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Environmental Awareness and Public Perception on Carbon Capture and Storage in Brazilian Universities

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Abstract: Carbon Capture and Storage (CCS) is a possible alternative in the effort to reduce GHG emissions on the planet. Despite this, the success of a new technology does not depend solely on technical engineering concepts, it also involves social factors, such as public acceptance. The objective of this research was to analyze the public perception about CCS technology, relating it to the environmental awareness of this public, in the context of climate change. To obtain the data, a questionnaire elaborated in federal universities in the southeastern region of Brazil was applied, answered by 671 individuals, including students and professors working in the studied universities. The results point to a low knowledge about the technology, with a majority favorable to its acceptance. In addition, a relationship was found between those concerned about climate change and those who accept the CCS, also showing that greater knowledge about the technology can influence its acceptance.

Keywords: CCS; Carbon Dioxide; Greenhouse Gases; Public Perception; Federal University.

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Introduction

Brazil is one of the signatory countries of the Paris Agreement, committing to take actions to mitigate the greenhouse effect. However, in 2020, gross carbon emissions in the country increased by 9.5%, while in the rest of the world global emissions were reduced by 7% (a period in which the world was facing the Covid-19 pandemic and the consequent slowdown of the global economy) (SEEG, 2021). Furthermore, total gross emissions in the country reached 2.16 billion tons of CO_2 equivalent ($GtCO_2$-eq) in 2020, compared to 1.97 billion tons in 2019 (the highest since 2006), failing to meet the PNMC's less ambitious target (2.068 $GtCO_2$-eq), in addition to returning from COP-26 backtracking on the target, without even a plan drawn up to meet it (TALANOA, 2020; Unterstell and Martins, 2022).

Based on the current panorama of environmental problems, especially those related to carbon dioxide (CO_2) emissions, and in view of Brazil's commitment to reducing GHG emissions, even though there is no regulation on how the commitments will be fulfilled in the energy sector, Carbon Capture and Storage (CCS) technology is inserted as a possible alternative in the effort to reduce carbon dioxide (CO_2) emissions. GHG in the country (Abreu Netto *et al.*, 2020).

CCS technology comes from the petroleum industry and consists of capturing and trapping CO_2 emitted from flue gases, mainly from stationary sources, such as those that occur in production processes and industrial facilities. According to Ampomah *et al.* (2017), CCS technology is composed of the capture of CO_2 from industrial sources and its transport to its destination, usually porous rock formations and saline aquifers.

Despite the Brazilian geological potential for carbon dioxide injection, research that investigates the characterization of social sites or public perception of SCC is almost non-existent in Brazil (Abreu Netto *et al.*, 2020), however, such perceptions are a key factor in guiding successful guidelines in the implementation of a new technology, such as CCS (Zhang *et al.*, 2018).

In one of the few studies of public perception about CCS, it was evidenced that, even in one of the capitals of the most economically developed region of Brazil, and where the only CCS project in operation in the country is located, the Southeast region, the technology is still quite unknown. In addition, the topic related to climate change is among the last considered as a priority in the face of other social demands, such as health and education, for example; this fact points to the fact that, even in the most economically developed region of the country, basic demands have not yet been fully met in order to enable the population to debate other important demands, such as those related to the climate, and, consequently, technologies such as CCS. Despite this, the concern with environmental aspects (a factor that can influence the acceptance of CCS) was identified in a large part of the interviewed population and is strongly more present in groups with a higher level of education (Lima *et al.*, 2021; IPEC, 2022).

Thus, based on the pessimistic scenario in which Brazil is inserted in the face of GHG mitigation goals, as well as the low amount of work on public opinion on CCS technology, and seeking to investigate more deeply the environmental awareness of the

group considered to be more concerned with climate change (higher level of education), in the most developed region of the country; The present study aims to analyze the public opinion about the use of CCS as a mitigating agent of GHG emissions, as well as the environmental awareness of this public in the context of climate change, using, as target audience, students and professors from federal universities in the southeastern region of Brazil, in order to relate the answers as a means of helping to understand the paths that CCS should follow for its effective acceptance by society.

Methodology

The methodological process consisted of applying a questionnaire elaborated, entirely online, in federal universities in the southeastern region of Brazil, answered by 671 individuals, including students and professors working in the universities under study. For the synthesis of the data, a descriptive analysis of the results was performed to compare the answers, as well as hypothesis tests with different groups of the population to assess the existence of an association between the variables of interest.

Delimitation of the study region and target audience

This research was conducted at Federal Higher Education Universities in the Southeast region of Brazil. Furthermore, all contact between the researchers and the target audience was done online, due to the pandemic period in which the research was conducted (pandemic caused by COVID-19).

The Southeast region comprises four states: Rio de Janeiro, Minas Gerais, São Paulo, and Espírito Santo; covering an area of approximately 924,620 km^2 (10% of the surface of Brazil). It has territorial limitations to the north by the state of Bahia, to the south and east by the Atlantic Ocean; to the southwest by Paraná; to the west by Mato Grosso do Sul; to the northwest by Goiás and the Federal District (IBGE, 2018).

Currently, the Southeast region has 19 federal universities in its territory (Table 1), four in Rio de Janeiro, three in São Paulo, one in Espírito Santo, and eleven in Minas Gerais (INEP, 2020).

Table 1 - Federal higher education institutions in southeastern Brazil.

UF	ACRONYM	EDUCATIONAL INSTITUTION
EN	UFES	FEDERAL UNIVERSITY OF ESPÍRITO SANTO
MG	UFMG	FEDERAL UNIVERSITY OF MINAS GERAIS
MG	Ufla	FEDERAL UNIVERSITY OF LAVRAS
MG	UFV	FEDERAL UNIVERSITY OF VIÇOSA
MG	UFJF	FEDERAL UNIVERSITY OF JUIZ DE FORA
MG	Unifei	FEDERAL UNIVERSITY OF ITAJUBÁ

MG	UFU	FEDERAL UNIVERSITY OF UBERLANDIA
MG	Unifal -MG	FEDERAL UNIVERSITY OF ALFENAS
MG	Ufop	FEDERAL UNIVERSITY OF OURO PRETO
MG	UFTM	FEDERAL UNIVERSITY OF TRIANGLE MINAS GERAIS
MG	UFSJ	FEDERAL UNIVERSITY OF SAINT JOHN DEL-REY
MG	UFVJM	FEDERAL UNIVERSITY OF JEQUITONHA AND MUCURI VALLEYS
RJ	UFRJ	FEDERAL UNIVERSITY OF RIO DE JANEIRO
RJ	UFF	FLUMINENSE FEDERAL UNIVERSITY
RJ	Unirio	FEDERAL UNIVERSITY OF THE STATE OF RIO DE JANEIRO
RJ	UFRRJ	FEDERAL UNIVERSITY OF RURAL RIO DE JANEIRO
SP	UFSCar	FEDERAL UNIVERSITY OF SAO CARLOS
SP	Unifesp	FEDERAL UNIVERSITY OF SAO PAULO
SP	UFABC	FEDERAL UNIVERSITY OF ABC

Source: Prepared by the authors, 2023.

The target audience was made up of students and professors from the universities listed in Table 1. According to data from Inep (2020), updated in May 2021, the estimated total number of students in the Southeast region is 411,400, while the number of teaching staff is 24,810, distributed across various undergraduate and postgraduate courses in the 19 federal universities in the Southeast region of Brazil, totaling a population of 436,210 individuals.

Sample size calculation

The calculation of sample size for populations above 100,000 individuals is performed using Equation 1 (Gil, 2008; Kauark, Manhães e Medeiros, 2010):

$$n = \frac{(Z_{\alpha/2})^2 . \ p \ . \ q}{e^2} \qquad \textbf{(Eq.1)}$$

Being:

n = sample size;

Zα/2 = critical value that corresponds to the desired confidence level;

p = percentage with which the phenomenon occurs;

q = complementary percentage (100% - p);

e = maximum allowable error.

The confidence level used in this research was 95% because, according to José Néto (2004), it is within the range of most common values in public opinion surveys. Furthermore, since most of the phenomena under study do not have prior estimates regarding their characteristics, this study adopted a P-value equal to 50 (corresponding to the highest variance value) and a maximum permitted error of 5%.

Given the above, using Equation 1, it was calculated that the sample size for this research was 671 individuals. In addition, the sample was stratified by: Southeast federative state, teacher, and student; and was carried out by calculating proportion by quantity.

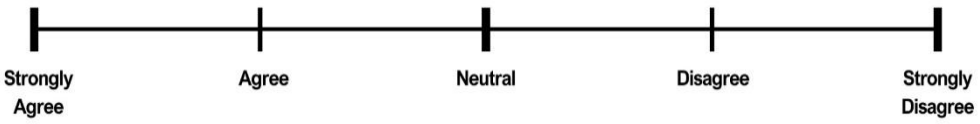
Preparation of the questionnaire and method of application

The questionnaire was prepared using the Google Forms platform and presented 29 questions, divided into 3 sections, with closed answers, using 5-point Likert scales (Figure 1). In general, the questionnaire was divided into the following sections:

a) **Interviewee's profile:** personal and professional information, such as age, gender, level of education, income, and educational institution in which he or she was inserted; totaling 11 questions;
b) **Environmental Awareness:** questions related to the interviewee's level of concern about climate change; totaling 12 questions;
c) **CCS technology:** presentation of CSS, including its advantages and disadvantages, as well as its risks, as well as questions related to the topic; totaling 6 questions.

To validate their participation, before starting with their answers, the participants had to agree to the Informed Consent Form (ICF), available at the beginning of the questionnaire, so that they could only continue the answers to those respondents who marked the option of acceptance.

Figure 1 - Representation of the five-point Likert scale



Source: Adapted from Gil (2008).

The method of application of the questionnaire was, in its entirety, done in the digital modality, via e-mail, to the bodies responsible for sending e-mails to students and

professors of all institutions listed in Table 1, presenting the research and its objectives, and sending the questionnaire for analysis and dissemination to the student body and faculty.

Data collection and organization

The answers to the questions were grouped according to their profile of acceptance, rejection or neutrality. For the present study, within the Likert scale, options 1, 2, 3, 4, and 5 of the scale referred, respectively, to "strongly disagree", "disagree", "do not know how to give an opinion", "agree" and "totally agree". Thus, the data obtained by the answers to the questionnaire were organized as follows:

Options 1 and 2: refer to the fact that the interviewee disagrees with the question;

Options 4 and 5: refer to the fact that the interviewee agrees with the question;

Option 3: is the neutral alternative, which will be evaluated as a neutrality option, and will enter the group of answers with a disagreement profile.

Thus, for the descriptive analysis, the median was calculated for each question that used the Likert scale, so that medians higher than 3 characterize a population profile of agreement with the questions. However, medians lower than 3 characterize a profile of disagreement with the questions. In addition, medians equal to 3 characterize a profile of neutrality or indecision. The mode was also calculated aiming to show the value that occurs most frequently for each question.

Criteria for analyzing concern about climate change

The following questions are designed to group respondents into people who are concerned or not about climate change:

- **Question 12:** *Do you consider that climate change is indeed happening in the world?*
- **Question 13:** *You consider that climate change is an important issue to be debated in Brazil?*
- **Question 15:** *You consider climate change to be a cause for concern in your personal life?*

The choice of a disagreement option for any of questions 12, 13 or 15 directly denoted a person with a profile of not being concerned about climate change, therefore, in order to be seen as a person concerned about climate change, the interviewee had to answer with agreement at least questions 12, 13 and 15.

Criteria for analyzing knowledge and acceptance of CCS technology

To assess whether the interviewee is aware of CCS technology, the following question was asked: "*Do you know, or have you heard of, carbon capture and storage (CCS) technology?*".

In this case, the answers "*I don't know*" and "*I've heard of it, but I don't know how to define*" were considered as options for disagreement, so that only the option "I know, and I know how to define" was seen as an option for agreement.

It is important to note that, regardless of the answer in question 23, the interviewee had the opportunity to learn about the definition and the general operating scheme of the CCS technology, presented in text and image form in the questionnaire. Subsequently, it is judged that the interviewee was able to answer the questions in Section 3 – CCS Technology.

To assess the acceptance, or not, of the CCS technology by the interviewees, after defining the theme, the following questions were asked:

- **Question 24:** *Do you consider CCS technology to be a necessary technology?*
- **Question 25:** *Do you consider that CCS technology is currently an effective technology in capturing and trapping carbon dioxide?*
- **Question 26**: *Do you agree with the development of CCS technology in Brazil, carried out with public Investments?*
-

The interviewee who answered questions 24 and 25 with the option of agreement was seen as someone who accepts the CCS technology. In addition, answering question 26 with the option of agreement also directly denotes an interviewee with a profile of acceptance of the implementation of CCS technology in Brazil made with public money.

Hypothesis testing

In total, 17 hypotheses were tested (Table 2), covering different characteristics of the population, to analyze the interviewees' knowledge about CCS technology, as well as their concern with climate change in relation to their individual characteristics of interest, such as: gender, income, age group, education level, among others.

In the set of hypotheses associated with the Likert scale, the non-parametric Mann-Withney and Kruskal-Wallis U tests were used, as they are more appropriate for ordinal scales (Miller and Salkind, 2002; Markus and Borsboom, 2012; Marôco, 2018). When the hypotheses involved only two groups, the Mann-Within U test was used, while for hypotheses whose tests involved more than two groups of variables, the Kruskal-Wallis test was used, according to Siegel and Castellan Jr (2006) and Morettin and Bussab (2010).

All tests were performed with α=5% using the IBM SPSS Statistics 21 software, whose functions include analysis, manipulation, data transformation, as well as the creation

of graphs and tables, and it is also possible to perform parametric and non-parametric hypothesis tests (IBM SPSS CATALOG, 2021).

Table 2 - Hypotheses to be tested.

No.	DESCRIPTION OF THE HYPOTHESIS
1st	There is no difference in the concern of climate change given the sex gender.
2nd	There is no difference in the concern of climate change given the income.
3rd	There is no difference in the concern of climate change given the level of education/ academicity.
4th	There is no difference in terms of concern about climate change given the fact that they have already taken courses related to the environment and renewable energies.
5th	There is no difference in the concern of climate change given the age group.
6th	Among those concerned about climate change, there is no difference in awareness of the relationship between global warming and climate change given the level of education/education.
7th	Among those concerned with climate change, there are no differences in awareness of the relationship between global warming and climate change, given the fact that they have already taken courses related to the environment and renewable energy.
8th	Among those concerned about climate change, there is no difference in availability to change habits, given income.
9th	There are no differences between knowledge about CCS technology given the level of education/academicity.
10th	There are no differences between the knowledge about CCS technology given the fact that they have already taken courses related to the theme: environment and renewable energies.
11th	There is no difference in the acceptance of CCS technology, given the level of education/academicity.
12th	There is no difference in the acceptance of CCS technology, given the fact that they have already taken, or not, some discipline related to the theme of environment and renewable energies.
13th	Among those who accept CCS technology, there is no difference in acceptance of public investments in the technology, given income.
14th	There is no difference in considering CCS technology safe given the level of education/education.
15th	There is no difference in considering CCS technology safe given the age group.
16th	Among those who do not think CCS is safe, there is no difference in the level of acceptance with the improvement in the safety factor of the technology given the level of education/academicity.
17th	Among those who do not think CCS is safe, there is no difference in the level of acceptance with the improvement in the safety factor of the technology given the age group.

Source: Prepared by the authors, 2023.

Results and Discussions

Analysis of concern about climate change

This survey revealed that the largest portion of the population under study understands that climate change is, in fact, happening in the world (97%) and is an important issue to be debated in Brazil (94%), in addition to considering that climate change is happening around them (78%) and is a reason for personal concern (69%).

In total, 68% of respondents were considered to be part of the group of people concerned about climate change, a result in line with studies carried out in Brazil in 2020, 2021, and 2022 by IPEC. Research carried out by Intelligence in Research and Strategic Consulting (IPEC), about climate change in the perception of Brazilians, exposed that in the years 2020, 2021, and 2022 the percentage of Brazilians considered to be very concerned about climate change was 61%, although about 80% think it is important to discuss the issue in the country (IPEC, 2022). Research by Lima *et al.* (2021) shows a more optimistic percentage regarding the concern about climate change. In their study in the state of Espírito Santo, southeastern Brazil, the results showed that about 85% of respondents are considered to be concerned about climate change in both cities addressed.

It is important to note that, although people are aware of climate change, there are those who do not feel its effects in their daily lives. This is due to the fact that the interviewee may be a person concerned about climate change, but not yet feel its effects around him, in his daily life, or in the place where he lives, although he knows that there is a possibility that it will occur in the future. This situation occurred for 27 individuals (4%).

In the present survey, analyzing the general sample, 78% of the interviewees stated that they feel the effects of climate change in their daily lives or in the region where they live (among those considered to be concerned about climate change, this number reaches 76%). This occurrence was also found in several countries, as exposed by Boyd, Hmielowski e David (2017) in Canada, Guo *et al.* (2019) in China, Lima *et al.* (2021) in Brazil, Pianta, Rinscheid e Weber (2021) in the USA, and Shaw and Mukherjee (2022) in India, in which most of the interviewees, among other aspects, revealed that they already felt the effects of climate change around them, Mainly because of air pollution, poor water quality, deforestation or increased temperature in the region where they live.

In the Brazilian scenario, studies carried out by Ipec (2022) indicate that 77% of the population perceives climate change and attributes this perception mainly to the natural change of environments, by human action, caused by deforestation and pollution of green areas. In the context of southeastern Brazil, in São Paulo, the most populous state in the southeast region, as well as the largest urban center in Brazil, the perceptions come mainly from poor air and water quality, in addition to the so-called heat islands.

Authors such as Cortese (2013) and Barros and Lombardo (2016) show that, because it is home to a large industrial park, the state of São Paulo suffers direct impacts on air and water quality, caused by industrial waste and an intense process of urban verticalization, aggravating the so-called "heat islands". In the state of Espírito Santo, Lima *et al.* (2021) show that perceptions about climate change are diverse; occurrences

ranging from the lack of water and its poor quality, to the presence of the so-called "black powder", especially in the capital Vitória, where several ore companies are established.

Climate change and global warming

In the present research, it was also found that there are more people who understand the concept of global warming than actually care about its consequences on the environment, which may indicate that, although there are direct links between the two topics, there are fewer people concerned about climate change than about global warming: The figures show that about 89% of the population in this study has an understanding of the relationship between climate change and global warming, compared to 68% considered to be concerned about climate change.

The results obtained by Ipec suggest the same idea: 61% of Brazilians are considered to be very concerned about climate change, 81% are strongly concerned about global warming, and only 21% consider that they understand its concept minimally (4% less than the previous year) (IPEC, 2022).

Various reasons can lead to the occurrence of almost unanimity about the knowledge of the concept of global warming and a relatively lower percentage regarding the concern of climate change. Part of this phenomenon has its origins in the so-called "climate denialism", an effect studied here in Brazil and in various parts of the world, in which people or organized groups of people do not believe in global warming resulting from human intervention. As exposed by the studies by Miguel (2020) and Santini and Barros (2022), on climate denialism in Brazil and online disinformation, which suggest that the effect of denying climate issues in the country has political interest, so that climate denialism serves as a rhetorical device for those who aim to deregulate environmental laws and not commit to international agreements.

It is also interesting to note that the percentage difference between the levels of knowledge on the topic of "global warming and climate change", between the Ipec surveys (61%) and the present study (68%), can be explained by the fact that the sample used in the present study is composed only of people with higher education (graduated or with an undergraduate degree in progress), therefore, it is expected that the degree of knowledge about more technical topics will be greater when compared to the general public, as is the case of the sample used in the Ipec study (2022). This explanation can be corroborated by the fact that, in the general public, the degree of knowledge about global warming and its relationship with climate change is also higher for the group of people with a higher level of education, according to *Lima et al.* (2022) and the present study.

Willingness to change habits

As for changes in habits in order to mitigate climate change, four were proposed: exchange the use of cars for the use of bicycles; exchange of car use for the use of public transport; payment of taxes related to the fight against climate change; pay a higher price for the use of low-carbon technologies at the expense of the use of fossil fuels.

In the present study, it was found that there is a tendency, on the part of those concerned with climate change, to change the proposed habits (58%). It is interesting to note that, among those not concerned about climate change, there was also a percentage interested in changing habits (39%), such as switching from using a car to using public transport. The exchange of car use for public transportation was a habit with more followers in the study by Lima *et al.* (2021) and in the present study, indicating that, for the aforementioned habit, there is a tendency to accept it. The acceptance of the use of public transport may be related to the fact that such a change could bring financial returns to the fans.

For the purpose of comparison with the present study, in the Brazilian scenario, Ipec (2022) provides information on the habits, in the sense of mitigating climate change, that Brazilians do most in their daily lives. The habits range from carrying out selective collection and using solar panels for residential energy generation, to voting for politicians whose agendas are in line with caring for the environment. The Ipec study showed that at least 75% of the sample says they perform some listed action. In addition, in the present survey, selective collection entered as the last priority compared to five other actions favorable to the environment, however, for the general public, this was the option with the most supporters in the Ipec study (2022) – an action that can be further explored by the population.

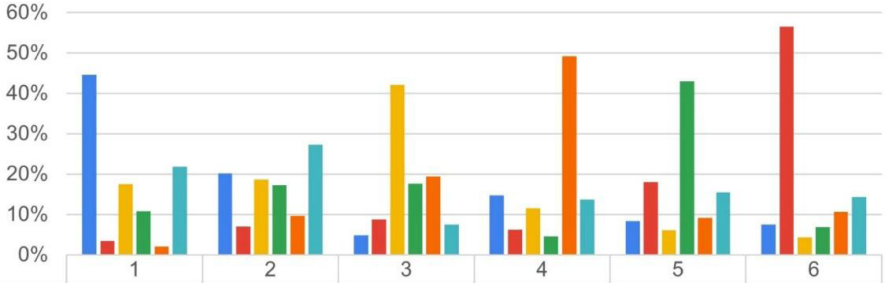
CCS Technology Perception Analysis

Regarding knowledge of CCS technology, this survey revealed that, of the group considered not knowledgeable, 55% had never even heard about the technology, so that only 7% of respondents could be considered to have knowledge about CCS – results in line with most of the research carried out on the subject around the world.

The results among countries around the world point to a low level of knowledge about CCS, with results around 5 to 15% for knowledge of the technology – except in the study carried out in the Netherlands, which obtained as a result 52% of people who knew what CCS was, because they were familiar with the Barendrecht project (EUROPEAN COMMISSION, 2011). It is evaluated, then, that the knowledge about the CCS technology for the present research is within the percentage range observed in the rest of the world, although still considered low.

It is interesting to question that, even using a public whose schooling is higher than the average of the country, the present study exposes that the knowledge of CCS technology is still low. Figure 2 shows that, despite obtaining a percentage of acceptance by the vast majority of the sample (65%), CCS remains among the last positions in terms of the priority of public investments in Brazil for technologies and actions to mitigate the greenhouse effect.

Figure 2 - Priority of public investments in Brazil for technologies and actions to mitigate the greenhouse effect.



	1	2	3	4	5	6
Reforestation	45%	20%	5%	15%	8%	7%
Selective Collection	3%	7%	9%	6%	18%	56%
Biofuels	17%	19%	42%	11%	6%	4%
CCS	11%	17%	18%	5%	43%	7%
Wind Energy	2%	10%	19%	49%	9%	11%
Solar Energy	22%	27%	7%	14%	15%	14%

Source: Prepared by the authors, 2023.

The priority for reforestation in the present research may be linked to the fact that the discussion about deforestation in Brazil is old and recurrent, as also shown in the most recent report by SEEG (2021), which shows that there is a trend of increasing deforestation in Brazilian biomes and this phenomenon is widely publicized. However, renewable energies, more specifically solar energy, is a relatively new technology that obtains, as shown by this and several other studies, such as those by Yang, Zhang e Mcaliden (2016) and Guo (2019), a better acceptance in relation to other technologies.

It is known that solar energy for many years has been disseminated through tax incentives for its use, in addition to massive information in the media. Currently, there are several companies that provide the installation, control and monitoring of solar panels. In addition, the federal government recently sanctioned Law 14,300/2022, which establishes the legal framework for distributed microgeneration and minigeneration, which consists of the generation of electricity through solar panels. Although the return on investment is still slow, the facilities found to spread solar energy may have had a direct impact on society: about 11% of Brazilian citizens show interest in using solar energy in their homes or commercial establishments, with a tendency for this percentage to increase (Kemerich, 2016; Birth, 2017; IPEC, 2022; BRAZIL, 2022). Such factors make it interesting to analyze how the knowledge of this technology has been transmitted over the years to the population, in order to compare how knowledge about SCC is being transmitted.

It is worth noting that, in the present research, through the hypothesis test, there were discrepancies regarding the knowledge of CCS technology given the level of education/academic level and the fact that they had already taken or had not taken

any discipline related to the theme of environment and renewable energies. The level of knowledge of the technology is higher for groups with postdoctoral degrees and for those who have taken courses such as those described. This occurrence can be explained by the fact that there is a trend towards greater concerns with the environment in groups with higher levels of education, as also exposed by Lima *et al.* (2021).

It is important to highlight that, despite the other technologies presented in Figure 2, CCS is the only one capable of obtaining significant emission reductions from the use of fossil fuels, with a greater range of results when combined with mitigating actions and technologies, as shown in the study by Moreira *et al.* (2016), whose focus has been on the use of bioenergy with CCS, a process called Bioenergy with Carbon Capture and Storage (BECCS), where carbon-neutral bioenergy would be combined with additional carbon capture, thus producing sub-zero emissions.

Analysis of CCS Technology Acceptance

Regarding the acceptance of the technology, it was observed that, after the introduction of the CCS theme, the results of the present survey indicated that the largest portion of the population has a profile of acceptance of the CCS technology (65%), and approves that it is implemented in Brazil with public investments (52%) – a more promising result when compared to studies around the world. In addition, in the present study, of the group of people who accept CCS technology, more than half understand that the technology is safe (54%). Among those who do not accept the technology and do not consider it safe, the vast majority consider accepting it if there is an improvement in the security aspects of the technology (60%).

Lima *et al.* (2021) expose that, in two cities in one of the four states in the southeast region, Espírito Santo, between 80 and 90% of respondents agreed with the development of CCS in Brazil, in addition to being in favor of its development with public resources.

For comparison, in China, the studies by Yang, Zhang e Mcaliden (2016) and Guo *et al.* (2019) showed that, among the methods and technologies available for climate change mitigation, renewable energies obtain the greatest support as a priority option to deal with climate issues, to the detriment of CCS technology, which obtained low acceptance (less than half of the population). Jiang and Ashworth (2021) point out that, in China, CCS has low adoption based on the public's lack of knowledge about the technology, in addition to a poor understanding of the trade-offs between risks, costs, and benefits, low trust in the developer, as well as low overall experience with the technology.

Although the present research has higher levels of acceptance of CCS technology, as well as greater acceptance of its development with public resources when compared to research carried out in other countries, it is possible to observe that, when placed in order of priority as a method to mitigate the greenhouse effect, the choice of CCS is always one of the last, being a preference for those technologies with which the public is more familiar, such as solar, wind and biofuels; a result also corroborated by the research of Yang, Zhang e Mcaliden (2016), Guo *et al.* (2019), and Jiang and Ashworth (2021) in China.

Regarding the risks associated with CCS technology, in line with the results obtained in the present research, authors such as Duan (2010), Gough, O'keefe e Mander (2014), Yang, Zhang e Mcaliden (2016), Braun (2017), Saito, Itaoka e Akai (2019), Abreu Netto *et al.* (2020), Pianta, Rinscheid e Weber (2021) and Jiang and Ashworth (2021), show that CCS is better accepted when its negative impacts are minimized, with better management, and even minimization, of risks, in addition to better social benefits, which the population can see an improvement in aspects such as job creation and less impacts in the region where they live, for example.

Finally, the present research found that the number of individuals who make up the group of those who accept CCS technology is very close to the number of those considered concerned about climate change, being 65% and 68%, respectively. This result points to a direct relationship between the two groups, indicating that among those who are concerned with climate change, the vast majority tend to recognize CCS technology as part of the range of effective technologies to combat such changes, even though it is not yet in broad discussions available to the public, as with other technologies, such as solar energy generation, for example.

In addition, the results indicate that greater knowledge about the technology can influence its acceptance, especially if security aspects are improved. Thus, in order to achieve a greater number of CCS projects in Brazil, it is necessary that there is, first, a wide dissemination of its general aspects, in order to present to the population its contribution and need in the Brazilian environmental scenario, especially in view of the NDC's to which the country has submitted to comply with the Paris Agreement.

Conclusions

Through the public opinion survey, it was possible to verify that most of the population under study is concerned about climate change, understands that climate change is, in fact, happening in the world and is an important issue to be debated in Brazil, in addition to considering that climate change is happening around them and is a reason for personal concern. In addition, it was found that individuals included in the groups of the female gender, income above 15 minimum wages, and age over 45 years are the most concerned about climate change, given the sample obtained.

In general, the population showed low willingness to accept the changes in habits proposed, however, of the group considered concerned about climate change, more than half were willing to change habits such as those described in this survey, with greater acceptance of the change from car use to public transportation.

It was also possible to ascertain that the vast majority of the population is aware of the relationship between climate change and global warming, although the results point to the fact that there are more people who understand the concept of global warming than actually care about its consequences.

Regarding the knowledge of the CCS technology, it was found that the population under study has low knowledge about the subject (7%), however, after a succinct

presentation about the general aspects of the technology, the results indicated that the largest portion of the population has a profile of acceptance of the CCS technology and approves that it is implemented in Brazil with public investments – pointing out that the knowledge of the technology favors its acceptance. In addition, from the hypothesis tests, it was possible to observe a higher level of knowledge of CCS technology in individuals with postgraduate degrees and in the group of people who had contact with disciplines on the environment, sustainability, and renewable energies.

In the perception of risks, it was found that there is indecision on the part of the population regarding the CCS technology being considered safe, with more people satisfied with the safety aspects of the technology in the groups aged between 40 and 44 years old. Despite this, among those who do not accept the technology and do not consider it safe, the vast majority consider accepting it if there is a decrease in the risks associated with it.

This study managed to achieve all the objectives it intended to meet, however, as shown by the various research listed here, the CCS technology, although promising, is still with low knowledge by the Brazilian population, being often seen as a secondary option to the detriment of other actions and technologies with the purpose of mitigating the greenhouse effect, such as wind energy, for example, largely due to the incentives and massification of information that these other technologies receive. Thus, for a more comprehensive understanding of the aspects of CCS, new studies should be carried out with broader and more representative audiences of the population, in order to investigate gaps that may be filled in order to favor its acceptance – especially regarding its wide dissemination and better understanding of its use.

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AMBIENTE & SOCIEDADE 25 anos 25 años 25 years

SciELO

Consciência Ambiental e Percepção Pública sobre a Captura e Armazenamento de Carbono em Universidades Brasileiras

Lucas Alexandre Franklin Toé
Ana Paula Meneguelo
Gisele de Lorena Diniz Chaves

Resumo: A Captura e Armazenamento de Carbono (CCS) se insere como uma possível alternativa no esforço de reduzir as emissões de GEE no planeta. Apesar disso, o sucesso de uma nova tecnologia não depende unicamente de conceitos técnicos de engenharia, envolve, também, fatores sociais, como a aceitação do público. O objetivo desta pesquisa foi analisar a percepção pública acerca da tecnologia de CCS, relacionando-a com a consciência ambiental, deste público, no âmbito das mudanças climáticas. Para a obtenção dos dados, aplicou-se um questionário elaborado em universidades federais da região sudeste brasileira, respondido por 671 indivíduos, entre alunos e professores atuantes nas universidades estudadas. Os resultados apontam para um baixo conhecimento acerca da tecnologia, porém, com maioria favorável à sua aceitação. Além disso, constatou-se relação entre os preocupados com as mudanças climáticas e os que aceitam a CCS, mostrando, também, que um maior conhecimento acerca da tecnologia pode influenciar em sua aceitação.

Palavras-chave: CCS; Dióxido de Carbono; Gases do Efeito Estufa; Percepção Pública; Universidade Federal.

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Concienciación Ambiental y Percepción Pública Sobre la Captura y Almacenamiento de Carbono en las Universidades Brasileñas

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Resumen: La Captura y Almacenamiento de Carbono (CCS) es una posible alternativa en el esfuerzo por reducir las emisiones de GEI en el planeta. A pesar de esto, el éxito de una nueva tecnología no depende únicamente de conceptos de ingeniería técnica, también involucra factores sociales, como la aceptación del público. El objetivo de esta investigación fue analizar la percepción del público sobre la tecnología CCS, relacionándola con la conciencia ambiental de este público, en el contexto del cambio climático. Para obtener los datos, se aplicó un cuestionario elaborado en universidades federales de la región sureste de Brasil, respondido por 671 personas, entre estudiantes y profesores que actúan en las universidades estudiadas. Los resultados apuntan a un bajo conocimiento sobre la tecnología, con una mayoría favorable a su aceptación. Además, se encontró una relación entre los preocupados por el cambio climático y los que aceptan la CCS.

Palabras-clave: CCS; Dióxido de carbono; Gases de invernadero; Percepción pública; Universidad Federal.