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Gender equity in soil science in Brazil: Still at the beginning of a long journey

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ABSTRACT: Current studies have highlighted a significant gender disparity in the field of soil science. However, the scarcity of research and data on this issue can hinder the urgent need to address it and effect meaningful changes. This was the first demographic survey of Brazilian soil science, focusing on gender composition over time at different academic and professional levels, as well as peer recognition. We examined the metrics of students and faculty from all Brazilian soil science graduate programs (2004-2021), as well as members, representatives, and awards of the Brazilian Soil Science Society (SBCS) (1947-2023). There is a concentration of graduate programs with the highest evaluation scores in the South and Southeast regions of the country, reflecting regional disparities in resources and infrastructure. In 2021, gender parity in doctoral enrollments was achieved, and women aged 25 to 29 became the majority of soil science students. However, the presence of women in faculty is still very low (19 % compared to men). Moreover, the proportion of women faculty members decreases as the hierarchical level increases, indicating that attrition occurs along the career ladder. The faculty shows a trend towards aging, especially among men, indicating a potential wave of retirements in the coming years. Women constitute only 30 % of SBCS affiliations, which are predominantly comprised of men professors. There has been a sharp decline in the overall number of affiliates over the past ten years, especially among students. Women are also a minority in the SBCS representative positions and are less recognized through its awards. There is a difference in thematic intersoil within soil science by gender, both at subdisciplines and at SBCS divisions and commissions, with women being more present in soil biology and men in soil physics and management. We emphasize the pressing need to address and correct the disparities and inequities found by our study, offering recommendations aiming at broader systemic and cultural reforms within the soil science community.

Keywords: women studies, graduate degree, SBCS, disparity, soil scientometrics.

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INTRODUCTION

Gender equity focuses on ensuring fair and unbiased treatment for individuals of all genders, considering their respective needs. To provide equivalent rights, benefits, obligations, and opportunities, the approach may include equal treatment or treatment that is different (adapted from International Labour Organization, 2007). The pursuit of gender equity in science has gained increasing prominence, as it not only shapes the composition of the scientific community but also influences the quality and innovation of research outcomes (Campbell et al., 2013). Recognized as the Goal 5 of the United Nations' Sustainable Development Goals, gender equity is essential for sustainable soil management (United Nations, 2019), as it promotes the active involvement of women in education, both as students and educators, in decision-making processes, and in leadership roles (Lal et al., 2021). Nevertheless, when it comes to gender-related studies within soil science, they remain notably scarce and receive limited attention (Barbosa, 2024).

Recent studies have offered valuable data and insights into the challenges surrounding gender in soil science, highlighting the importance of the issue and the broader implications it holds for the discipline. Over the past decade, women have surpassed men in master's and doctoral degrees in soil science at universities in the United States (US), and with the Soil Science Society of America (SSSA) witnessing a ~44 % growth in women's membership and participation in meetings, while men's has shown a decline (Vaughan et al., 2019). In Italy, women constitute the majority of researchers in the Council for Research and Agricultural Economics, comprising 54 % of the workforce (Adamo et al., 2022). The concern for gender equity is also reflected in the International Union of Soil Sciences (IUSS), which, in its bye-laws – secondary rules that support the Statute –, has outlined the Executive Committee should pay special attention to proposing a list of Permanent Committee Members with equal gender representation (IUSS, 2023).

However, despite some progress, gender inequity persists, and soil science remains a predominantly men-dominated field in many countries. On a global scale, women's membership in soil societies and on the editorial boards of soil international soil science journals is approximately one-third of the men's rate. Moreover, women have held only 20 % of presidencies in soil societies; their participation as keynote speakers at the World Congress of Soil Science (WCSS) and SSSA meetings has been as low as 6 and 21 %, respectively (Dawson et al., 2021); and they are significantly underrecognized through soil societies Fellows and awardees (Vaughan et al., 2019). Researches also revealed a concerning trend where the representation of women in soil science diminishes as positions rise up the hierarchy (Vaughan et al., 2019; Adamo et al., 2022). This global overview of gender equity in soil science sets the stage for our specific exploration in soil science in Brazil, as a diverse portrait across different nationalities and regions of the world is essential to understanding the true extent of the issue within the field.

In pursuit of this goal, this paper is the first to provide and discuss historical and current gender distribution data for all Brazilian graduate programs in soil science and for the Brazilian Soil Science Society (SBCS). We aim to gain a deeper understanding of the demographic shift occurring within soil science, the implications for the future, and the changes that lie ahead. We hope the findings of this research can be used as an instrument to foster a more inclusive, equitable, and fairer soil science community.

MATERIALS AND METHODS

Data acquisition

Initially, we conducted a search in 2023 on *Plataforma Sucupira* (https://sucupira.capes.gov.br/) to identify MSc and PhD graduate programs specifically containing the word "soil" in their titles. Subsequently, we collected data from *Dados Abertos CAPES* (https://dadosabertos.capes.gov.br/) for students and faculty from these

programs covering the period from 2004 to 2021. This data encompassed both permanent and collaborator faculty information. We extracted data from the graduate program websites for details on faculty subdisciplines.

To analyze faculty rank, we sourced faculty names from *Plataforma Sucupira* in 2023 and obtained rank levels from each faculty member curriculum on *Plataforma Lattes* (https://lattes.cnpq.br/), via email requests and/or by accessing the university departmental websites. Universities that employed career plans distinct from federal universities were excluded from this analysis when we could not match the faculty rank level.

Data related to scholarships for international mobility programs were gathered from *Dados Abertos CAPES* from 2009 to 2019. We considered only data categorized under both “ciências agrárias” (agrarian sciences) and “agronomia” (agronomy).

Information regarding coordinators and vice-coordinators was compiled through searches in the *Diário Oficial da União* (https://in.gov.br/servicos/diario-oficial-da-uniao/), Rectorate Minutes available on university websites, email correspondence with graduate programs, and/or responses received from Ombudsman’s Offices (for state universities) and *Plataforma Fala.BR* (https://falabr.cgu.gov.br/) (for federal universities).

The Coordination for the Improvement of Higher Education Personnel (CAPES) removed gender disclosure from their data due to the General Data Protection Law (Brasil, 2018). Consequently, gender could only be identified through names, pronouns used in *Plataforma Lattes* curricula, and/or photographic clues. As a result, the research was limited to binary gender categories (woman or man), and we cannot rule out that biases may have occurred.

Data from the SBCS were provided exclusively for this study through a request via the secretary office email (sbcs@sbcs.org.br) (SBCS, 2023). In the SBCS, members select their gender when registering on the website, but the only mandatory options for natural person are "M" (male) and "F" (female). For juridic person, there is no requirement for gender categorization, and the data is collected by the system as "does not apply" (https://associado.sbcs.org.br/). Data on the Board of Directors from 2011 to 2021 were obtained via email from SBCS (SBCS, 2023). Data from previous years were sourced from Oliveira et al. (2015), the SBCS website, and SBCS Informative Bulletins. Regarding the divisions and commissions data, we used the first option chosen by the member at registration. When the first option was left blank by the member, the second option was used. In some cases, both options were left blank, and these data were consequently excluded from the total count of members in the division or commission analysis. Data on awards and honors were compiled from Oliveira et al. (2015) and the SBCS website.

RESULTS AND DISCUSSION

Currently, there are 14 active graduate programs in soil science (or with a concentration on soil), all offering both MSc and PhD degrees (Table 1). All programs receiving the highest evaluations from CAPES, scores 7 and 6, are located in the South and Southeast regions of Brazil, reflecting regional differences in resources and infrastructure. CAPES Quadrennial Assessment is the primary quality indicator for Brazilian graduate programs, influencing public funding transfers, diploma issuance, and deactivation of programs with scores below 3. This may explain the incorporation of UFPI’s “Agronomy (soil and plant nutrition)” and UFPB’s “Soil and ecosystem quality” programs into “Agricultural sciences” programs in 2018 and 2019, respectively (Table 1).

Table 1. Graduate programs in soil science (or with a concentration on soil) in Brazil

Graduate program	University	CAPES score[1]		State	Region	Year of fundation	Data start year		Data end year
		MSc	PhD				MSc	PhD	
Agronomy (soil and plant nutrition)[3]	Fed. Univ. of Piauí (UFPI)	3[2]	-	PI	Northeast	2009	2009	-	2018
Agronomy (soil sciences)	Fed. Rural Univ. of Rio de Janeiro (UFRRJ)	7	7	RJ	Southeast	1972	2004	2004	2021
Agronomy (soil science)	São Paulo State University (UNESP)	5	5	SP	Southeast	1996	2004	2005	2021
Soils and ecosystem quality[3]	Fed. Univ. of Recôncavo da Bahia (UFRB)	3[2]	-	BA	Northeast	2010	2010	-	2019
Soils and plant nutrition	Univ. of São Paulo (USP)	7	7	SP	Southeast	1964	2004	2004	2021
Soils and plant nutrition	Fed. Univ. of Viçosa (UFV)	6	6	MG	Southeast	1977	2004	2004	2021
Soil and water management[4]	Fed. Rural Univ. of the Semi-arid Region (UFERSA)	4	4	RN	Northeast	2008	2008	2012	2021
Soil and water management and conservation	Fed. Univ. of Pelotas (UFPEL)	4	4	RS	South	2011	2011	2011	2021
Soil science	Fed. Univ. of Rio Grande do Sul (UFRGS)	6	6	RS	South	1965	2004	2004	2021
Soil science	Fed. Univ. of Lavras (UFLA)	7	7	MG	Southeast	1976	2004	2004	2021
Soil science	Fed. Univ. of Ceará (UFC)	4	4	CE	Northeast	1976	2004	2011	2021
Soil science	Fed. Rural Univ. of Pernambuco (UFRPE)	5	5	PE	Northeast	1977	2004	2004	2021
Soil science[5]	Fed. Univ. of Paraíba (UFPB)	3	3	PB	Northeast	1977	2004	2011	2021
Soil science	Fed. Univ. of Paraná (UFPR)	5	5	PR	South	1978	2004	2012	2021
Soil science[6]	Santa Catarina State University (UDESC)	5	5	SC	South	1997	2004	2008	2021
Soil science[7]	Fed. Univ. of Santa Maria (UFSM)	7	7	RS	South	1971	2004	2004	2021

[1] CAPES score (scale from 1-7, with 7 being the top rating) according to the Quadrennial Assessment 2021 (2017-2020). [2] CAPES score (scale from 1-7, with 7 being the top rating) according to the Quadrennial Assessment 2017 (2013-2016). [3] Program name changed to "Agricultural sciences" in 2018 and 2019, respectively. Data after those years were not used. [4] Program name was "Agronomy (soil science)" until 2013. [5] Program name was "Soil and water management" until 2013. [6] Program name was "Soil sciences" until 2005, and "Soil management" until 2010. [7] Program name was "Soil biodynamics" until 1988, and "Agronomy" until 2003.

Graduate enrollments

Through the analysis of the historical data series on enrollments in MSc and PhD programs, we identified trends in gender distribution showing women are increasingly pursuing graduate degrees in soil science in Brazil (Figure 1). Although women were a minority in the number of enrollments in all years analyzed for the MSc (n = 3,083 of 7,113) and in almost all years for the PhD (n = 3,519 of 8,031), in general, women showed a trend of growth in enrollments, especially in PhD programs, while men showed volatile growth rates in both graduate degree levels over the years. In 2004, there were notable disparities between the number of enrollments in soil science programs: women represented slightly over one-third of all graduate students, comprising 36 % of MSc degrees and 35 % of PhD degrees. By 2021, the proportion of women increased to 46 % at the MSc level and reached parity with 51 % at the PhD level (Figure 1). Considering the historical trend of higher annual growth in women's enrollments compared to men, it is possible to assume that women may also achieve parity or even a majority in MSc enrollments in the coming years.

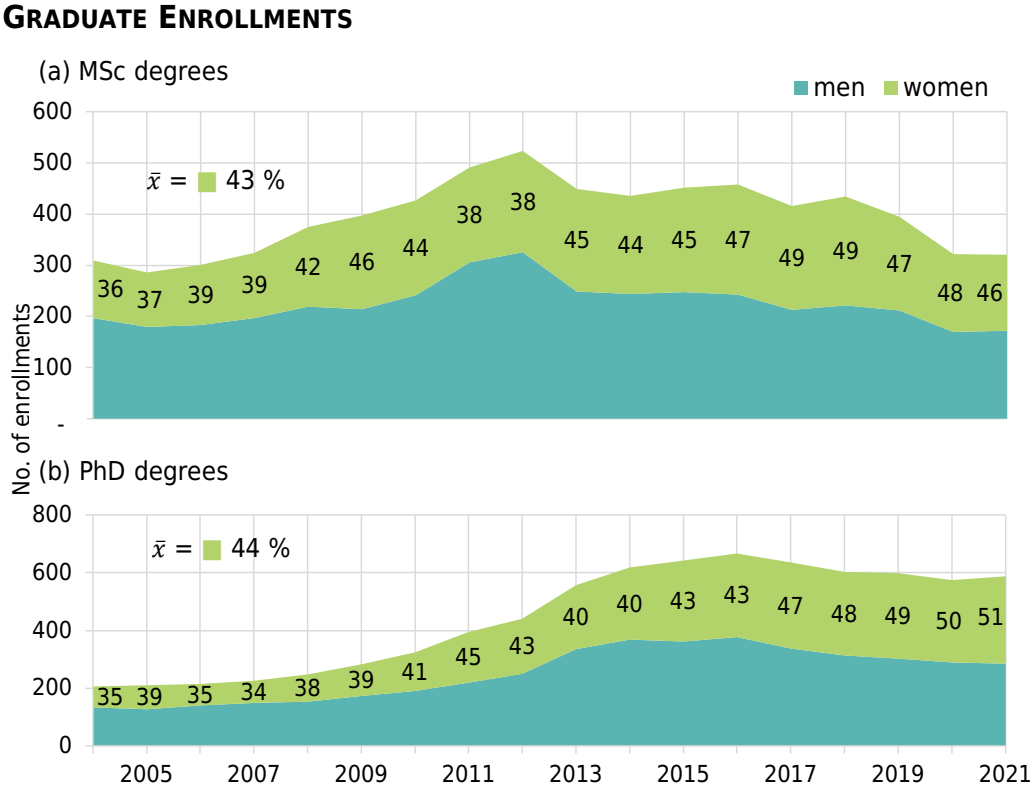

Figure 1. Enrollments in MSc (a) and PhD (b) degrees in soil science in Brazil from 2004 to 2021. Numbers on the graphs correspond to the relative percentage of women each year. Note different scales on graphs (a) and (b).

Although there has been growth, Brazilian figures still lag behind the enrollment rates of women in soil science at North American universities. In 2004, women comprised 46 % of students in master's degrees and 38 % of students in doctoral degrees, increasing to 54 and 53 % by 2017, respectively, indicating a continuous upward trend (Baveye et al., 2006; Vaughan et al., 2019). The proportion of women in soil science in Brazil is also lower when compared to the national average of women in the agrarian sciences and the average across all fields of knowledge (Candido et al., 2023).

Currently, women achieved majority or parity in gender distribution in only two of the 16 soil science graduate programs analyzed, UFPEL's and UDESC's, with women representing 53 % in MSc degrees and 56 and 54 % in PhD degrees, respectively (Figure 2). Notably, UFPR's and USP's programs stand out for having the highest absolute numbers of women in the last 17 years (n = 293 in MSc and 427 in PhD, respectively) (Figure 2). However, when analyzing only the absolute numbers, it should be taken into account that the results are more related to the annual number of available spots and scholarships, which are influenced by factors such as the CAPES score, and the program's length of time, rather than solely issues related to gender.

There has been a noticeable trend towards younger students in soil science, especially among women (Figure 3). Currently, the majority of graduate students in soil science in Brazil are women aged 25 to 29 years, who comprise 32 % of all students at the MSc level (n = 102 of 319) and 23 % at the PhD level (n = 133 of 588). This comprises over half of all women in soil sciences who have graduated with degrees solely in this age group (52 %, n = 235 of 450). This marks a significant shift from 2004, when men dominated all student age groups in both degrees. Additionally, women aged 30 to 34 years, when compared to men, also hold a majority in PhD programs, accounting for 21 % of all students (Figure 3).

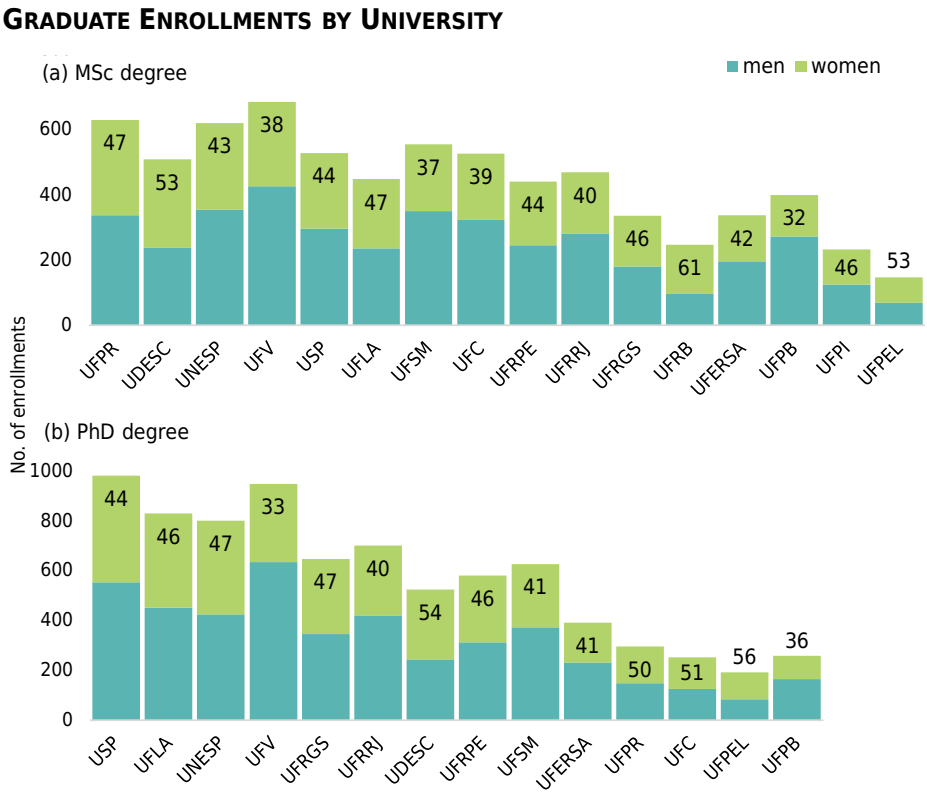

Figure 2. Enrollments in MSc (a) and PhD (b) degrees in soil science in Brazil by university (2004-2021). Universities are categorized in descending order based on the absolute number of women. Numbers on the bars correspond to the relative percentage of women for each university. Note different scales on graphs (a) and (b).

Graduate degrees earned

There is a positive trend in the number of women earning graduate degrees in soil science in Brazil compared to men, considerably narrowing the gender gap in recent years (Figure 4). In 2004, women earned slightly over a third of soil science's degrees (32 % at the MSc level and 38 % at the PhD level). In contrast, in the last five years for MSc degrees and the last three for PhD degrees, the proportions of women have consistently been above 48 %. Although the annual growth rates are highly variable for both genders, the rates of degrees received by women have generally been more positive, and they have shown a quicker recovery after years of decline (Figure 4). If this trend continues, women may close the gap or even surpass men in the number of degrees earned in the near future. For comparison purposes, in the US between 2013 and 2018, an average of 46 % of all advanced soil science degrees were granted to women, with percentages ranging from 38 to 53 % for MSc degrees and 33 to 53 % for PhD degrees (Vaughan et al., 2019).

Graduate degree dropouts/shutdowns

The dropout and shutdown rates reflect students who discontinued or were dismissed from their graduate studies, respectively. Over the past 17 years, women in Brazil's soil sciences programs have demonstrated lower average dropout/shutdown rates than men (Figure 5). At the MSc level, these rates were 4 % for women and 6 % for men, while at the PhD level, they were even lower, with 2 % for women and 3 % for men. Surprisingly, this trend contradicts the general pattern observed in the field of science, technology, engineering, and mathematics (STEM) (Unesco, 2017). These figures might be influenced by the nearly equal gender distribution among Brazilian soil science graduate students (Figure 1). A study by Bostwick and Weinberg (2018) suggested women in STEM are more

prone to dropping out in the first year of doctoral studies in programs with less than 38.5 % of women representation. Additionally, although the overall proportions have fluctuated over the years, and the average rate remains low, there is a general upward trend in dropouts/shutdowns for both genders and graduate levels (Figure 5), possibly linked to increasing enrollment numbers (Figure 1).

Migratory graduate students

From 2010 to 2019, across all destination countries, women students received a higher average number of CAPES' exchange scholarships than men in graduate programs within the field of agricultural sciences/agronomy in Brazil (55 %, n = 640 of 1,174; Table 2). Among these scholarships, 1,165 were designated for the sandwich doctorate, four for the full doctorate, and five for sandwich master's programs (of which 54, 25 and 100 % were granted to women, respectively). Notably, women held ~60 % of the scholarships in European countries (n = 321 of 545), and ~70 % in Latin America countries (n = 34 of 49). Surprisingly, these findings diverge from the national trend, wherein women researchers exhibit lower migration rates than men (Allagnat et al., 2017). In Asian countries, despite the low number of scholarships granted, women were the minority (20 %, n = 2 of 10), as well as in Oceania (41 %, n = 20 of 49) (Table 2).

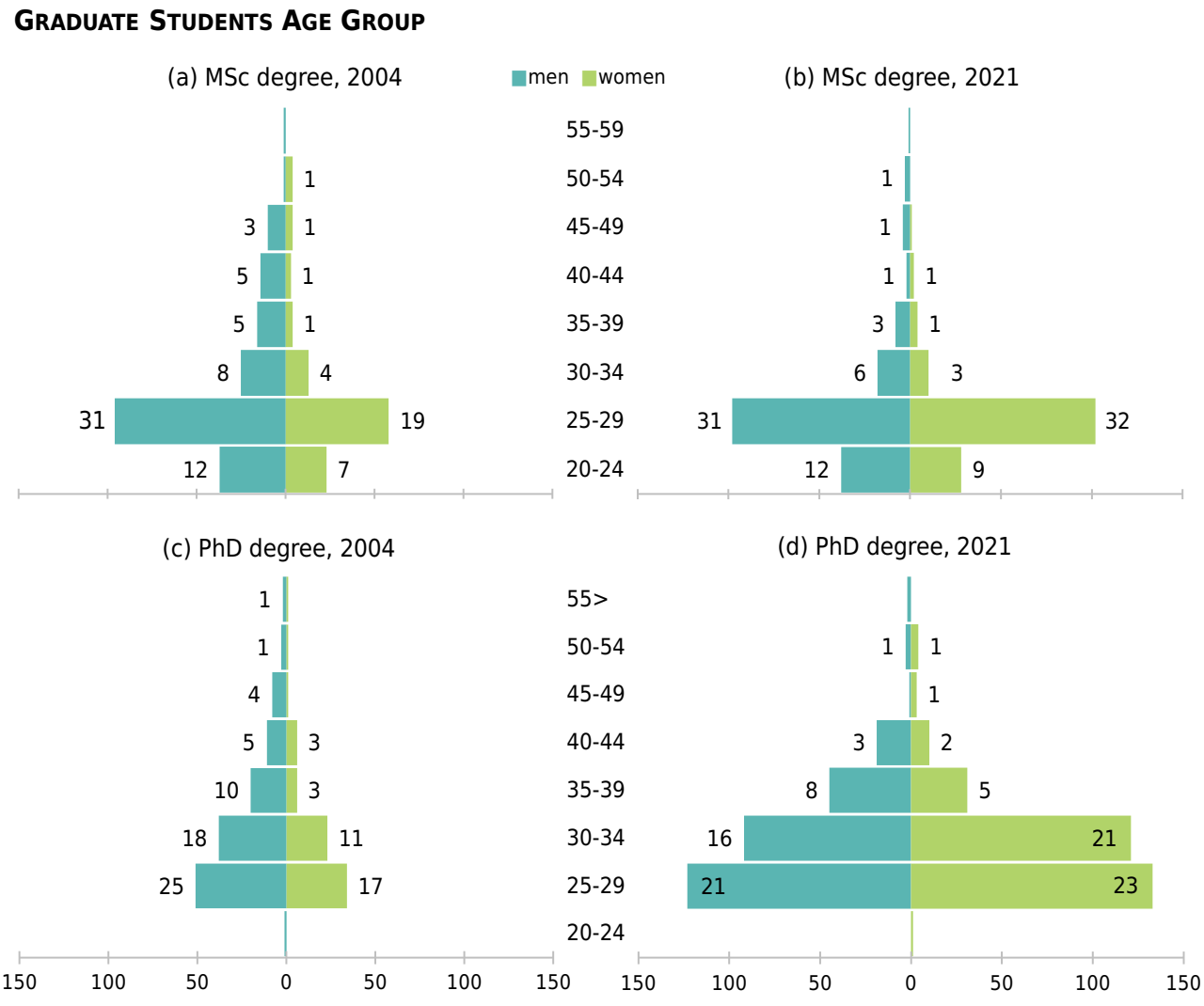

Figure 3. Age distribution of students persuing MSc (a, b) and PhD (c, d) degrees in soil science in Brazil in 2004 and 2021. Numbers on the bars correspond to the percentage of women and men students relative to the total number of students for each graduate degree and year.

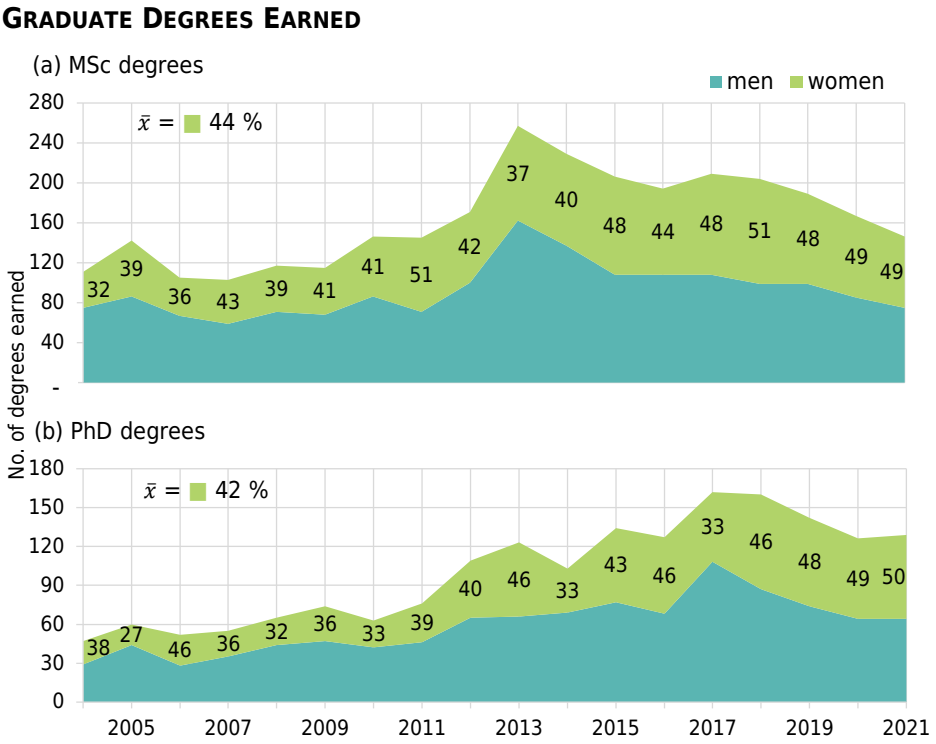

Figure 4. Degrees earned in MSc (a) and PhD (b) degrees in soil science in Brazil from 2004 to 2021. Numbers on the graphs correspond to the annual relative percentage of degrees earned by women. Note different scales on graphs (a) and (b).

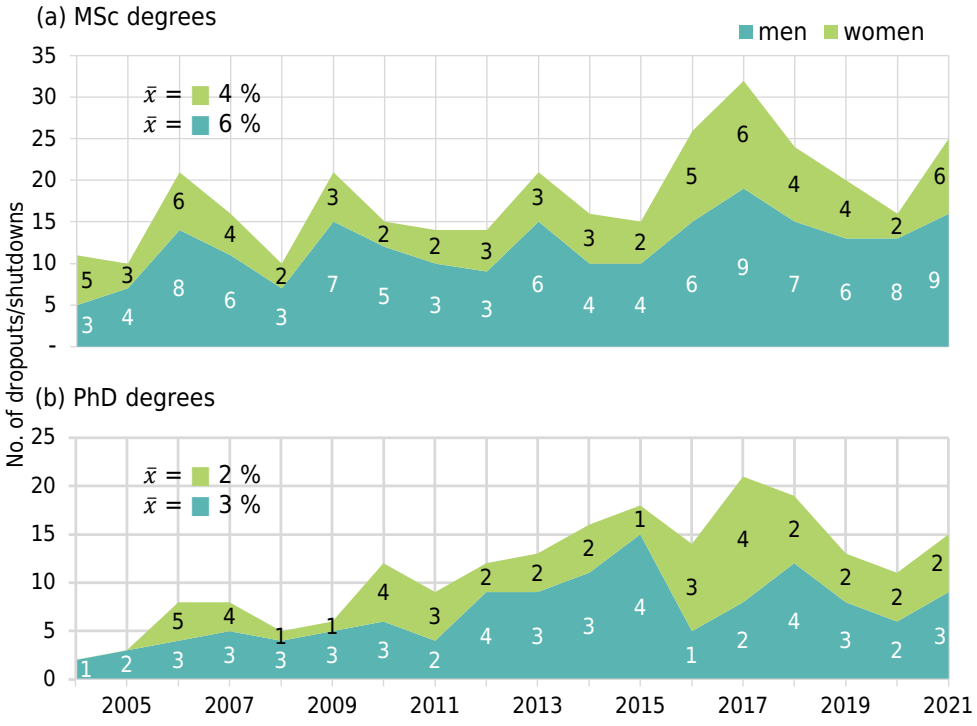

Figure 5. Dropouts/shutdowns from MSc (a) and PhD (b) degrees in soil science in Brazil from 2004 to 2021. Numbers on the graphs represent the annual percentage of women and men dropouts/shutdowns relative to their respective total enrollments for that year. Note different scales on graphs (a) and (b).

Table 2. Recipients of CAPES exchange scholarships in graduate degrees in agricultural sciences/agronomy in Brazil by destination country (2010-2019)

Country	Women	%	Men	%	Total
United States	239	50	239	50	478
Spain	78	63	45	37	123
Portugal	47	61	30	39	77
The Netherlands	38	60	25	40	63
France	30	49	31	51	61
Italy	35	63	21	38	56
Germany	26	50	26	50	52
United Kingdom	28	56	22	44	50
Canada	23	56	18	44	41
Australia	17	44	22	56	39
Belgium	14	52	13	48	27
Argentina	10	67	5	33	15
Cuba	8	62	5	38	13
Mexico	8	80	2	20	10
New Zealand	3	30	7	70	10
Denmark	6	75	2	25	8
Ireland	4	57	3	43	7
Sweden	4	67	2	33	6
Uruguay	5	71	2	29	7
Japan	2	50	2	50	4
Czech Republic	2	50	2	50	4
Norway	2	67	1	33	3
Switzerland	2	67	1	33	3
Austria	2	100	0	0	2
Philippines	0	0	2	100	2
Israel	0	0	2	100	2
Paraguay	1	50	1	50	2
Chile	2	100	0	0	2
Cape Verde	0	0	1	100	1
Russia	0	0	1	100	1
Thailand	0	0	1	100	1
South Africa	1	100	0	0	1
Slovenia	1	100	0	0	1
Finland	1	100	0	0	1
Poland	1	100	0	0	1
	640	55 %	534	45 %	1,174

The top ten countries that received the highest number of exchange students collectively accounted for 90 % of all scholarships offered, and they exclusively represented nations from the global North. Among these countries, the US attracted nearly the same number of students as the European countries (41 vs. 46 %) (Table 2). Equal proportions of women and men exchange students in the US and Germany possibly indicate the existence of rules promoting gender equity in scholarship allocation. Japan, the Czech Republic, and Paraguay also had an equal distribution in the number of scholarships between genders.

However, since the number of scholarships was low, the equitable distribution might have been by chance and not due to gender equity policies.

From 2004 to 2021, soil science programs in Brazil welcomed 309 foreign students (Figure 6). Foreign women constituted the minority in both MSc (29 %) and PhD degrees (46 %). Overall, foreign students were predominantly from Latin American countries (43 % men and 22 % women at the MSc level, and 41 % men and 39 % women at the PhD level), mainly from Colombia (n = 61) and Peru (n = 34) (Figure 6). This trend can be attributed to factors such as geographic proximity, linguistic similarities between the Portuguese and Spanish, and cultural connections among Latin American countries, all of which facilitate and even incentivize the arrival of students in Brazil. Additionally, governmental economic incentives, such as the exemption of visas within the Mercosur countries, contribute to this trend. Beyond the Latin American context, the second-largest proportion of foreign students in master and doctoral programs comes from the African continent (18 and 6 %, respectively), mainly from Mozambique (n = 22) (Figure 6), a nation where Portuguese is also the official language.

To attract more foreign students, especially from countries beyond Latin America, Brazilian soil science programs should offer more subdisciplines in English, either on a regular basis or as a permanent part of their curriculum. This approach could also help improve English language proficiency, addressing the primary challenge faced by Brazilian students applying for international mobility scholarships (Moraes and Costanti, 2022).

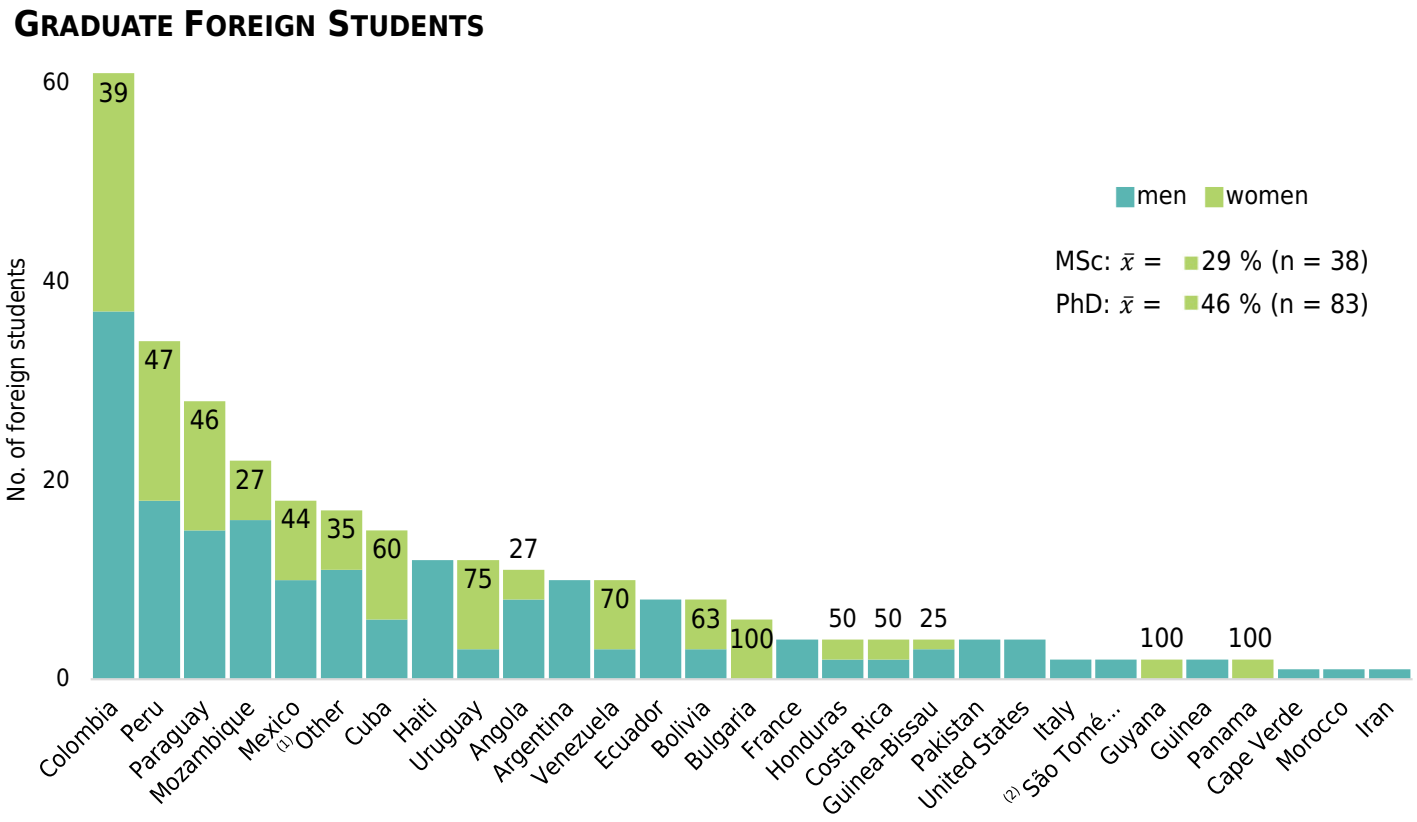

Figure 6. Foreign student enrollment in soil science graduate degrees in Brazil by country of origin (2004-2021). Numbers on the bars correspond to the relative percentage of women international students. (1) Countries of origin were not reported. (2) São Tomé and Príncipe.

Faculty members

Representation of women faculty in soil science graduate programs in Brazil has seen very little progress from 2004 to 2021, with the proportion increasing from 15 to only 19 % (Figure 7). Unfortunately, this modest increase has proportionally mirrored the slow growth also observed in Brazilian agricultural sciences faculty, which went from 22 % in 2004 to 26 % in 2020 (Candido et al., 2023). In contrast, Italy had an increase in the proportion of women faculty in soil science from 25 in 2001 to 40 % in 2021 (Adamo et al., 2022). In the US, the proportion of women faculty is closer to Brazil's, but remains higher, at 24 % (Vaughan et al, 2019).

The total number of faculty also increased from 220 members in 2004 to 266 in 2021, a growth of approximately 21 %. It is worth noting the decline in the number of men professors around 2018 (Figure 7) is due to the deactivation of the UFPI and UFRB's programs (2018 and 2019, respectively), as 25 of the 30 faculty members in these programs were men. Although the growth rate for women faculty in soil science is notably higher – around 60 % compared to 14 % for men –, the absolute difference in the number of faculty of each gender has increased. Specifically, the difference went from 156 men in 2004 to 164 men in 2021. This means that, in absolute terms, the gender gap in soil science faculty in Brazil is actually widening, and the growth in the number of women faculty, although encouraging, is still not sufficient to close this gap. In other words, while relative metrics may indicate some positive advancements, albeit modest, in the representation of women, absolute metrics reveal that there is still a long way to go to achieve gender parity. Both perspectives are important for a comprehensive understanding of the issue and to inform effective strategies for inclusion and gender equity.

Currently, 13 out of the 14 active graduate programs in soil science in Brazil have less than one-third women faculty, with averages ranging from 6 to 28 % (Figure 8). The programs at UFSM and UFPB have the lowest numbers of women faculty, with only one each, compared to 17 and 14 men, respectively. The only exception is UFPEL's program, where the number of men and women is equal (7 each, Figure 8). However, this gender parity in UFPEL's faculty is a recent development, achieved only in 2021, and is more attributable to a decrease in the number of men faculty than to an increase in women faculty. Nevertheless, in the historical average (2004-2021), UFPEL's program has maintained the highest proportion of women faculty (35 %), although this still represents a relatively low average. The programs with the lowest historical averages are UFSM (6 %), UFRGS, UDESC, and USP (9 % each) (Figure 8). According to the CAPES score (Table 1), UFSM, USP, and UFRGS have excellence programs in soil science, but they lag significantly in achieving gender parity among their faculty.

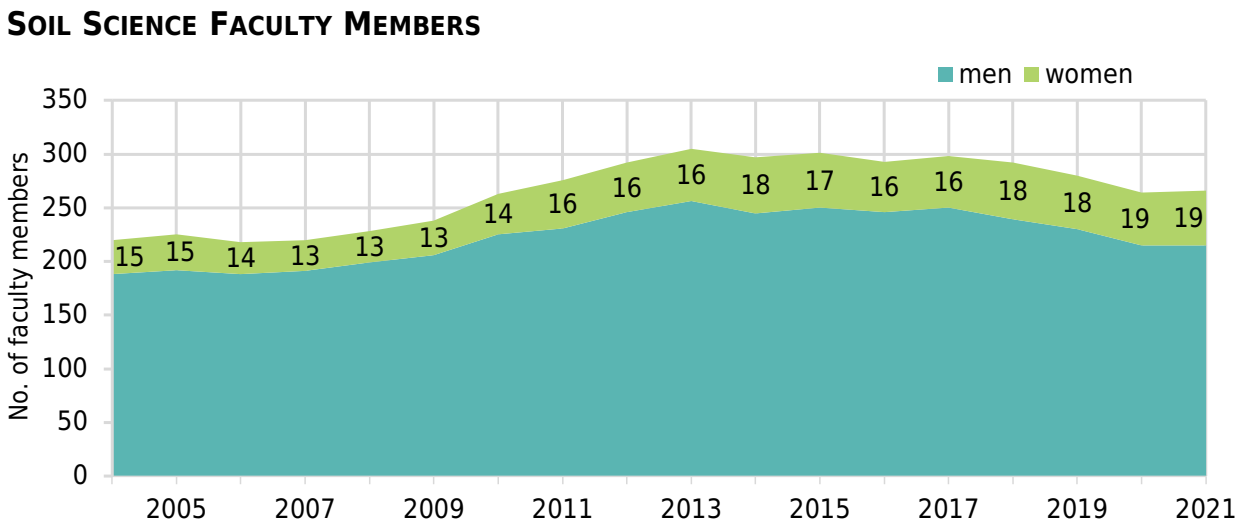

Figure 7. Faculty members in soil science graduate programs in Brazil from 2004 to 2021. Numbers on the graph correspond to the annual relative percentage of women faculty.

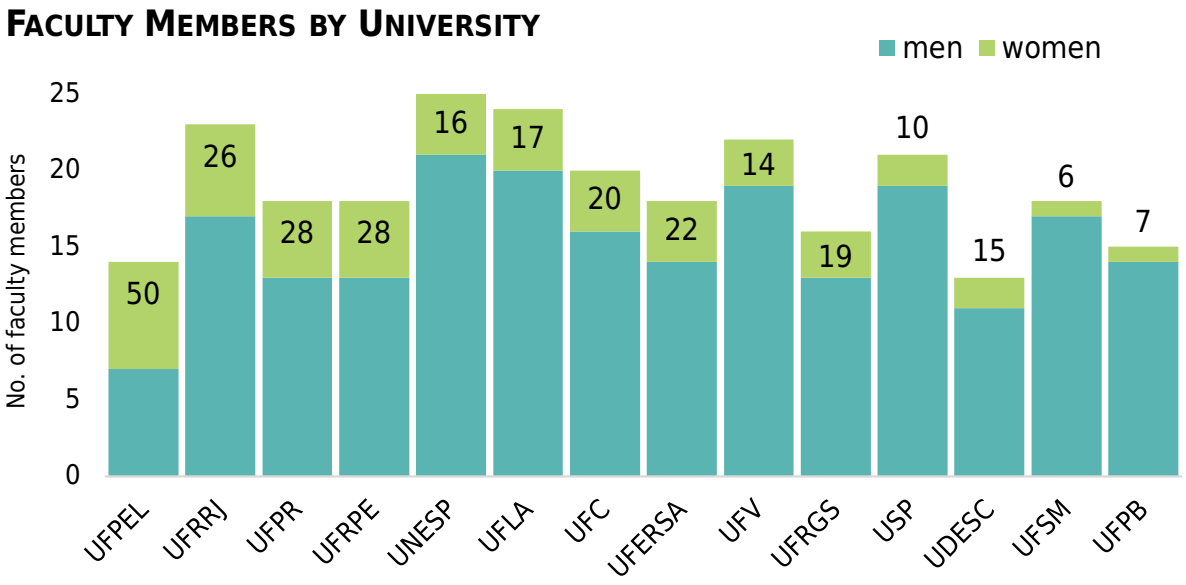

Figure 8. Faculty members in soil science graduate programs in Brazil by university (2021). Universities are categorized in descending order based on the absolute number of women. Numbers on the bars correspond to the relative percentage of women faculty for each university.

The age group analysis across two distinct time points, 2004 and 2021, revealed gender disparity among soil science faculty members in Brazil is evident and persistent in favor of men in all age groups (Figure 9). Overall, soil science women professors are younger than men professors, indicating the recent entry of women into the faculty. In 2021, around a quarter of all women faculty were aged 40-44 years (5 % in relation to total), while the largest proportion of men was found in the age group of 55-59 years (14 % in relation to total). Another noteworthy trend is the increase in faculty members aged 60 years and above, a phenomenon particularly pronounced among men (total proportion of faculty in this age group increased from approximately 11 % in 2004 to 24 % in 2021) (Figure 9).

The aging trend among men faculty members suggests an imminent wave of retirements, which could create opportunities for increasing women faculty representation if these vacancies are intentionally filled with a focus on gender equity. However, it's important to understand that the mere departure of older professors, just as the increased entry of women into soil science, is not sufficient and will not automatically ensure greater equity. Proactive measures are necessary to ensure that women fill these positions and receive the support needed to advance in their academic careers. This requires recognizing and addressing systemic barriers that have historically impeded women progression in academia, and an active commitment to affirmative actions and institutional policies that promote gender equity.

Academic stage and leadership positions

A clear trend emerges concerning the decline in the proportion of women as the academic hierarchy in soil science increases (Figure 10). While women constitute 51 % of PhD students (Figure 1), only 19 % hold professorial roles, with 30 % serving as Assistant Professors, 27 % as Associate Professors, and a mere 9 % as Full Professors (Figure 10). The proportions are even smaller in leadership positions, with only four out of the 14 active programs currently being coordinated by women (29 %), and just one program having a woman in the position of Head or Chair of Department (6 %) (Figure 10).

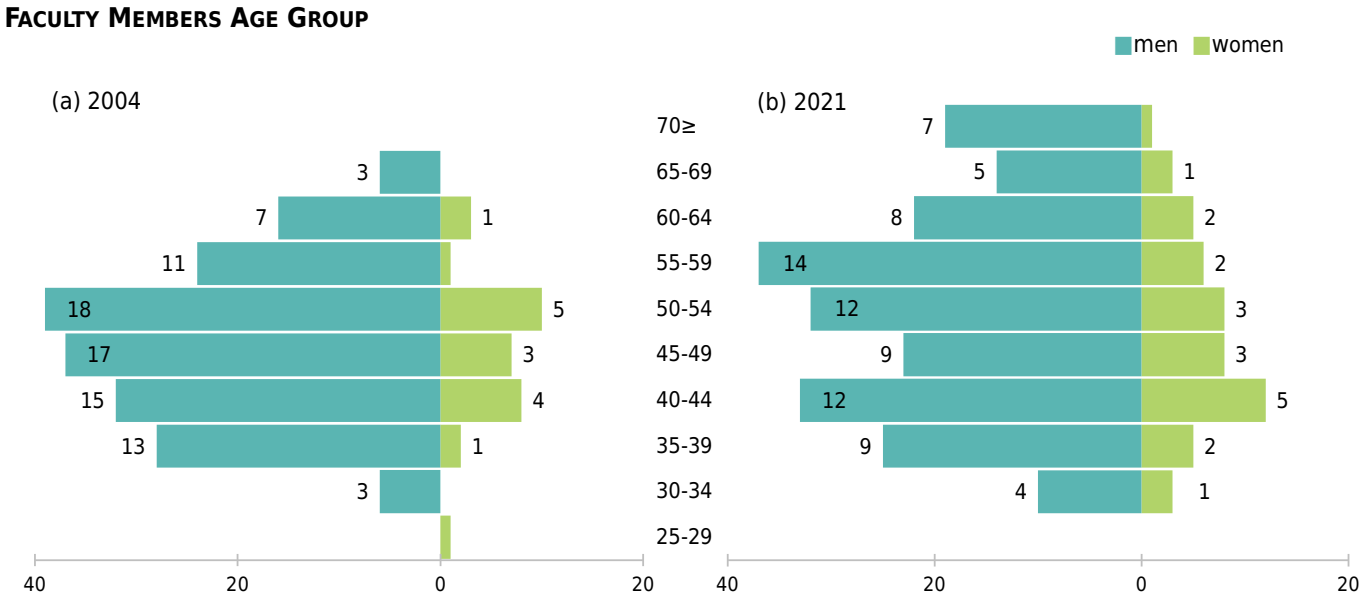

Figure 9. Age distribution of faculty members in soil science programs in Brazil in 2004 (a) and 2021 (b). Numbers on the bars correspond to the percentage of women and men faculty relative to the total number of faculty members for each year.

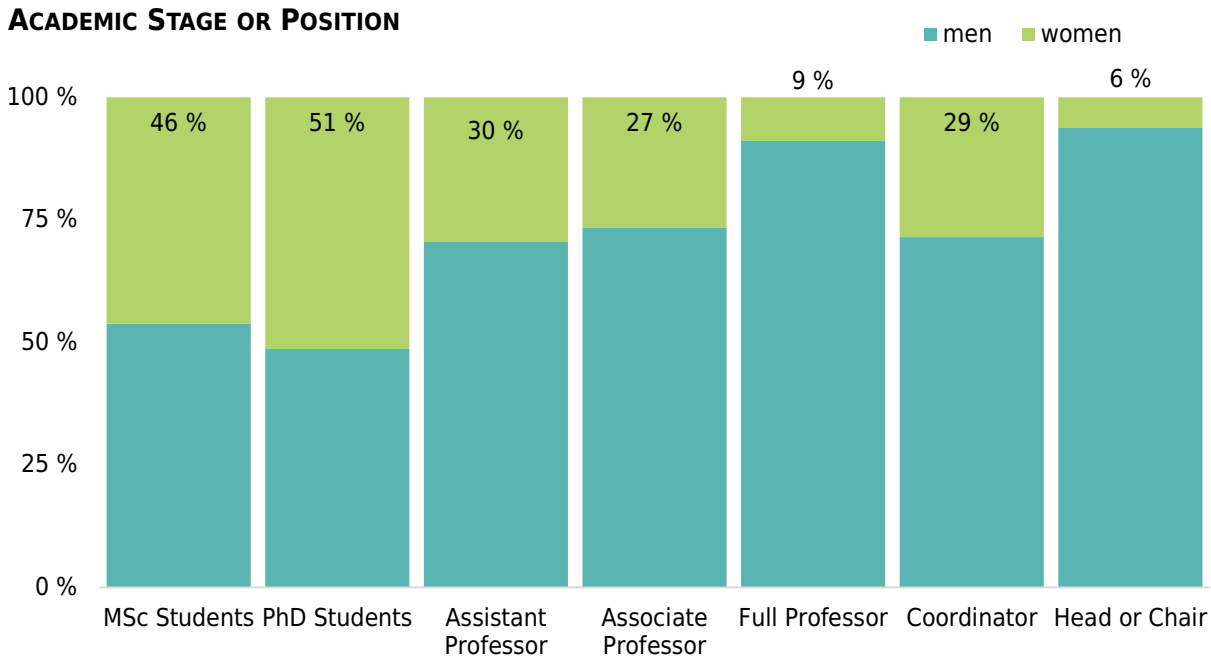

Figure 10. Gender distribution of graduate students (2021), faculty members, Coordinators, and Heads or Chairs of Departments (2023) housing soil science programs. Percentages on the graph are the relative porcentage of women for each category.

In addition to the data for the most recent year (2021), we analyzed 129 past tenures in coordination and 81 in vice-coordination roles within soil science programs in Brazil. Our findings reveal that only 16 and 15 of these tenures (12 and 19 %, respectively) were held by women. The historical distribution of the graduate student population does not explain these low percentages. The current relative proportion of women faculty across all academic ranks remains lower than that of women graduate students in soil science 17 years ago (~35 % women) (Figure 1). This suggests that a considerably smaller number of women have transitioned from PhD degrees into faculty positions and/or sustained their careers in academia than men, painting a rather pessimistic picture for Brazilian soil science in the short and medium term.

Furthermore, it is deeply concerning that this is not a problem limited solely to Brazil. Examples from other countries also demonstrate a similar descending trend in the proportion of women as hierarchical levels increase. In the US, despite women constituting more than half of the graduate students, 36 % are Assistant Professors, 24 % are Associate Professors, 18 % are Full Professors, and only 13 % hold the position of Head or Chair of Department (Vaughan et al., 2019). Italian universities, within the pedology sector, also follow a similar pattern, with women as Assistant and Associate Professors corresponding to 38 % each of the total faculty and only 14 % (n = 1) as Full Professors (Adamo et al., 2022).

Faculty members by subdiscipline and field of knowledge

The faculty distribution across subdisciplines in soil science programs in Brazil is relatively balanced (Figure 11). With an 11-17 % average range (n = 179), faculty are allocated between pedology, soil biology (also encompassing microbiology, biogeochemistry, and ecology), soil chemistry, soil fertility, soil management, soil conservation, and soil physics. However, there are evident differences in gender representation within these subdisciplines (Figure 11). The lowest composition of women faculty is in soil physics (9 %) and soil management (10 %), followed by soil fertility (13 %), pedology (14 %), soil chemistry (23 %), and soil conservation (25 %). In contrast, soil biology stands out with the highest proportion of women faculty (46 %). These findings are strikingly similar to those reported for soil science in the US (Vaughan et al., 2019), suggesting a potential pattern in soil science's faculty gender distribution based on the thematic focus of the subdiscipline.

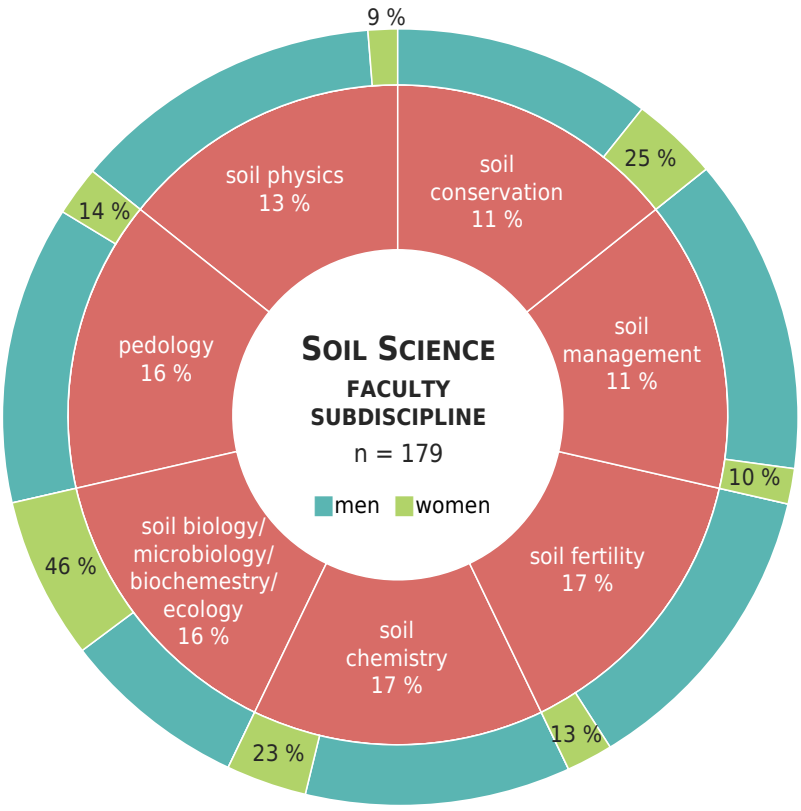

Figure 11. Soil science faculty by subdiscipline from soil science programs in Brazil (2023). Percentages within the chart are the relative percentage of faculty in each subdiscipline. Percentages of women faculty (green) are relative to men faculty for each subdiscipline.

Analysis of the main fields of knowledge of faculty training by gender also reveals the same thematic focus trends (Tables 3 and 4). Almost one-third of both men and women professors had training in agronomy, agricultural engineering, or agrarian sciences, followed by soil science. Considering other areas, women professors come from courses linked to microbiology and biochemistry (9 vs. 3 % of men) and chemistry (6 vs. 3 % of men) (Table 3), as well as other engineering, geosciences, and conservation of nature or soil and water. On the other hand, men have a greater presence in areas such as soil fertility and fertilization (5 vs. 2 % of women), and soil management and conservation (4 vs. 2 % of women), in addition to irrigation and drainage, genesis, morphology and classification of soils, and physics (general and soil) (Table 4).

Table 3. Top ten fields of knowledge for the highest degrees obtained by women faculty members in soil science, compared with those of men faculty members (2004-2021). Percentage of women and men faculty is calculated relative to the total number of faculty members within each gender

Field of knowledge	Women	Men
	%	
Agronomy, agricultural engineering, agrarian sciences	31	31
Soil science	28	30
Microbiology, biochemistry (general/soil/agricultural)	9	3
Chemistry (general/soil)	6	3
Engineering (other)	4	1
Geosciences	3	0.2
Phytotechny	2	3
Conservation (nature/soil and water)	2	0.4
Soil fertility and fertilization	2	5
Soil management and conservation	2	4

Table 4. Top ten fields of knowledge for the highest degrees obtained by men faculty members in soil science, compared with those of women faculty members (2004-2021). Percentage of men and women faculty is calculated relative to the total number of faculty members within each gender

Field of knowledge	Men	Women
	%	
Agronomy, agricultural engineering, agrarian sciences	31	31
Soil science	30	28
Soil fertility and fertilization	5	2
Soil management and conservation	4	2
Irrigation and drainage	3	0
Phytotechny	3	2
Genesis, morphology and classification of soils	3	0.5
Chemistry (general/soil)	3	6
Physics (general/soil)	3	0.8
Microbiology, biochemistry (general/soil/agricultural)	3	9

Brazilian Soil Science Society (SBCS)

The SBCS is the only soil scientist professional organization in Brazil. Established in 1947, the SBCS is a non-profit civil entity that is currently headquartered at the Federal University of Viçosa, in Minas Gerais. Since 2012, the SBCS has transitioned to a digital system for information management and member data collection. The society follows the same organizational structure of the IUSS, consisting of Regional (RN) or State Nuclei (SN) and four divisions that are subdivided into commissions (Oliveira et al., 2015).

SBCS membership

Women have consistently comprised a minority in SBCS membership, with an average of 30 % over the past decade (Figure 12). In 2022, this percentage decreased to 26 % (n = 431), reaching the lowest proportion of women members in our analysis. Both figures fall below the global average of 32 % for soil science societies (Dawson et al., 2021). Overall, SBCS membership peaked in 2015 (n = 1,189), possibly influenced by the International Year of Soils (FAO, 2015). Since then, there has been a general trend of decline. Both genders have followed a similar trend, indicating external factors likely impacted membership rates for both genders (Figure 12). The recession of the Brazilian economy in the last decade and the COVID-19 pandemic in recent years (The World Bank, 2022) may have impacted the decline of overall members, discouraging active participation in the society.

In a global study conducted in 2020 (Dawson et al., 2021), the Venezuelan (54 %), Argentine (50 %), and Colombian (46 %) Soil Science Societies had the highest percentages of women members in Latin America, with SBCS ranking behind nine countries out of 16. However, the data cannot indicate trends in gender equity within these societies. At the SSSA, the average women's membership in the last 20 years also mirrors that of the SBCS, but with the difference of a substantial 43 % increase in the past decade, in contrast to an 8 % decrease in men's membership (Vaughan et al., 2019).

The student category had the sharpest decline in SBCS membership, with an average loss of 88 % of both women and men members over the past ten years (Table 5). In 2013, the category of graduate and undergraduate students constituted, respectively, 19 (n = 223) and 10 % (n = 119) of the total membership (n = 1,198). However, by 2022, these figures had plummeted to 8 (n = 36) and 2 % (n = 9) of the total membership (n = 431). By comparison, in the SSSA the proportion of women students nearly doubled

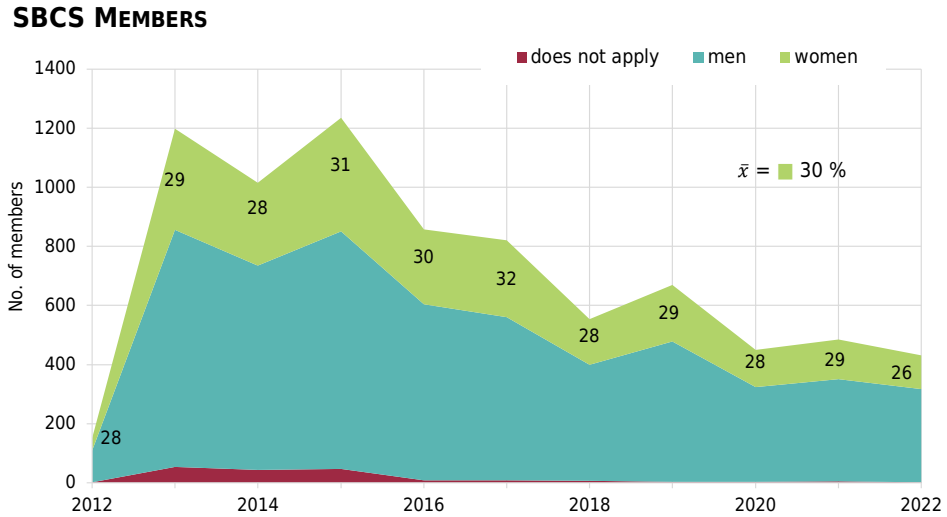

Figure 12. Members in the Brazilian Soil Science Society (SBCS) from 2012 to 2022. Numbers on the graph correspond to the women membership percentage relative to the total membership for each year.

from 2009 to 2018 (Vaughan et al., 2019). An important factor that may have contributed to the decline of student members is the devaluation of graduate scholarships in Brazil. By the end of 2022, graduate scholarships had completed a decade without adjustment, resulting in a 78.6 % lag in relation to inflation, making the financial viability of paying the fees of scientific societies increasingly challenging (Maia, 2022).

Regarding all membership categories, women had the highest proportional loss, with a 67 % decline over the past 10 years, but men also witnessed a comparable 61 % decrease (Table 5). The academic background of SBCS members, averaged over the period from 2012 to 2022, showed that 74 % had PhD degree (28 % women), 14 % had MSc degree (34 % women), and 12 % had undergraduate degree (37 % women). Notably, when we compared the gender composition of members with PhD degrees to the corresponding trends among PhD degree recipients in soil science over the past 17 years (Figure 3), a clear gender gap in SBCS membership became apparent.

Although women students are on parity with men students in graduate programs (Figure 1), their overall representation in the SBCS is relatively low compared to other categories. Thus, the general average of women participation in the SBCS (Figure 12) seems to reflect more the proportion of women with graduate titles and working with research or as professors rather than the parity specifically observed among students in graduate programs.

Additionally, despite the total number of members in the university professor category decreasing from 457 to 250 members, the proportion of representation for this category compared to other types of membership notably increased from 38 to 58 %. These trends altogether highlight the challenges SBCS currently faces in sustaining the active engagement of its members, particularly among women students, and also highlight the dominance of men faculty members in the society.

Analyzing SBCS membership data across Brazilian regions and their affiliated nuclei, it becomes evident that membership dynamics are influenced by regions housing universities offering prestigious soil science programs (Figure 13, Table 1). Southeast region stands out with the highest total membership in the last decade (n = 2,575), as well as the largest number of women members (n = 816) (Figure 13a). This prominence can be attributed to institutions such as USP, UFLA, and UNESP (Figure 2). It is also noteworthy that the Northeast region has the highest proportional representation of women (36 %) (Figure 13a). Although members at registration may not always choose the same state of affiliation as their chosen RN or SN, the RN East records the highest membership count (n = 1,718) (Figure 13b). Conversely, lower membership figures in the RN Northwest, RN Western Amazon, and RN Eastern Amazon (Figure 13b) can be attributed to low population density and the absence of soil science graduate programs in the Northern region. Among the states, Minas Gerais leads in total membership and women members (n = 272 of 977), followed by São Paulo (n = 254 of 908), and Rio Grande do Sul (n = 225 of 891).

Table 5. Women membership in the Brazilian Soil Science Society (SBCS) in 2013 and 2022. The 10-yr difference in affiliation rates between women and men is quantified as a percentage over the 2013 baseline value

Membership category	Women Membership				10-yr change	
	2013		2022		Women	Men
	No.	% of total	No.	% of total	%	
All categories of membership	343	29	114	26	–67	–61
University professor	112	25	67	27	–40	–46
Research	63	25	19	21	–70	–61
Graduate student	89	40	20	56	–78	–88
Undergraduate student	51	44	1	11	–98	–88
Other	28	19	7	15	–75	–53

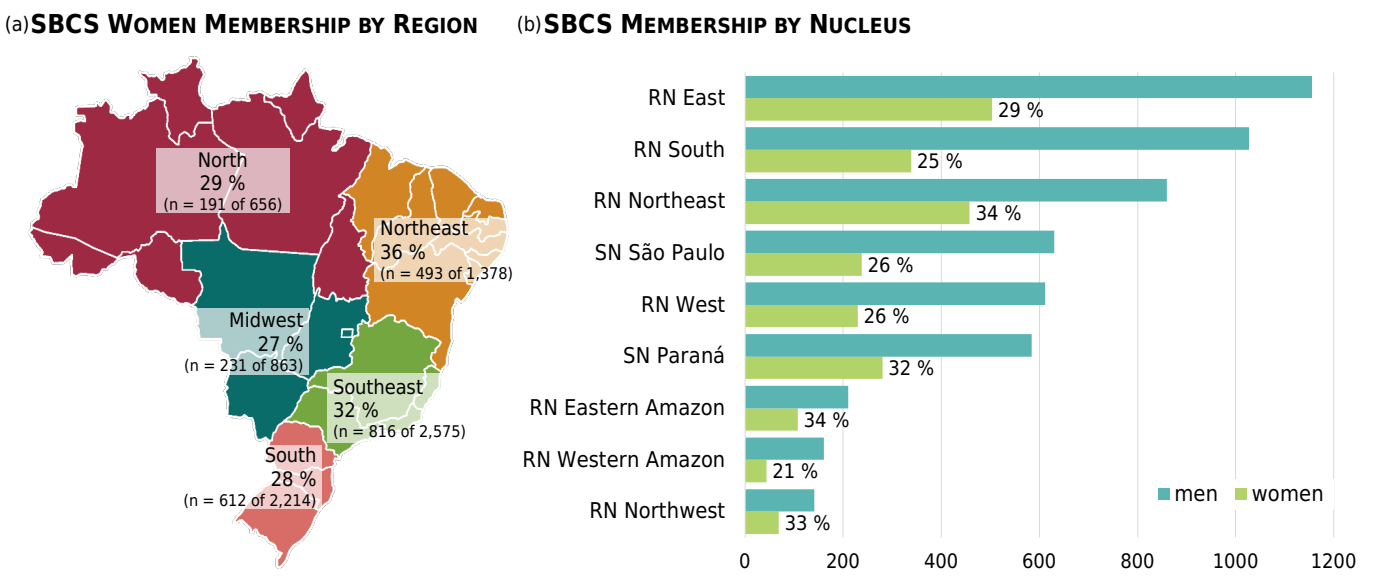

Figure 13. Membership in the Brazilian Soil Science Society (SBCS) by Brazilian region (a) and Regional or State Nucleus (b) (2012-2022). Percentage of women is relative to the total membership for each region (a) and Nucleus (b). RN: Regional Nucleus; SN: State Nucleus.

SBCS members and representatives by divisions and commissions

At registration in the SBCS, members choose their preferred subdiscipline from four main divisions. Each division (D) allows members to further narrow their focus by selecting specific topics from various commissions (C). The gender distribution across these thematic areas generally mirrors that observed within faculty subdisciplines. Women have established a notable representation of 59 % in D4 “Soils, environment, and society” (Figure 14a). The proportions are even more pronounced in the commissions related to this division, notably C4.1 “Soil Education and public perception of soil” and C4.3 “History, epistemology, and sociology of soil science”, where women constitute 72 and 68 % of the membership, respectively (Figure 14a). These figures highlight women’s interest in these areas and underscore their decisive role in shaping the discourse around soil science and its societal implications. Another commission where women are a majority is C2.1 “Soil biology”, accounting for 51 % of its members (Figure 14a), also reflecting the higher proportion of women found in the faculty subdisciplines (Figure 11). However, this representation pattern is not uniform across all SBCS subdisciplines. Lower rates of women representation are observed in D1 “Soil in space and time”, and D3 “Soil use and management”, in which women constitute 26 and 29 % of the members, respectively. The gender disparity is particularly glaring in C3.2 “Correctives and fertilizers” (18 %), C1.2 “Soil survey and classification”, and C2.2 “Soil physics” (20 % each) (Figure 14a).

Regarding the divisions representatives, D4 “Soils, environment, and society” has the highest average percentage of women at 34 %, while D3 “Soil use and management” has the lowest at 11 % (Figure 14b). Among the representatives of the commissions established in 2011, C2.1 “Soil biology” stands out, with 61 % of its representatives being women, along with C4.1 “Soil education and public soil perception”, with 47 %. However, two commissions stand out for not having any women representatives: C3.1 “Soil fertility and plant nutrition”, which boasts the highest total membership, and C3.2 “Correctives and fertilizers” (Figure 14b). Unfortunately, the gender disparity within the SBCS becomes even more apparent when we notice that D4 has the smallest overall membership (4 %, n = 274), in contrast to D3, which has the strikingly largest membership (52 %, n = 3,989).

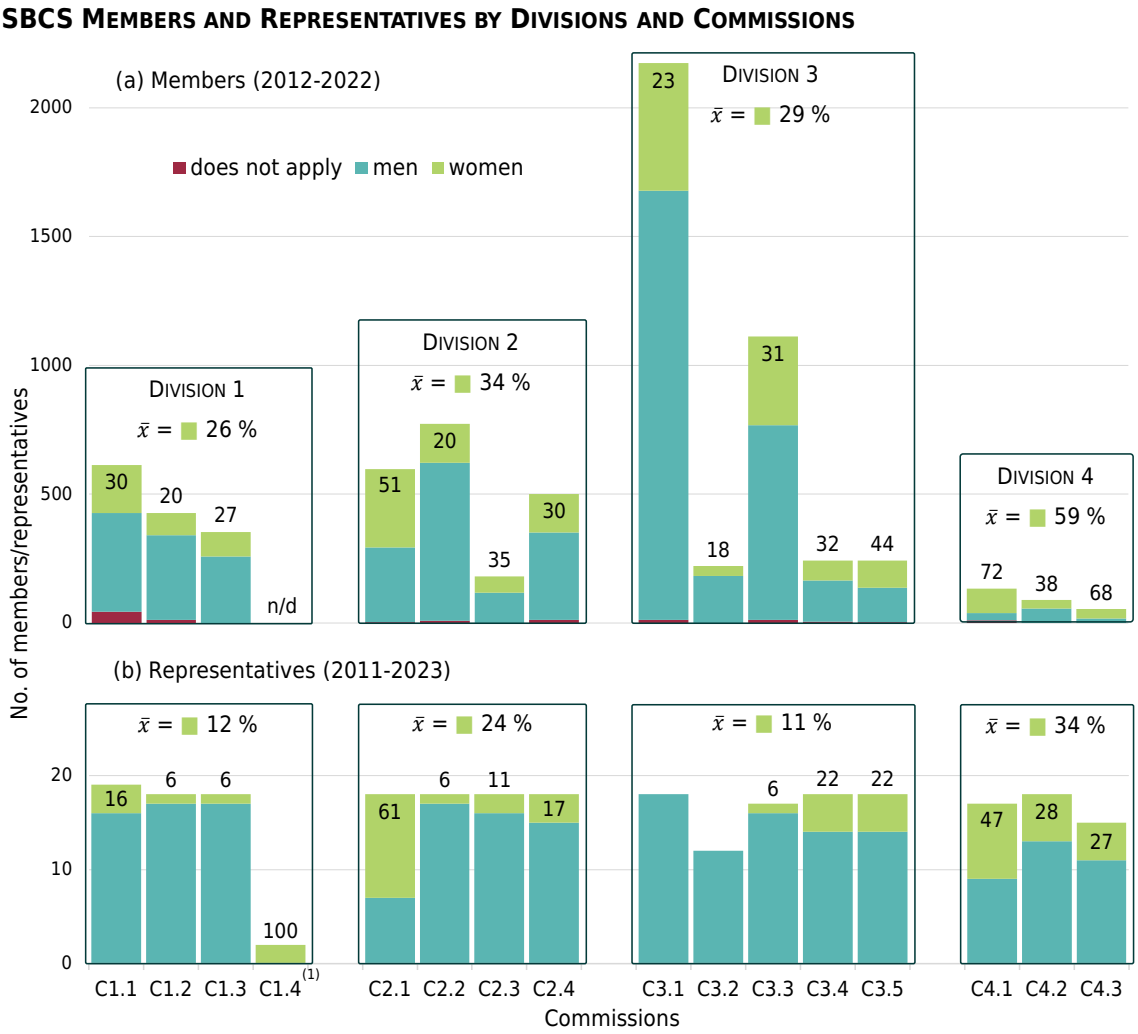

Figure 14. Members (a) and representatives (b) in the Brazilian Soil Science Society (SBCS) by division and commission. Percentage of women is relative to the total membership for each division. Numbers on the bars correspond to the percentage of women relative to the total membership for each commission. Note different scales on graphs (a) and (b). n/d = no data. Division 1 – Soil in space and time: C1.1 Soil genesis and morphology; C1.2 Soil survey and classification; C1.3 Pedometrics; (1) C1.4 Paleopedology (established in 2019); Division 2 – Soil processes and properties: C2.1 Soil biology; C2.2 Soil physics; C2.3 Soil mineralogy; C2.4 Soil chemistry; Division 3 – Soil use and management: C3.1 Soil fertility and plant nutrition; C3.2 Correctives and fertilizers; C3.3 Soil and water management and conservation; C3.4 Land use planning; C3.5 Pollution, soil remediation and recovery of degraded areas; Division 4 – Soils, environment and society: C4.1 Soil education and public perception of soil; C4.2 Soils and food security; C4.3 History, epistemology and sociology of soil science.

Within the SSSA, a similar pattern emerges, where divisions such as “Soil Education and Outreach” (46 %), “Soil Biology” (43 %), and “Urban and Anthropogenic Soils” (39 %) lead to higher women representation. This trend is even more pronounced among women graduate students, with their proportions in these divisions being 55, 53, and 41 %, respectively. In contrast, divisions like “Soil Physics and Hydrology” (18 %), “Soil Fertility and Plant Nutrition” (23 %), and “Consulting Soil Scientists” (24 %) have the lowest women membership rates. Additionaly, exploring graduate student membership in the SSSA, this low influx of women also holds among additional divisions: “Soil Mineralogy”, “Forest, Range, and Wildland Soils”, and “Soils and Environmental Quality” (Vaughan et al, 2019). In Italy, women were more prevalent in societies with a primary focus on biology and chemistry, as opposed to those concentrating on pedology and hydrology, and were similarly more prominent in scientific journals emphasizing ecology, environmental sciences, and biology (Adamo et al., 2022). Collectively, these numbers reveal areas with marked gender disparities, highlighting the need for measures to promote inclusion and stimulate more balanced engagement throughout the discipline of soil science. However, they also reveal areas where women have greater interest within soil science.

SBCS leadership positions and awards

The SBCS was established in 1947 with 31 founding men members (Barbosa, 2023). Since then, the society has shown a slow progression towards the inclusion of women in its leadership roles. It took 46 years after its foundation for the first women to join the society's Board of Directors, one serving as Secretary and another as an Advisor. In 1999, a woman assumed the Vice-Presidency of the society for the first time, and two years later, she became its first women President (Oliveira et al., 2015). It was not until 12 years later that the second women President was elected for the terms of 2015/2017 and 2017/2019. Currently, the Board of Directors is still led by a woman, the third to hold this position, along with a women vice-chair, both for the terms of 2019/2021 and 2021/2023. Thus, unsurprisingly, in 73 years of the SBCS history, women accounted for just 8 % (n = 36 of 459) of the Board of Directors' representatives (Figure 15). In the role of President, women accounted for 14 % (n = 5 of 37). Similar trends are visible in the role of the 1st Vice-President (8 %, n = 3 of 38), and Advisor (9 %, n = 26 of 280). In the positions of 2nd Vice-President, General Secretary, Assistant Secretary, and Treasurer, women representation has been completely absent (Figure 15).

In the divisions of the SBCS, there is an indication of progress towards gender parity in the role of Director, which depicts an equal distribution of men and women (Figure 15). However, it is important to note this position has only been held by 12 individuals, and this balance is not mirrored in other roles. Within the SBCS commissions, women comprise less than a quarter of the representatives, with proportions ranging between 11 and 23 %. Furthermore, in the Regional and State Nuclei of the SBCS, women are more likely to hold positions such as General Secretary and Treasurer, while men predominantly occupy top roles such as Director and Vice-Director (Figure 15).

Only 20 % of the soil science societies affiliated with the IUSS are led by women presidents. Notably, this percentage is lower than the 32 % global average of women membership (Dawson et al., 2021). As in the SBCS, the proportion of women in other related scientific society leadership roles also reflects a broader issue of underrepresentation. For instance, in the SSSA, founded in 1936, a mere 2.4 % (n = 2) of its presidents have been women, with terms occurring in 2005 and 2015. Similarly, the Agronomy Society of America (ASA), established in 1907, has seen only 2.7 % of its presidents as women, all of whom have served since 2013 (Vaughan et al., 2019). In Italy, both the Italian Society of Soil Science and Italian Society of Pedology demonstrate a similar pattern of gender inequity within their executive boards (Adamo et al., 2022).

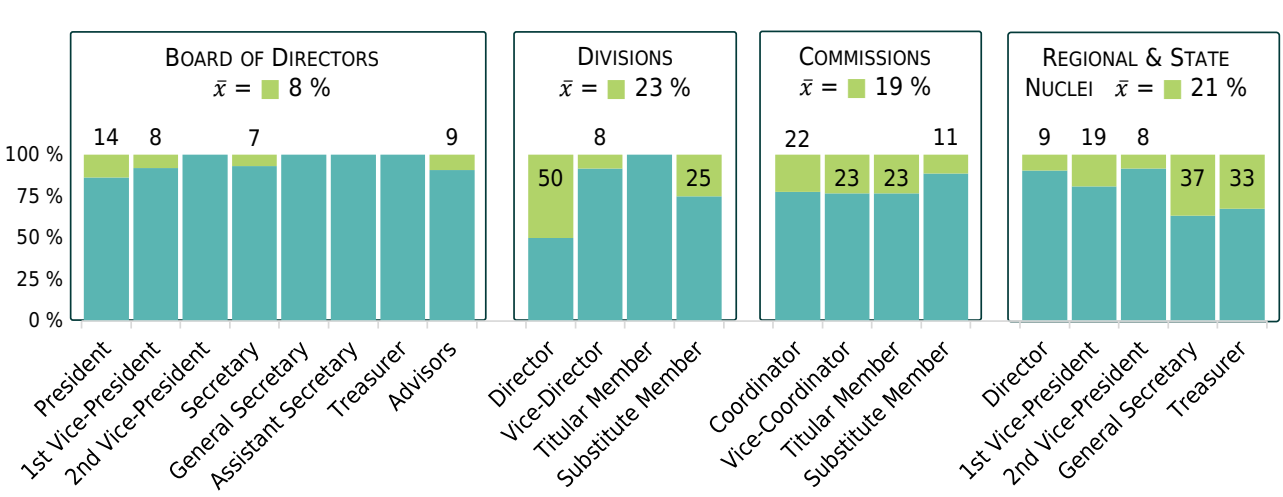

Figure 15. Representatives in the Brazilian Soil Science Society's (SBCS) Board of Directors (1947-2023), Divisions (2011-2023), Commissions (2011-2023), and Regional and States Nuclei (2011-2022) by office position. Percentage of women representatives is relative to men representatives for each category. Numbers on the bars correspond to the relative percentage of women representatives for each category and office position.

Despite this reality, the Solos Floripa 2023 conference – held in Brazil, combining the XXIII Latin American Congress of Soil Science (CLACS) and the XXXVIII Brazilian Congress of Soil Science (CBCS) – witnessed a historical milestone for women leadership in soil science. For the first time, it brought together the first women presidents of the IUSS and the Latin American Society of Soil Science (SLCS), Laura Bertha Reyes-Sánchez and Elisângela Benedet da Silva (terms of 2021-2022 and 2019-2021, respectively), along with the then-president of the SBCS (2019-2021 and 2021-2023), Lúcia Helena Cunha dos Anjos. This significant moment underscored the growing influence and recognition of women within the Latin American soil science community, highlighting recent progress in gender equity within leadership dynamics in the field.

The acknowledgment of soil scientist contributions to the discipline through awards and honors is an important form of peer recognition. However, it is clear that within the SBCS, women have not been sufficiently recognized. Out of 94 titles awarded, only 7 (7 %) have been conferred to women (Table 6). This pattern of low recognition extends beyond the SBCS to other organizations such as the SSSA, ASA, Crop Science Society of America, and European Geosciences Union (Vaughan et al., 2019; Dawson et al., 2021).

Advancing soil science in Brazil: a call for equity

Our analysis of the demographic evolution of soil science in Brazil reveals a consistent increase in the proportion of women in graduate programs over almost the last two decades. In the past five years, women have earned nearly half of the graduate degrees in the field. However, this growing representation of women in academia does not find a proportional reflection in the professional landscape or peer-recognition. Although women are near parity in graduate programs, their limited advancement in academic careers, professional societies like the SBCS, and receiving awards reflect a broader underrepresentation issue.

Our results also highlighted a marked prevalence of women faculty in Brazil working in soil science subdisciplines related to biological sciences and ecology. In the SBCS, women have a substantial relative proportion in commissions focused on soil education and public perception of soil, as well as on history, epistemology and sociology of soil science, and soil biology. These trends indicate a shift in the identity of soil science in Brazil towards broader applications in education, social and environmental issues, and natural resources, closely paralleling those observed in the US, Canada and the SSSA (Baveye et al., 2006; Brevik et al., 2018; Vaughan et al., 2019; Adamo et al., 2022). These observations suggest these changes in soil science are not occurring merely by coincidence. The evolving entry of women into soil science marks a key step towards gender diversity and significantly contributes to the field progress. By bringing new interests and perspectives, women are helping to shape a future for soil science that is more responsive, integrated, and sustainable. This shift reflects a growing recognition that soil science, like any scientific field, must constantly evolve to meet the emerging needs of society and the environment.

Table 6. Awards and honors granted by the Brazilian Soil Science Society (SBCS)

Award or Honor	Women	%	Men	%	Total
Soil Science Commendation[(1)]	0	0	2	100	2
Honorary Members	1	8	12	92	13
Meritorious Members[(1)]	0	0	7	100	7
Honors	2	11	17	89	19
Posthumous Honors	3	7	43	93	46
Antonio Carlos Moniz Award	1	14	6	86	7
	7	7	87	93	94

[(1)] The category no longer exists in the current SBCS Statute.

The advancement in graduate studies is influenced by multiple and overlapping factors at biological, family and peer, school, and societal levels (Unesco, 2017). Our findings indicate men students in soil science are more sensitive to the factors that influence the decision to drop out. For instance, in a patriarcal and sexist culture with stereotypical masculinities and strong gender-biased roles like Brazil's (Baldwin and DeSouza, 2001), men are often still seen as the main providers. The pressure to secure a well-paying job after graduation may lead them to consider dropping out if they perceive that graduate studies do not offer a return on the investment as expected. For women, on the other hand, graduate studies could potentially enhance and provide a more stable career trajectory, encouraging them to pursue their studies – or, given the persistent gender inequity in the workplace, a graduate degree may also be the only way for women to level the playing field, earning credentials that help them overcome professional barriers. Furthermore, higher education can be seen as a form of empowerment and a way to challenge patriarchal norms. Therefore, continuing in graduate studies can be both a personal decision and a political statement.

The systemic nature of the gender disparity revealed by our study suggests this issue is deeply entrenched in the field of soil science across Brazil. The results highlighted are symptomatic of a glass ceiling, also known as vertical segregation, which refers to an invisible but palpable barrier that prevents women from advancing to higher hierarchical levels, despite their qualifications and achievements (Rosser, 2004; Hirata, 2015). While women may enter soil science at similar rates as men, their transition and progression to higher academic ranks is often stymied. Women faculty, in particular, encounter numerous barriers, including receiving fewer research fellowships and grants (Pereda et al., 2022; Reichert et al., 2022), being less likely to be named as authors on articles (Rossiter, 1993; Ross et al., 2022), being assigned less prestigious tasks (Carrigan et al., 2011), being perceived as less competent than men with similar qualifications (Moss-Racusin et al., 2012), and experiencing lower promotion rates even when outperforming men (Benson et al., 2023).

Paradoxically, women faculty often shoulder heavier loads of invisible work, which is often considered a "natural" extension of gender roles, associated with nature, love, and even maternal duty (Hirata and Kergoat, 2007). This invisible work includes spending more time on campus service, advising students, and performing teaching-related activities (O'Meara et al., 2017). Furthermore, they are often viewed as more approachable by their students, leading to an increased number of work requests, special favors, friendship behaviors, and expectations that their requests will be met (O'Meara et al., 2017; El-Alayli et al., 2018). Additionally, the expectation that these tasks should be also undertaken outside of work hours and for free ends up reinforcing gender stereotypes and contributes to a wide range of economic and social inequalities (Hirata and Kergoat, 2007). This dynamic leaves women with less time for their own research, perpetuating a cycle that hampers their chances of publishing, earning tenure, obtaining research grants, and career progression. Moreover, the existence of a glass ceiling has broader societal implications. It sends a discouraging message to aspiring girls and women, potentially deterring them from pursuing scientific reasearch careers (Unesco, 2017), feeding back into the cycle of underrepresentation.

Blickenstaff (2005) emphasizes that the underrepresentation of women in STEM is not due to lack of qualification, competence, commitment, or biological differences. In fact, the factors behind the lack of gender diversity in STEM are complex and multifactorial, resembling layers of a gender-based filter – or barriers. While no single factor can be identified as the primary cause, some significant barriers can be highlighted, such as implicit biases – unconscious beliefs and attitudes that influence the behavior of the majority group or those in positions of power. These biases can manifest in microaggressions that, although often subtle, contribute to the perpetuation of structural inequity (McGee, 2016; Marín-Spiotta et al., 2020).

Reflecting this phenomenon, the metaphor of a "chilly climate" is often used to illustrate how seemingly trivial practices can accumulate, negatively affecting emotional well-being and mental health, as well as learning, engagement, and the sense of belonging (Marín-Spiotta et al., 2020). This process can result in decreased self-confidence and may lead to segregation, lower professional expectations, or even career abandonment (Hall and Sandler, 1982; Cabay et al., 2018). One type of implicit bias is affinity bias (i.e., homophily), which leads us to prefer individuals who are similar to ourselves. Thus, when leadership is predominantly composed of white men, new leadership nominations are also likely to consist of white men, who, in turn, will tend to recognize, promote, and award white men (Grummell et al., 2009; Hurley, 2014). Affinity bias perpetuates a cycle of gender inequity and may explain the lower rates of women soil scientists in senior faculty positions, leadership roles in scientific societies, and nominations to awards, as demonstrated extensively in our study.

Another notable example of implicit bias is the "Matilda Effect", which highlights the discrimination faced by women in receiving scientific awards, with their contributions often being overlooked or attributed to men (Rossiter, 1993). This phenomenon reinforces gender stereotypes and exacerbates inequity in the scientific field, adversely affecting women's visibility, career progression, and representation in prominent positions and prestigious awards. Interestingly, Holmes et al. (2011) noted women are more represented in awards for early career achievements and in service and education sectors, suggesting a nuanced landscape of recognition where women's contributions are acknowledged differently across various stages and areas of their careers. However, the scarcity of women nominations for research awards and the tendency to favor men candidates in selection processes reflect how unconscious gender bias and entrenched stereotypes continue to shape recognition in the scientific community.

To deepen the understanding of gender disparities in soil science, it is essential to adopt the perspective of intersectionality. This approach argues that oppressions, such as race, gender, class, sexuality, among others, do not operate in isolation, but intertwined, shaping unique experiences of discrimination and privilege (Crenshaw, 1994). Thus, the experience of a Black woman in science, for example, may significantly differ from that of a white woman, not only due to sexism but also because of racism and other forms of discrimination (Davis, 1981). Therefore, intersectionality allows for a more in-depth analysis of women's experiences in soil science, taking into account how different identities impact their presence, evolution, and recognition in the field. This focus contributes to recognizing, understanding, and ultimately dismantling the systemic barriers that perpetuate inequalities (Davis, 1981).

Moreover, it is essential to consider how the objectivity culture in science can inadvertently favor discrimination by disregarding the role of feelings, emotions, identities, and ideologies in scientific work (Haraway, 1988). The belief in objective and meritocratic science ignores structural barriers faced by women (Cech and Blair-Loy, 2010), such as biases in recruitment (Moss-Racusin et al., 2012), unequal allocation of resources (Bronstein and Farnsworth, 1998), and sexual harassment (Marín-Spiotta et al., 2018). These conditions contribute to a distorted assessment of scientific achievements, negatively affecting women, especially in fields historically dominated by men, such as soil science.

In discussions on diversity and representation, we have to address the long-standing issue of the global North devaluing scientific research from the global South. The phenomenon of "parachute science" (or "helicopter research"), where Northern researchers extract data and resources from the South without equitable partnerships or acknowledging local contributions, exemplifies this imbalance (Dahdouh-Guebas et al., 2003; Minasny et al., 2020). These practices perpetuate neocolonial legacies and undermine scientific integrity. They overlook the rich knowledge in the global South, impeding the development of more robust and culturally sensitive scientific advancements. This is especially critical

within the context of soil science's efforts to address global environmental challenges. Resolving this issue requires a systemic change in research collaboration structures, emphasizing inclusion and equal recognition of work by scientists from the global South, while ensuring equitable benefits for both researchers and the affected communities.

The influence of these factors on decision-making and daily interactions underscores the need for conscious and deliberate strategies to combat them. The distinction between equality and equity is fundamental to advancing this purpose. While equality focuses on providing identical conditions for all individuals, equity demands recognition and implementation of differentiated measures to correct historical and systemic inequities (International Labour Organization, 2007). Therefore, adopting a multifaceted and integrated approach implemented at institutional, individual, and collective levels, coupled with affirmative actions – not as a detriment to men but as a means of achieving justice for women – strategically addresses men dominance and persistent gender disparities in soil science.

In this context, graduate programs, scientific societies and research funding agencies need to adopt equitable, diverse and inclusive values, diversify their leadership, and evaluate current practices to create an environment that encourages the full participation of women (Hall and Sandler, 1982). Some suggestions to facilitate this process include:

- Gathering intersectional data, supporting interdisciplinarity, qualitative methods, and studies addressing equity issues (Mattheis et al., 2019).
- Expanding the available gender identity options during membership, application, and subscription processes – as well as include options for race/ethnicity. The SSSA already provides the options "female", "male", "gender non-binary", and "prefer not to answer" for voluntary gender data collected about members (Carter et al., 2021). We suggest that "female" and "male" be corrected to "cisgender woman" and "cisgender man", along with the inclusion of "transgender woman", "transgender man", "gender non-binary" and "other". The collection of such data will become an essential and invaluable tool for formulating targeted and effective actions aimed at promoting inclusion and equity for all individuals in the field.
- Developing codes of conduct to ensure equitable treatment, creating awareness, holding people accountable, and addressing harassment in the academic environment and in fieldwork (Marín-Spiotta et al., 2018). As an example, the American Geophysical Union (AGU) has a Scientific Integrity and Professional Ethics Policy, with a general code of conduct directed at members (AGU, 2023). This includes principles, responsibilities, recommendations for graduate advisors, and the inclusion and definition of harassment, bullying, and discrimination, characterizing these acts as scientific misconduct (Kuo, 2017). Additionally, the AGU has codes of conduct for authors, contributors, editors, and reviewers of publications (AGU, 2023); Board of Directors members (AGU, 2024a); Council members (AGU, 2024b); and meetings and events (AGU, 2024c).
- Implementing an affirmative action policy that sets quotas for the selection of women faculty members, consciously selecting more women than men. Reviewing gender ratios periodically to monitor progress and adjust the policy as needed.
- Actively recognizing and combating sexism, racism, and colonialism in science, publicly standing against these and any other forms of prejudice, and actively committing to inclusive teaching and research practices (Berhe and Ghezzehei, 2021).
- Actively and continuously promoting the work of women across diverse media (e.g., social networks, official websites, bulletins, newsletters, special edition publications in journals). This strategy involves disseminating their achievements, research, and contributions not only on specific or commemorative dates but as a consistent and ongoing effort.

- Forming research groups, offering classes and lectures, and implementing communication strategies that focus on gender disparities in soil science.
- Recruiting students and faculty from diverse identities and backgrounds, challenging stereotypes, revising nomination and selection committees, reviewing award criteria, diversifying event sponsorships, ensuring equitable representation in leadership roles, keynote speaking opportunities, awards, and involvement in political decisions (Holmes et al., 2011; Williams et al., 2014).
- Ensuring equity in workload, access to education, and promotion opportunities. Women, in particular, should not be burdened with additional tasks in service or teaching at the expense of research. Moreover, balancing domestic responsibilities and ensuring job stability is important, especially for pregnant women and mothers (Dawson et al., 2021).
- To the SBCS, which is currently predominantly composed of men professors, we recommend to consider the possibility of reducing membership and/or publication fees in the Revista Brasileira de Ciência do Solo (RBCS) for women. Currently in agricultural sciences, the publication ratio is 0.82 women to every man who publishes an article in Brazil (Kleijn et al., 2020). Furthermore, the probability of women obtaining funding grants from CNPq (National Council for Scientific and Technological Development) and FAPESP (The São Paulo Research Foundation) is significantly lower than that of their men counterparts (-5.6 p.p. and -8.8 p.p., respectively) (Pereda et al., 2022). Therefore, this affirmative action could increase women presence and representation in SBCS while demonstrating that the society supports and encourages women publications in the RBCS.
- To the SBCS, similarly to practices implemented by the IUSS, we recommend the provision of scholarships for women doctoral students or early career researchers (e.g., national/international conference grants). Eligibility criteria such as race, social class, and geographic location could also be considered in the selection process to ensure broad and inclusive representation.

CONCLUSIONS

The unprecedented analysis conducted in our study reveals that soil science in Brazil has always been, and continues to be, a men-dominated field. While women have nearly achieved parity in enrollment and degrees earned in soil science graduate programs, they still face barriers in attaining leadership, senior academic positions, and recognition within the SBCS. This scenario reflects deeper systemic issues. Ensuring women effective inclusion, with fair advancement opportunities and support, is vital for the discipline's future. The shift towards a more diverse inclusive field is promising, but it hinges on a commitment to equity-oriented practices and actions at the individual, collective, and institutional levels. Soil science in Brazil will truly mirror the society it serves and realize its full potential only by altering cultural, structural, and systemic norms, thereby fostering genuine inclusivity and diversity within the scientific community.

DATA AVAILABILITY

The data will be provided upon request.

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SUPPLEMENTARY DATA

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