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A social perspective on soil functions and quality improvement: Romanian farmers' perceptions

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ABSTRACT

Agriculture is a key player in the conservation of natural resources and cultural landscapes and one of the most prominent interfaces between human activity and soil. The present paper reveals a social perspective on soil functions. In this context, it was assumed that perceptions of soil functions could transform themselves into components of agro-ecosystems and influence the whole decision-making process. Therefore, it is indispensable to look at farmers when approaching soil functions. The objective of this study was twofold. Firstly, Romanian farmers' perception of the importance of soil functions was investigated. Secondly, it was revealed how well farmers' perception of soil functions importance and socio-economic variables could predict the "Use of compost". Soil functions were selected based on an extensive literature review. Farmers' perceptions of soil functions and the use of compost as a measure taken to improve soil productivity were studied through a questionnaire applied to a sample of 278 Romanian farmers randomly selected from sixteen villages. Binary logistic regression revealed that the perceived importance of two soil functions could predict the use of compost – "Water quantity regulation" and "Water quality maintenance and enhancement". The study concluded that strengthening the importance of the "Water quantity regulation" function in farmers' minds can stimulate the use of compost. It was also inferred that because younger farmers are more prone to composting, they will be more receptive to marketing actions related to compost use, such as the acquisitions of materials and instruments useful for compost production and use. In a context where a real dialogue to elaborate well-grounded environmental policies is still elusive because of differences between farmers and policy-makers' views, investigation of farmers' perceptions can bring a significant contribution towards a bottom-up approach for sustainable soil management.

1. Introduction

Soil quality plays a major role in agricultural productivity through the supply of food, raw materials, and bio-fuel (de Souza Mello Bicalho and Trippia dos Guimarães Peixoto (2016)). Supplying food is recognized as the main objective of agricultural production worldwide, and consequently, healthy soil is the foundation of the food system (FAO, 2015a). As predicted by scientists, in the next 40 years, global food demand for food will increase, and on the same or even less land the world, we will need to produce around 70%–100% more (Godfray et al., 2010). That is why, unsustainable agricultural practices rooted mostly in the expansion of agricultural land and the use of agricultural inputs play an essential role in soil degradation, pollution of air, water and soil, fragmentation of habitats, and destruction of biodiversity (Evans et al., 2019; Pykälä, 2019).

It is in this context that we should consider agriculture as an essential player in the conservation of natural resources and cultural landscapes. Globally, more than half (52%) of all fertile, food-producing soils are classified as degraded, many of them severely degraded (UNCCD, 2015), and 12 million hectares of land is lost to food production every year (FAO, 2015a). Not coincidentally, FAO (2015a) justly posits that alongside climate change, soil degradation must be tackled as one of the most pressing problems humanity is faced with. In Romania, erosion, the decline in organic matter, or contamination of soil resources are some of the soil degradation causes (see Figs. 1–3). Also, after the accession to the EU and implementation of the Common

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Fig. 1. Failed corn crops in Dolj county (South-West of Romania). *Source:* Ion Patrutoiu, personal archive (June 2019).

Fig. 2. Degraded soil in in Dolj county (South-West of Romania). *Source:* Ion Patrutoiu, personal archive (June 2019).

Fig. 3. Hills intensively grazed (North-West of Romania). *Source:* Authors' personal archive (May 2020).

Agricultural Policy, agricultural intensification and land abandonment had severe negative consequences on many species plant and animal species (Culbert et al., 2017). Romania has an average soil loss rate by the water of 2.84 tons per hectare per year (t ha^{-a} $yr.^{-y}$), compared to the EU average of 2.46 t ha^{-a} $yr.^{-y}$ (European Commission, 2019). About 42% of the total agricultural land is affected by water erosion (Sevastel et al., 2010), a natural process that is aggravated by inappropriate human activities, such as unsustainable agriculture.

Given this background, farmers are increasingly faced with a new challenge – how to bring together the increase of productivity (which is vital for economic and food security) and sustainability (reflected in environmental protection, social, and economic welfare). Heeding such calls, one answers is the sustainable soil management (SSM). In an agricultural context, SMM means that soil functions that contribute to "ecosystem services and biodiversity, natural and economic resources are utilized efficiently, farming remains profitable, and production conditions adhere to ethical and health standards" (Helming et al., 2018); overall, SMM is not compromising the possibility of future generations to meet their own needs from that soil (Smith and Powlson, 2007). Within SSM, soil information, including local perceptions and knowledge are essential for understanding soil functions and soil conditions, as well as for targeting interventions to increase productivity (FAO, 2017b) because SSM is often geared towards promoting sustainable agriculture.

Within the umbrella of SSM, some may embrace new technologies such as conservation agriculture (CA) (Brown et al., 2019; Michler et al., 2019). CA is judged to be able to increase both productivity and sustainability, because it is based on several principles that imply soil quality also [e.g., maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species (FAO, 2017a)].

Conservation and stewardship of soil gain increased visibility (Basch et al., 2017), especially through research in soil science, agronomy, or biochemistry (Bennett, 1948; Holland et al., 2017; Morgan, 2009; Wu et al., 2020). Since agriculture is one of the most prominent interfaces between human activity and soil (Bartkowski and Bartke, 2018) and because soil is a key component of both natural and human-influenced environmental systems (Nortcliff, 2002), it is indispensable to look at farmers when approaching soil functions [where "function" is used with the meaning of service (Glenk et al., 2012)]. However, social sciences contribution to the understanding of soil functions, in particular, is fairly scarce. Within this social area of investigation, much of the current literature is focused on farmers' knowledge of soil conservation practices, paying particular attention to determinants for their adoption. As pinpointed by de Souza Mello Bicalho and Trippia dos Guimarães Peixoto (2016) this knowledge is often not given due consideration as it is criticized as socially naive, not valid or even useless. The Global Soil Partnership raises the problem of the general lack of societal awareness of the importance of soil in people's lives and the well-being of the planet, the more so as healthy soil is "the precondition for human well-being and economic welfare and therefore plays the key role for sustainable development" (FAO, 2012).

Against this backdrop, it is, therefore, crucial to investigate how farmers perceive the importance of soil functions, in a context where the real dialogue needed to elaborate well-grounded environmental policies is still elusive because of the fundamental differences between farmers and scientific community and policy-makers views (de Souza Mello Bicalho and Trippia dos Guimarães Peixoto, 2016), which impede a policy bottom-up approach. Farmers' perception of soil functions, where "perception" is understood as a belief, opinion, or representation in the farmers' mind (Duncan, 1990), is based on farming experience with evaluations and observations, environmental and social narratives (Yageta et al., 2019). These are key determinants for making everyday soil management decisions (Bado and Bationo, 2018). Furthermore, perceptions guide decisions and actions, and shape the beliefs (Tacca, 2011), a process that is highly subjective and influenced by an individual's frame of reference (Petrescu et al., 2017).

The little information and systematic feedback of farmers' knowledge related to soil made the investigation of the Romanian farmers' perceptions of utmost importance especially when national agro-

Table 1
The soil quality functions and the reviewed literature.

Soil quality functions	Reviewed literature
Ensure productivity	(Dimal and Jetten, 2018; Doran and Zeiss, 2000; Glanz, 1995; Granatstein and Bezdicek, 1992; Gruver and Weil, 2007; Karlen, 2005; Lal, 2016; Lima et al., 2011; Sombroek and Sims, 1995; Stavi et al., 2016; Valujeva et al., 2016)
Generation and support of microorganisms useful for agricultural cultures	(Acton and Gregorich, 1995; Briones, 2014; Dimal and Jetten, 2018; Doran and Safley, 1997; Glanz, 1995; Karlen et al., 1997; Sombroek and Sims, 1995)
Support for biodiversity (gene pool)	(Blum, 2005; McBratney et al., 2014; Robinson et al., 2009; Vogel et al., 2019)
Climate-regulative	(Dimal and Jetten, 2018; Lal, 2016; Sombroek and Sims, 1995; Techen and Helming, 2017; Valujeva et al., 2016; Vogel et al., 2019)
Water quantity regulation	(Dimal and Jetten, 2018; Gruver and Weil, 2007; Rabot et al., 2018; Sombroek and Sims, 1995; Stavi et al., 2016)
Buffer for pollution control	(Acton and Gregorich, 1995; Liu et al., 2006; Robinson et al., 2009; Sombroek and Sims, 1995; Techen and Helming, 2017)
Water quality maintenance and enhancement	(Acton and Gregorich, 1995; Dimal and Jetten, 2018; Doran and Safley, 1997; Karlen et al., 1997; Valujeva et al., 2016)
Storage	(Dimal and Jetten, 2018; Sombroek and Sims, 1995; Warkentin, 1995)
Living space	(Haslmayr et al., 2016; Karlen et al., 1997)
Geogenic and cultural heritage	(Blum, 2005; Duru et al., 2015; FAO, 2015b; Sombroek and Sims, 1995)
Connective space function for community members	(Sombroek and Sims, 1995)
Support of plant, animal and human health	(Doran and Safley, 1997; Doran and Zeiss, 2000; Karlen et al., 1997; Oliver and Gregory, 2015; Wall et al., 2015)

environmental policies, which should encompass social interaction and compatibility of values and interests, are negotiated and elaborated. Besides the need of farmers' participatory approach, the following socio-economic data [extracted from National (Romanian) Institute of Statistics, 2017] are another argument towards the investigation of Romanian farmers' perceptions: 60% of the used agricultural area of Romania (8.2 million ha) is the arable land; although the contribution of agriculture to GDP is declining, Romania still has the largest share of the agricultural sector in the GDP structure (6%) of all the European Union countries, three and a half times higher than the European average; in addition, agriculture employs a quarter of the employed population and about 27.3% of the active population of Romania [in the second quarter of 2019, Romania's active population was 9.159 million people according to National (Romanian) Institute of Statistics, 2019], more than six times higher than the European average.

The present study assumes that perception and knowledge of soil quality can transform themselves into components of agro-ecosystems and influence the whole decision-making process. In this context, the main goal of this paper is to investigate farmers' perception and knowledge of soil quality functions based on the premise that they are components of agro-ecosystems and influence farmers' decision-making process. The specific objectives of this study were: i) to investigate Romanian farmers' perception of soil functions importance and ii) to reveal how well farmers' perception of soil functions importance and socio-economic variables can predict the "Use of compost". When considering soil functions, much of the current literature has principally focused on the farmers' assessment of the indicators of soil quality, especially fertility (Dawoe et al., 2012; Desbiez et al., 2004; Kuria et al., 2019; Liebig and Doran, 1999; Odendo et al., 2010) or the description of the functions, without investigating farmers' perceptions of them (Blum, 2005; FAO, 2015b). In this context, the present study adds to the research progress on soil quality by exploring determinants (namely perceived importance of soil functions and socio-economic variables) of the use of compost as a measure to improve soil quality.

1.1. The soil quality concept

Soil quality is a key component of sustainable agriculture (Larson and Pierce, 1994; Warkentin, 1995) and the evaluation of sustainable soil management in agroecosystems is often done by resorting to soil quality concepts (Carter, 2002). The concept of soil quality emerged in the early 1990s and the first formal definition was proposed in 1997 by the Soil Science Society of America (Karlen et al., 1997). Karlen et al. (1997) contend that three key components must be regarded when considering soil quality, namely sustained biological productivity, environmental quality, and plant and animal health. Thus, soil quality can be understood as "the capacity of soil to function as a vital living system, within the ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health" (Doran and Zeiss, 2000). Soil quality is closely related to soil functions, as soil is valued as a living and dynamic finite resource (Doran and Zeiss, 2000).

Soil vulnerability is increasing as a consequence soil erosion, soil fertility decline, and associated changes in soil physical and chemical (Moges and Taye, 2017), all affecting agriculture productivity. Thus, in regard to the agricultural use of soil, it is undeniable that soil productivity is of utmost relevance for farmers as it is defined as the capacity of a soil to produce a certain yield of agricultural crops using a set of management practices (Karlen, 2005). There are several chemical, physical, and biological properties of soil that are linked to its productivity – one of the soil main properties which arouses a special interest, both on the part of researchers and the farmers. Nevertheless, soil quality is not limited to soil productivity, and environmental quality, human health, and food quality should be closely considered (Doran and Zeiss, 2000; Karlen et al., 1997; Parr et al., 1992; Zornoza et al., 2015). It is self-understood that soil quality is not a new topic and that the definition of soil quality is quite elusive, however, the concept of soil quality evolved over time along with the concerns for the health of the environment or food safety and good quality food. As pointed out by one of the most limiting aspects of soil quality evaluation refers to the lack of a universally acceptable method to develop soil quality indices (Qi et al., 2009). Just like scientists, farmers have their own perception of soil functions derived from their farming experiences with soil, which is worthy of investigation.

2. Methodology

2.1. The soil quality functions reflected in the literature

The research methodology was developed in two stages. Within the first stage, we use secondary data to review the soil functions (Table 1). These were not searched in the literature in relation to a specific soil use purpose. Besides one prominent agricultural soil function – "Productivity", other functions related to ecosystem services relevant for the functioning of terrestrial systems and for human well-being have been selected. Therefore, starting from the descriptions of soil functions made by Sombroek and Sims (1995), a list of soil quality attributes was reviewed. The reference time frame was 1995–2020. A total of 214

Table 2
Farmers' socio-economic characteristics.

Variable	Category			
Age (average)	Years			
	44.04			
Gender (percentage)	M			
	57.2			
Education (percentage)	8 years of education	12 years of education	Higher education	
	11.5	37.1	51.4	
Monthly average family income (percentage)	Maximum 212 Euro/ month	Between 213 and 638 Euro/month	Between 639 and 1064 Euro/month	Over 1065 Euro/ month
	7.6	40.3	33.5	18.7
Cultivated area (average)	Ha			
	7.7			

manuscripts and documents were retrieved and they were selected based on several criteria: English language and peer-reviewed journals, journals with an IF higher than 0.1 or present in Scopus, books, reports, and normative acts. Searches were conducted in electronic databases (e.g., Cambridge Journals, Emerald Management Journals 200, ScienceDirect Freedom Collection-Elsevier, Scopus-Elsevier, SpringerLink Journals, Springer, Web of Science-Core Collection, Wiley Journals) downloaded from Anelis plus platform (Enformation portal). Titles and abstracts were reviewed separately and 24 records of full-text were, finally, retained.

2.2. Farmers' survey and statistical analysis

The second methodological step was the investigation of farmers' perception of soil functions. Farmers' perceptions of soil functions and the use of compost as a measure taken to improve soil productivity were studied through a questionnaire with a sample of 278 Romanian farmers. Statistical analyses included descriptive statistics and regression analysis. Standard linear regression was performed using SPSS to test the relationship between the "Use of compost" as dependent variable and the following independent variables: importance of 12 soil functions (Ensure productivity; Generation and support of microorganisms useful for agricultural cultures; Support for biodiversity (gene pool); Climate regulative; Water quantity regulation; Buffer for pollution control; Water quality maintenance and enhancement; Storage; Living space; Geogenic and cultural heritage; Connective space function for community members; Support of plant, animal and human life and health) and five socio-economic variables (age, gender, education, cultivated surface, and average income/ month). When the "Use of compost" was tested in the questionnaire, farmers were explained that the question refers to both types of compost: self-produced and purchased. The dependent variable is a dichotomous variable, importance of soil functions was measured on a 5-point scale (1 = not at all important, …, 5 = very important) and the socio-economic variables are a mixture of discrete and continuous. Analyses were performed with the software Excel and SPSS.

The questionnaire was first prepared in English, translated to Romanian and translated again to English by a Romanian translator to ensure consistency check before its use for data collection. Data was collected through face to face interviews. Multistage random sampling was used to create the sample. Random sampling was preferred firstly because it allows the study of geographically extended areas at affordable costs and, secondly, because a list with all farmers in the country does not exist, while a list with all counties and rural localities in each are easily available. Random sampling was preferred to cluster sampling because people in a cluster tend to be more similar than people in different cluster units and, thus, the standard error associated with parameter estimates is usually higher in cluster compared to random samples (Fife-Schaw, 2000). The sample size was influenced by budget and time constraints. Four counties were selected at random, out of the total 41 counties plus the capital region (all counties were numbered, four random numbers were generated in Excel program, and the counties with those numbers were included in the sample). A list with all rural localities was created for each of the four selected counties and rural localities were numbered from 1 to n in each county. Four rural localities were randomly selected in each county as follows: a list with four random numbers was generated four times (in Excel) and the localities with the corresponding numbers were selected in each county. Then, between 10 and 40 interviews were carried on in each of the rural locality. The first household was selected at random like this: firstly, the number of households in the locality was observed; secondly, a random number between 1 and the maximum number of households was selected. This represented the household where the first interview was requested to a person who was over 18 years old and who was involved in agricultural activities at least 4 h/ month. From there, in every third house, an interview was requested. The acceptance to respond rate was 37%.

3. Results and discussion

3.1. Farmers' characteristics

Different socio-economic independent variables that characterize the investigated farmers were considered. The key characteristics of the sample, including the age, gender, education, income, and cultivated area, are summarized in Table 2.

3.2. Farmers' perception of soil functions importance

All soil functions have high importance according to investigated farmers, gathering average scores per sample above the medium level of 2.5 points (Table 3). This is a positive fact, indicating that farmers understand the importance of tested soil functions. Soil functions "Ensure productivity" and "Generation and support of microorganisms useful for agricultural cultures" are perceived by farmers as having the highest importance. This is probably because they have the most visible connection to the profitability of agricultural activity. Similar to this finding, in a study of Gruver and Weil (2007) dedicated to the USA farmers' perceptions of soil quality, the most important indicator of soil quality was pointed, by the majority of the farmers (88%), to be the soil organic matter (SOM), a function directly linked to soil productivity. Also, Granatstein and Bezdicek (1992) and Lima et al. (2011) revealed that SOM is largely perceived as the most significant indicator of soil quality. At the farm level, the relationship between productivity and economic return is evident, and at the global level, productivity is strongly linked to food security and with feed, and fiber production

Table 3
Farmers' perception of the importance of soil functions (average score on a scale from 1, the lowest importance, to 5, the highest importance).

Soil function	Average score
Ensure productivity	4.4
Generation and support of microorganisms useful for agricultural cultures	4.3
Support for biodiversity (gene pool)	3.9
Climate regulative	3.9
Water quantity regulation	4.1
Buffer for pollution control	3.9
Water quality maintenance and enhancement	3.9
Storage	3.4
Living space	3.4
Geogenic and cultural heritage	3.3
Connective space function for community members	3.2
Support of plant, animal and human life and health	4.1

(Karlen, 2005). A study of Moges and Holden (2007) linked productivity with crop performance and they showed that the most important perceived indicator of soil productivity is the crop yield, followed by the crop performance. Similarly, "Productivity" was considered the most important function by farmers in the Philippine (Dimal and Jetten, 2018). In the present study, the lower importance was given to social-cultural functions "Geogenic and cultural heritage" and "Connective space function for community members" which have the weakest connection to the profitability of the agricultural activity. The same orientation was present in Philippine, where the last place was also given to a cultural function ("Allows for recreation") (Dimal and Jetten, 2018). The "Water quantity regulation" and the "Support of plant, animal and human life and health" were placed on the third place in farmers' evaluation (Table 3). Likewise, the soil hydrologic function was mentioned by more than half of the USA farmers as contributing to the soil quality, and several of them appreciated that soil water-holding capacity was the most relevant feature between good and poor-quality soils (Gruver and Weil, 2007). Plant species diversity is considered a desirable indicator in the agroecosystem (Suárez et al., 2001) and many farmers worldwide are relating soil quality with nature and vegetation conditions (FAO, 1997). It is important to mention that there is a rich vein of research focused on the investigation of farmers' perceptions regarding soil indicators (physical, chemical, and biological) [see for example, (Dawoe et al., 2012; Idowu et al., 2008; Kuria et al., 2019; Raghavendra et al., 2020)], while the perceptions of soil functions have been less explored in the literature, which leads to less extensive discussions on the comparisons of results.

3.3. The "use of compost" to improve soil productivity

Important economic and environmental benefits are obtained by home composting (Andersen et al., 2012; Vázquez and Soto, 2017). It prevents not only the landfilled but also recovers nutrients essential for crop production which impacts on crop productivity and chemical fertilizers usage (Bekchanov and Mirzabaev, 2018). Viaene et al. (2016) reviewed the potential strengths of compost application which, of course, depends on the climate, compost dose, crop rotation, etc. Among them, they mentioned the large amounts of organic matter in the compost, which enhances the soil organic carbon content, improvement of soil physical properties such as available water content, the presence of nutrients that reduces the need for other fertilizers, or its potential to enhance the biological diversity of the soil. Consequently, the "Use of compost" as a dependent variable was selected as compost is an organic residue acting as a multifunctional soil improver (Bernal et al., 2017) that enhances the microbial activity and improves the physical properties and nutrient-supplying capacity of the soil (Wiesman, 2009). At the same time, compost production is a means to reduce the quantity of organic waste, thus bringing a positive contribution to the circular economy. Literature also points to the disadvantages of composting such odor and bioaerosol emissions (these can be overcome through better operation management and technology), space requirements, the need to market the product (Epstein, 1996), or the leachate production (Lin et al., 2018). In Romania, almost 43% of the total population lives in rural areas (National Institute of Statistics, 2018), that is why home composting could play a significant role to recover the biowaste as compost. The biodegradable waste is the main component of municipal waste, as long agricultural waste and biosolids are increasing; around 95% of municipal waste is landfilled, a significant number of the composting facilities are not in use, or poor coverage of rural waste collection services are few examples of the waste management challenges Romania is facing (Feodorov, 2018). For example, from a total capacity of about 1.4 Mt/y, only 8.7% (0.12 Mt/y) is in operation (Feodorov, 2018). However, Mihai and Ingrao (2018) revealed the potential of home-composting as a sustainable solution in Romanian rural areas, and they point out the need for good practices among rural inhabitants. Based on a quantitative assessment, Mihai and Ingrao (2018) performed four scenarios analysis. For example, the realistic scenario considered that 70% of uncollected biowaste is used for household composting purposes. Ghinea and Gavrilescu (2016) assessed the performance of various waste management scenarios in terms of costs, among which composting was also considered. The scenario which included sorting, composting, and landfilling was the most suitable alternative to the existing municipal solid waste management system (Ghinea and Gavrilescu, 2016).

The existence of a compost market makes it a very attractive product. Currently, in Romania, the price/kg of compost is about 0.20 Eurocents. Apparently, even if the marketing price per kg seems low, given that compost can be used in all crops, in quantities of 15–25 tons per hectare (Romanian Ministry of Environment and Water Management, 2005), the use of the compost in significant quantities can increase suppliers' revenues. The high price of composting plants for large and medium farms should not be ignored. The cost of constructing and operating a composting facility varies from one location to another, it depends on the volume of material processed, on the use of additional feed materials. There are several financial instruments that citizens can access to finance composting projects. One program was the "Waste management program – Composting" (total budget of about 10 400 000 Euro, 2016) financed through the Romanian Environmental Fund. In 2019, the Priority Axis 3 (of Large Infrastructure Operational Program) was launched. This Axis 3, entitled "Development of environmental infrastructure in conditions of efficient management of resources" (allocated amount 2 892 443 785 Euro) may include the construction of transfer and recovery/treatment facilities, including composting platforms and individual composting units.

The binary logistic regression revealed that the use of compost with the aim of increasing productivity can be predicted by two variables, namely the perceived importance of the soil function "Water quantity regulation" and "Age" (Table 4). This is not surprisingly, as compost acts as a natural sponge and it is recognized for its water-holding capacity (Hernando et al., 1989).

The Cox & Snell R Square and the Nagelkerke R Square values suggest that between 10.9% and 14.7% of the variability in the use of compost is explained by a set of three variables: perceived importance of soil functions "Water quantity regulation" and "Water quantity regulation" and farmer age. The percentage accuracy in classification is 66.2, meaning that the model is able to predict the correct category (use of compost/no use of compost) in 66.2% of the cases. For each level of increase in the perceived importance assigned to the soil function "Water quantity regulation", the odds of a farmer reporting the use of compost increases by a factor of 1.737 all other factors being equal

Table 4
Results of binary logistic regression analysis for the impact of selected variables on the use of compost to improve soil productivity (only variables with prediction power are included in the table).

Independent Variable	Dependent Variable	B	S.E.	Wald	df	*p*	Exp(B)
The importance of soil function: Water quantity regulation	Use of compost	0.552	0.265	4.348	1	0.037	1.737
The importance of soil function: Water quality maintenance and enhancement		−0.636	0.231	7.363	1	0.006	0.529
Age		−0.027	0.010	7.797	1	0.005	0.973

Legend: B is Regression Coefficient; S.E. is Standard Error; Wald is Wald Statistic; df is degree of freedom; *p* is Significance; Exp(B) is odds ratio.

(Table 4). This suggests that efforts in increasing farmers' awareness of the soil function "Water quantity regulation" can stimulate the use of compost. Surprisingly, for each level of decrease in the perceived importance assigned to the soil function "Water quality maintenance and enhancement", the odds of a farmer reporting the use of compost increases by a factor of 0.529, all other factors being equal (Table 4). A possible explanation may be that farmers consider the soil polluted and, thus, not contributing to "Water quality maintenance and enhancement". Another cause could be that water quality regulation function is not correctly understood by farmers, which suggests that correct and understandable information should be provided to farmers about this issue. Further studies should find out the exact cause of this perception. In a study dedicated to Flemish farmers, it was shown that they believed that compost application contributed to better water infiltration and drainage (Viaene et al., 2016), a perception supported by data from the literature (Curtis and Claassen, 2009). The use of compost to enhance soil quality is proved to help nutrient leaching to groundwater (Grey and Henry, 1999) and, in the long term, it enhances soil fertility. The younger the age is, the higher the chances to use compost are. The same inverse relationship between age and soil conservation practices was observed for Ethiopian farmers (Moges and Taye, 2017). This result indicates that younger farmers are better contributors to SSM and they will be more receptive to marketing actions related to compost use, such as the acquisitions of materials and instruments useful for compost production and use (e.g., bins, tools). At the same time, the older ones should be targeted by awareness campaigns to stimulate them to use compost.

In terms of limitations, the stimuli and deterrents to on-farm composting and compost application would have been relevant to grasp a more complete image on the reasons for the discordance between the recognition of the compost as valuable soil enhancement and its actual use. Farmers' perceptions regarding the availability of information from a reliable source can be included in the analysis. Thus, information from sensors, or basic equipment, to monitor the soil quality and availability of a technological advisor from the local community, government agency or local University should also be added in a future study to observe the importance of such objective information for farmers. Moreover, understanding what supports the current perceptions of soil function importance is relevant in correcting or strengthening these perceptions to obtain a desired behavior. In addition, the selection of a larger sample size in future study will allow achieving higher confidence level and confidence interval.

4. Conclusions

Soil degradation is an escalating global threat and must be, therefore, placed at the top of the new global development agenda. Increasing soil quality and fertility in a sustainable way is a topical issue of modern agriculture. SSM is often advanced as a solution and it is clear that SSM is determined by the interaction between soil resources and human activities. Relying on the premise that interventions for agricultural productivity increase must incorporate farmers' perceptions and knowledge, this paper aimed to reveal Romanian farmers' perceptions of soil functions importance.

Based on the findings, several key proposals can be implemented. Firstly, our research showed the perceived importance of soil functions like "Buffer for pollution control", "Water quality maintenance and enhancement", or "Support of plant, animal and human life and health" was lower than for "Ensure productivity". That is why special attention should be paid to a more participatory approach for integrating environmental issues into farmer's need to generate profit. Secondly, the understanding of how different economic, agri-environmental policies may affect farmers' behavior towards the adoption of different measures for soil conservation is key to creating a policy environment that supports farmers in their efforts to adapt to the new technical, economic, and environmental challenges related to soil protection. If policies and actions in support of soil health are to be effective, they must be connected to the on-the-ground farmers' realities. Thus, decision-making processes for sustainable soil management are most effective if they are responsive to the affected farmers, and provide support for effective participation in soil/land governance. Consequently, it is a challenge to ensure that farmers are involved as key partners in soil research and development of soil management strategies. For this, investigation of how farmers think and act in relation to the soil is of utmost importance. This paper took this challenge of focusing on farmers as active participants in the quantitative assessment of the importance of soil functions and, therefore, it made a step forward towards a bottom-up approach. Lastly, local soil knowledge systems are an important component of the agroecosystem, and, therefore, authors support the principle that the knowledge of soil quality should be valued as an entry point for scientists to understand and build on local soil–crop management practices (Mairura et al., 2007).

There is a need to raise the awareness of farmers through information and education campaigns, on the production, application, benefits of the use of compost, and, of course, the existing regulations. Moreover, financial incentives to stimulate on-farm composting to compensate for the high production costs will be helpful.

To grasp a complex image on farmers' soil knowledge system, the soil quality indicators for each soil function must be approached in future studies. Because of the need to integrate the social perspective in soil science literature, a better understanding of how farmers perceive soil quality is required. Thus, a deeper investigation of farmers' understandings of soil functions will help to better respond to their interests and needs by providing information and products in accordance with them. For instance, for the "Climate regulative" function, it would be useful to know which components farmers associate with it – precipitation level, temperature level, intensity of storms, or others. Also, more measures possible to be used for improving soil quality can be studied, such as crop rotation, use of bio-pesticides, or use of manure as fertilizer. Finally, because soil quality should not be viewed in isolation, but also as part of adaptation to the new economic, social, and environmental challenges, other research can investigate agricultural management indicators that reflect soil management decisions. This is all more important as for Romania information is poorly documented and reported.

Summing up, a national perspective on how local farmers assess soil functions is always advisable as long as policies and regulations on how soil is utilized is decided primarily by national and local authorities. In line with Herrick's view (2000), we also consider that soil quality can be used as an indicator of SSM and, consequently, the relevance of such an investigation stands in the fact that farmers' perception of soil functions importance can significantly contribute to the adoption of sustainable agricultural practices. It is clear from this study that Romanian farmers assign high importance to all soil functions, however placing soil productivity in the first place. The use of compost as a means to improve soil quality can be stimulated among younger farmers who perceive "Water quantity regulation" function as important and "Water quality maintenance and enhancement" function less important. From a practical perspective, the insights on farmers' perception of soil functions and determinants of compost use revealed by this study can serve to design and implement sustainable soil management measures.

Declaration of Competing Interest

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

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