of Soil Science (SBCS), Embrapa, the Geological Survey of Brazil (CPRM) and the Brazilian Institute of Geography and Statistics (IBGE).

PronaSolos University will promote the training and qualification of the target audience that will work in the activities of soil survey and classification in the National Soil Survey and Interpretation Program in Brazil (PronaSolos). The actions will be carried out mainly by the SBCS and by Brazilian universities that have postgraduate programs in soils and related areas in agricultural sciences, with the support of technical teams from Embrapa, CPRM and IBGE. The program also aims to serve the public from schools by providing information about soil science in an appropriate language and through playful teaching methodologies.

Coordinated by the Ministry of Agriculture, Livestock and Supply, with the cooperation of more than 30 public and private institutions, PronaSolos will develop, for the next 30 years, a wide range of detailed work on the knowledge of Brazilian soils.

Information about PronaSolos can be obtained at <https://www.embrapa.br/pronasolos>

Appendix 5

Embrapa Soils institutional videos can be obtained at <https://www.embrapa.br/embrapa-escola/videos-das-nossas-pesquisas>.

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