Climate-U
Transforming Universities for a Changing Climate

Higher Education Institutions Facing Climate Change: The Brazilian scenario

Transforming Universities for a Changing Climate
Working Paper Series
No. 5

By Luciana Londero Brandli, Amanda Lange Salvia, Janaína Mazutti, Giovana Reginatto

October 2021

GCRF
UK Research and Innovation

Climate-U
Transforming Universities for a Changing Climate

Higher education institutions facing climate change: the Brazilian scenario

Transforming Universities for a Changing Climate
Working Paper Series, No. 5

Luciana Londero Brandli, Amanda Lange Salvia, Janaína Mazutti, Giovana Reginatto

October 2021

Contact: Luciana Londero Brandli brandli@upf.br

www.climate-uni.com
Tweet @ClimateUniv

ISSN: 2754-0308

GCRF
UK Research and Innovation

Abstract

Climate change is a topic of global concern and demands efforts from all sectors. Higher education institutions have an important role in acting towards sustainability and climate action, not only through their main domain – teaching and learning – but also in opportunities related to research, outreach and campus operations. This working paper focuses on the Brazilian context and presents how climate change has been dealt with in each of the main university dimensions: curricula, research, outreach and operations. It reflects on the main challenges for further action in these dimensions, and suggests future research needs in terms of climate change in universities. This national assessment is useful for a better understanding of the main factors that guide or hinder higher education efforts towards climate action and highlights the importance of climate change research projects to overcome challenges, especially in low- and middle-income countries. Although the Brazilian higher education system can be considered well developed and complex, climate action efforts are diffuse, do not have support from specific and national guidelines, and depend on availability of resources. This working paper proposes a set of recommendations that could apply to other similar contexts that would improve the impact of universities in addressing climate change.

Acknowledgments

This study forms part of the Transforming Universities for a Changing Climate research project, funded by the Economic and Social Research Council as part of the Global Challenges Research Fund. We would like to thank Tristan McCowan, Charlotte Nussey and José Baltazar Salgueirinho Osório de Andrade Guerra for their perceptive comments on an earlier draft of this paper, and David Heymann for the design.

Authors

Prof. Dr. Luciana Londero Brandli is a Professor at the University of Passo Fundo, Brazil. Her work focuses on sustainability in higher education, the 2030 Agenda, Climate Change, Education for Sustainability and Sustainable Cities. She is Deputy Editor of the Encyclopedias of Sustainability in Higher Education and of the UN Sustainable Development Goals. She serves on the editorial board of various journals, supervises a number of master's and doctoral students on engineering, environment and sustainability issues and has in excess of 300 publications. She is the co-investigator in Brazil for the Transforming Universities for a Changing Climate research project.

Dr. Amanda Lange Salvia is a Research Associate of the international project Transforming Universities for a Changing Climate at the University of Passo Fundo, Brazil, and Deputy Editor of the Encyclopedia of the Sustainable Development Goals. Her work focuses on the role of universities towards sustainability, the impacts of climate change and the Sustainable Development Goals.

Janaina Mazutti has a degree in Environmental Engineering (2018), a Master's in Civil and Environmental Engineering (2021) and she is currently a PhD student at the Graduate Program in Civil and Environmental Engineering, at University of Passo Fundo, Brazil. Her interests include sustainability in higher education, the 2030 Agenda for Sustainable Development and climate change adaptation and mitigation. She is currently a researcher on the international project "Transforming Universities for a Changing Climate".

Giovana Reginatto has a degree in Civil Engineering (2020), and she's a master's student in the Graduate Program of Civil and Environmental Engineering, at the University of Passo Fundo, Brazil. Her interests are on Sustainable Development Goals, sustainability at universities, adaptation and mitigation to climate change. She is also a researcher of the project "Transforming Universities for a Changing Climate".

1. Introduction

Climate change can significantly affect a nation's society, culture and economy, and vulnerability to it depends largely on socio-economic level (Santos et al., 2017). Inhabitants, especially from low-income groups, may suffer from the consequences caused by extreme weather events, with risk scenarios and urban fatalities caused by improper occupation of land, disordered urbanization and precarious human settlements, exposed to floods and landslides (Jacobi and Sulamain, 2016). With the growing effects of climate change in the world, communities need to adapt to these changes and learn how to be resilient.

In Brazil, the causes and impacts of climate change are of particular concern in the Amazon (Marengo et al., 2011; UNDP, n.d.), due to its importance in regulating global climate, in preserving biodiversity and in influencing the carbon cycle on Earth. Nevertheless, events such as drought, torrential rains, landslides, intense winds, tornadoes and tropical cyclones are increasing in intensity and frequency in the whole Brazilian territory (Nexo, 2017). Furthermore, the country has been experiencing increases in average annual temperatures, following the global temperature increase (National Geographic, 2020). In this context, Carlos et al. (2019) highlighted the importance of disseminating knowledge about climate change in Brazil, focusing on the need for educating people to adapt to these changes.

Climate Action, expressed in the United Nations Sustainable Development Goal 13, has been a challenge for several global territories, not solely for Brazil. Research presented by Salvia et al. (2019) shows that when compared to the other SDGs, the topic of climate change stands out as a major global research trend, being the most studied SDG in several continents, reflecting its importance. Additionally, Nerini et al. (2019) emphasised that research on climate change is essential since it is a problem for many global regions, affecting both developed and developing countries. The effects of climate change could make the achievement of all SDG targets harder by posing challenges for social, economic, political, and environmental aspects.

In this context, climate change education becomes an increasingly relevant theme for all levels and contexts of education, and should be addressed in formal, non-formal and informal education (UNESCO, 2010). Regarding formal education, higher education institutions play a significant role since they are educating the leaders and decision makers of the future society (Fahey, 2012). In addition, they are spaces of teacher training for basic education (Junges, 2019). In this way, universities operate indirectly at all levels of education (primary, elementary, secondary and higher) and in all forms of education.

As Brazil is a country with continental dimensions, it is inevitable that its higher education system is equally vast and in a certain way, complex. The consolidation of higher education in Brazil, with the establishment of universities, is relatively recent, with the first institutions dating from the 1930s. Currently, higher education in Brazil is working on ways to contribute to research aimed at climate change. However, its contributions are still not properly incorporated into the educational system, mostly due to the absence of guidelines for climate change education in higher education or at any level of education in Brazil.

This working paper aims to explore how climate change is expressed in different dimensions of universities. The following parts of this working paper first briefly set out the higher education system in Brazil, before exploring specific efforts regarding curricula, campus operations, research and outreach, followed by a final section discussing challenges and opportunities for future efforts, which can apply also to other countries with similar educational contexts.

2. The higher education system in Brazil

In general, the higher education system in Brazil can be classified by the form of financial maintenance and the academic organization of the institutions (Stallivieri, 2007). In terms of academic organization, Decree nº 9.235/2017 divides the system into three categories: universities (institutions that carry out research and community outreach activities in addition to teaching, with at least one third of the teaching staff qualified at master's and doctoral level); university centres (institutions that promote teaching in various courses, but unlike universities are not required to conduct research); colleges and integrated schools of higher education (smaller institutions with little autonomy). Regarding financial maintenance, higher education institutions are classified as public (maintained by the public authorities and free of charge to students) and private (maintained by student fees). They may be community[1], denominational, philanthropic or for-profit (Stallivieri, 2007).

1 The community model, specific from southern Brazil, encompasses universities that despite being private, are non-profit institutions and revert possible profits to the local and regional communities. In this model, in addition to the central focus on teaching and research, the university is committed to improving its community by promoting outreach projects (Stallivieri, 2007; Neves, 2015)

According to the latest survey of the Map of Higher Education in Brazil (Semesp Institute, 2019), both the number of institutions and the number of enrolments in higher education are growing within the country. This growth is mainly driven by the private education system, which represents 88% of the Brazilian higher education institutions, while the public system represents only 12% (Semesp Institute, 2019). When analysed by student enrolment figures, the private system accounts for 71% of student numbers.

In terms of graduate programmes, Brazil has 6,965 courses (3,652 Masters, 2,427 PhD, 853 Professional Masters and 33 Professional PhD) (data from 2019). Regarding knowledge production, the country ranks 13th in a list of number of publications indexed in the database Web of Science (2011-2016), with 250,680 documents, a citation impact of 0.86, and 32.03% of international collaborations (Cross et al., 2018). These results compare well with neighbouring and economically similar countries: the country has also the best situation in Latin America in relation to research and development expenditure as percentage of GDP (1.3%) and has the second highest of rate of researchers per million people (887) – only behind Argentina, with 1,206 researchers (UNESCO, 2020). These figures are low, however, when compared to top countries in these indicators, such as Republic of Korea (4.3% and 6,826 researchers) and Finland (3.2% and 7,009 researchers), for example, suggesting the importance of more investment in research, science and technology, in addition to training human resources. It is also important to highlight the fact that although public HEIs account for only 12% of institutions in Brazil, they occupy the highest positions in international rankings around research and sustainability efforts.

Regulation of higher education in Brazil is overseen by the Ministry of Education (MEC) and the Federal Council of Education, which are responsible, among other things, for authorizing the establishment of new higher education institutions, new courses and changes in curricula through the National Curriculum Guidelines for Higher Education (Neves, 2015). The Ministry of Education specifies the content units that must be covered by the courses and their respective workload. Within these units, MEC also specifies relevant topics to be addressed, but allows universities to prioritize specific themes, safeguarding the peculiarities of their contexts. Therefore, the curricula for undergraduate courses in Brazil are prepared by universities, following the National Curriculum Guidelines for Higher Education, proposed by the Ministry of Education and the Federal Council of Education (Neves, 2015).

3. Addressing climate change in higher education

A number of policies set up the potential for addressing climate change in higher education institutions. The earliest of these, the National Environmental Education Policy[2] from 1999, provides principles for the integration of environmental education into formal and non-formal education. Nevertheless, it addresses education for sustainable development in a very superficial manner and has no recommendation for climate change education specifically. Thus, although environmental education is considered "an essential and permanent component of national education" (Brazil, 1999, Art 2), in which its contents must be present transversally[3] at all levels of education, there is no national reference for specific guidelines on education for sustainable development nor on climate change education (Brazil, 1999; MMA, 2010). In 2010, the Department of Environmental Education (DEA) of the Brazilian Ministry of the Environment (MMA) promoted and coordinated the discussion on the development of guidelines for Environmental Education in the context of climate change. However, no public information is available on the results of this discussion and the guidelines have not been formalized

More recently, in order to address this gap, the Education Commission of the Chamber of Deputies approved the Law Project 5203/2013 which includes in the National Policy of Environmental Education the themes of climate change, biodiversity protection and the risks and vulnerabilities to socio-environmental disasters (Brazil, 2013). In the project report, one of the proposed changes suggests the "insertion of themes related to climate change, the protection of biodiversity and other aspects related to environmental issues in the institutional and pedagogical projects of Basic Education and Higher Education" (Brazil, 2020a). Despite this significant progress, the Project was shelved in 2015, since the full Chamber of Deputies did not vote on it before the end of its term. Thus, in addition to not being sanctioned by law, the project is no longer under study. This was the most recent Brazilian initiative towards environmental education in the context of climate change and its integration into the pedagogical projects of basic education and higher education.

In the Brazilian higher education system, environmental education or climate change education policies are not formally registered in national guidelines. The closest effort was made in 2002 by the University Network of Environmental Education Programs (RUPEA) together with the National Association of Graduate Studies and Research in Education (ANPEd) when in a joint effort they created thematic working groups on environmental education for elaboration of a proposal to create an Environmental Education Policy in Higher Education (Brazil, 2005). Nonetheless, there is no public information available on the outcomes of this proposal, and it is not clear whether it was implemented.

The implementation of the 2030 Agenda at the national level reinforced the importance of developing efforts focused on the topic of the Sustainable Development Goals (SDGs) and, consequently, on the theme of climate change. According to the new ordinance of the Ministry of Education, undergraduate courses should encourage students to present the relationship between their research topic and the SDGs. In the specific case of undergraduate programs in engineering within the "Engineering

2 Brazil (1999) Law nº 9.795, April 27th, 1999. Addresses environmental education, institutes the National Environmental Education Policy and establishes other measures. Available at: http://www.planalto.gov.br/ccivil_03/leis/l9795.html.

3 These contents do not need to be approached as a new discipline, instead, they must integrate and reinforce topics in existing disciplines.

Area 1" (national classification), the Area Document suggests the approach and insertion of SDGs 6 (Water and Sanitation), 9 (Industry, Infrastructure and Innovation) and 11 (Sustainable Cities and Communities) for being directly linked to the themes covered by this area (CAPES, 2017). Climate change by means of SDG 13 is not specifically mentioned, but it is closely related to these other goals.

Following these general efforts and developments, the subsequent sections present university efforts in the main higher education areas of curricula, campus operations, research, and outreach.

3.1 Curricula

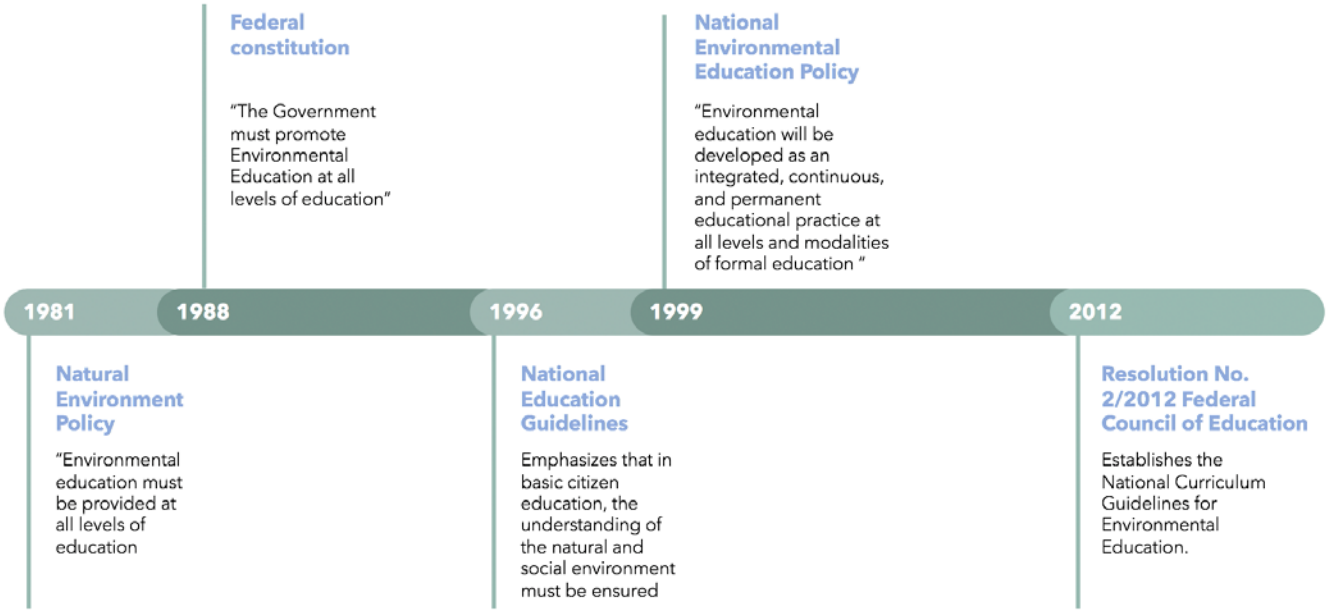
As described by Hesselink (2000) and Rocha et al. (2020a), climate change education (CCE) is a specific theme within the field of study of education for sustainable development (ESD), which is, in turn, part of the larger topic of environmental education (EE). For Meira Cartea (2019, p.1), climate change education can be seen as "a specific area of Environmental Education aiming at designing and developing educational responses based on informed decisions intended to be effective in the context of the climate crisis". Although one might argue about the differences between environmental education and education for sustainable development (Pavlova, 2011), climate change education connects to both aspects in order to avoid inefficiencies in achieving its goals and as both aim to equip citizens with competencies to respond to sustainability challenges (UNESCO, 2017).

According to Silva et al. (2016), ESD is not yet consolidated in Brazil, thus CCE is worked with in a transversal way, within environmental education. Ribeiro (2015) argues that both the 1981 National Environment Policy (PNMA) and the 1988 Federal Constitution make it mandatory to promote environmental education at all educational levels (Brazil, 1981; Brazil, 1988). Additionally, in 1999, the National Environmental Education Policy (Law 9,795/1999) provided guidance on the promotion of environmental education as an essential component of national education, which should be included in formal and non-formal education in Brazil (Brazil, 1999). More recently, in 2012, Resolution 2/2012 of the National Council of Education and the Ministry of Education established the National Curriculum Guidelines for Environmental Education at secondary level (Brazil, 2012). Figure 1 shows the evolution of these regulatory frameworks over the years.

According to Silva et al. (2016), in Brazil, the theme of climate change is also a topic addressed within environmental education. Therefore, it is understood that its approach at all levels of education is mandatory, although there is no official document that regularizes and formalizes CCE and ESD in Brazil. However, there are specific efforts to gradually discuss this situation and test implementations. One example is the study developed by Rocha et al. (2020b), that used international materials, like the UNESCO guidelines (UNESCO, 2014), which were adapted to the Brazilian context and applied in an elementary school.

Regarding formal education, the National Curriculum Guidelines for Higher Education guide the approach of pedagogical projects for undergraduate courses at the national level. These guidelines aim to guarantee the training of professionals committed to the community and interdisciplinary training that includes the theme of sustainable development in its three dimensions, environment, economic and social. Courses from different areas of knowledge reinforce in their guidelines the commitment to approach the theme of environmental education across the board. The guidelines focus mainly on the integration of contents related to environment management, environmental education and sustainability; however, no specification is given to climate

Figure 1. Evolution of the Brazilian regulations on environmental education (Prepared by the authors based on Brazil (1981, 1988, 1996, 1999, 2012)



change education or climate change issues. In addition, how this content related to environmental education should be dealt with and the topics that it should address are not clearly specified in the guidelines.

Although the Brazilian national government resolution (No. 2/2012) from the Ministry of Education (MEC) emphasizes that curriculum planning should address environmental issues, the curriculum in environmental education, education for sustainable development and climate change education in Brazil is not adopted mandatorily by universities, being themes worked more in the context of primary and secondary education, even though they are not mandatory for these levels either. This fact is also perceived in other contexts: after a survey that was carried out with university students from the United States, Wachholz and Chene (2012) highlighted that climate change education has been focusing on elementary and secondary education while its approach is limited in universities. Leal Filho et al. (2019) commented that, in general, although universities promote a lot of research on climate change, not all institutions integrate content related to the theme in their curricula.

In Brazil, isolated initiatives are taken, such as the one adopted by the University of São Paulo (USP). Correia et al. (2010) reports that the School of Arts, Sciences and Humanities (EACH) adopted the so-called "Basic Cycle" in the 11 undergraduate courses offered. In addition to eight hours per week of classes related to specific fields of training, students have 12 hours per week of "interdisciplinary knowledge", of which 6 hours are dedicated to "General Disciplines". These disciplines include themes that address environmental issues and climate change (Correia et al., 2010).

In the view of Jacobi (2014), in addition to addressing the global context of the climate crisis, the curriculum on climate change education in Brazil should include topics related to the difficulties experienced in each region. In this sense, the author emphasizes that curricular adaptation to regional and cultural differences is one of the challenges of the climate change education curriculum (Jacobi, 2014). Similarly, Perkins et al. (2018) argues that cultural differences should be taken into account when thinking about teaching about climate change.

On the other hand, Caetano et al. (2018) argue that the curriculum approach to climate change in HEIs does not necessarily need to meet the formal education model. In the authors' view, climate change education can include aspects of non-formal education such as online courses or MOOCs (Massive Open Online Courses). These courses can disseminate basic knowledge on climate change to all students enrolled at the university and in some cases, they can also be made available to society as a whole.

In addition, when it comes to climate change education, Meira Cartea (2019) describes the need to "include Climate Literacy[4] among its tools" but also go beyond that and "incorporate a sense of social and environmental urgency and emergency" (p.1), calling for civic education and commitment. Cooper et al. (2019 p.10) emphasize the need for climate literacy to include "political, societal, economic, and psychological aspects of climate change, as well as strategies for action, adaptation, and mitigation". Complementing this view, an important contribution is made by Trajber et al. (2019) showing how holistic approaches to climate change, which consider in parallel the promotion of strategies for adaptation and mitigation, can promote the emancipation of individuals and highlight the protagonism of individual actions.

Thus, as Silva et al. (2016) argue, for a successful integration of CCE in the curricula of all levels of education, interdisciplinary discussions should be promoted, seeking to understand not only the climatic phenomena themselves, but also to understand their impacts on different communities, turning attention also to the social impacts of climate change. In this sense, this section presented some specific actions taken in Brazil when it comes to including climate change in the curricula, but the lack of support from specific guidelines and integrated and interdisciplinary movements hinders success in this area. Another challenge related to this integration refers to the lack of a clear definition, distinction, and relation of CCE, ESD and ED, which contribute to the risk of using these as empty signifiers (Jickling and Sterling, 2017).

3.2 Campus operations

University campuses are widely recognized as part of the dynamics of cities (Finlay and Massey, 2012). Therefore, strategies for sustainable management that include mitigation and/or adaptation to climate change proposed in urban centres can also be used and replicated in a university campus, and vice versa. According to Fissi et al. (2021), the main projects related to campus operation are green buildings, related to energy efficiency and use of renewable energy, with the aim of reducing greenhouse gases emissions; waste management, encouraging responsible consumption; and sustainable mobility, promoting the sustainable use of public and individual modes of transportation.

The Brazilian national government resolution (No. 2/2012), highlights that the management of an educational institution must stimulate, contribute and promote a culture of sustainability both internally and in the society around it. In the view of Layrargues et al. (2011), when a university adopts a sustainable posture and promotes environmental management in campus activities, it is also favouring curricular environmentalization, as it presents in a practical way the promotion of a pro-environmental posture.

In this sense, many examples can be found in Brazilian university campuses. Energy is one of the main axes worked with in terms of climate action and reduction of carbon emissions, with the participation of renewable sources in the energy matrix of universities being increasingly frequent. Likewise, aiming at reducing greenhouse gas emissions, universities are investing in sustainable mobility on their campuses, encouraging the use of

4 Climate literacy refers to competence or "knowledge in the area of climate change, its impacts, and its solutions" (Johnston, 2019, p. 1).

public transport or bicycles and, in some cases, restricting the circulation of individual vehicles. Also, the forest management of the campus and the conservation of green areas also contribute through the capture of carbon from the atmosphere by vegetation, reinforcing the presence of so-called carbon sinks. Although these general recommendations are important for mitigating the impacts of climate change, their implementation depend not solely on the university efforts, but also on the city context (e.g., the possibility to use public transportation) and on public administration efforts. The potential of implementation in universities relies greatly on available budget and funding opportunities in each institution and their contexts. Table 1 presents a compilation of sustainable actions taken by some Brazilian universities to contribute to mitigation and/or adaptation to climate change.

These initiatives show how universities have been adapting and innovating in different aspects in order to create more sustainable spaces. The adaptation of these institutions comes both to comply with their social responsibility and to meet external pressure (as in the case of environmental and clean energy certifications). Since the training of students at a university also involves life on campus, new experiential learning opportunities are created where a sustainable lifestyle is shown in practice, promoting mitigation and adaptation strategies to climate change. In addition, Mandai and Brando (2018) emphasize that pioneering actions in universities have a strong influence for similar actions both in other universities and in local communities, catalyzing transformations towards a more sustainable society.

It is worth noting that as important as developing these actions is the promotion of institutional governance that guarantees sustainable management of activities on campus. The case of USP, presented by Mandai and Brando (2018), shows how the implementation of an Environmental Management Superintendence (SGA) has expanded sustainability actions and promoted climate change mitigation and adaptation especially by promoting the efficient use of water and energy and by coordinating actions to reduce the ecological footprint on campus.

Table 1. Some examples of activities adopted by Brazilian universities

Axis	Action	Contribution	University/ Region	Reference
Governance	Creation of the Environmental Management Superintendence (SGA)	Coordination of sustainability actions at the university	USP/ Southeast	Mandai e Brando (2018)
	ISO 14001 Certification	Commitment to guarantee the sustainable development of the university	Unisinos/ South	Unisinos (2020)
Forest management	Preservation and reforestation of green areas on campus	Preservation and increase of "carbon sinks"	USP/ Southeast	Mandai e Brando (2018)
			UPF/ South	Melo et al. (2019)
Water	50% reduction in water use at the university.	Adaptation strategy in the face of water scarcity due to drought	UFBA/ Northeast	Marinho et al. (2014)
Mobility	Bicycle incentive programme	Reduction of GHG emissions	UFPR/ South	Nakamori et al. (2015)
	Ride incentive programme	Reduction of GHG emissions	UFPE/ Northeast	Silva (2017)
Energy	Use of energy from renewable sources	Mitigation strategy to reduce carbon emissions	UNISUL/ South	Ribeiro et al. (2020)
			UPF/ South	Rebelatto et al. (2019)
	Increased energy efficiency	Mitigation strategy that aims to reduce carbon emissions by reducing energy consumption	UNISUL/ South	Ribeiro et al. (2020)
			UPF/ South	Rebelatto et al. (2019)
			UFBA/ Northeast	Costa et al. (2019)
	Changing conventional lamps to LED lamps	Mitigation strategy that aims to reduce carbon emissions by reducing energy consumption	UPF/ South	Rebelatto et al. (2019)

In general, these activities aim to make universities more sustainable by reducing the environmental impacts of operations on campuses. This set of cases also highlights the predominance of the South and Southeast regions in the analysis, most likely due to the fact that the largest number of Brazilian universities are concentrated in these regions. These experiences also indicate how the national higher education system connects climate action to sustainability measures.

3.3 Research

Research on climate change involves a huge variety of topics, approaches and objectives. The university has a central role in the development of research not only to further disseminate the theme, but also to develop content, new technologies and methods to assist local communities, companies and the government in the implementation of plans, monitoring, mitigation and adaptive measures, among others.

As presented by Berchin et al. (2018), climate change is a term that stands out in academic conferences on sustainability in Brazil. On the other hand, in a global study on climate change education, Molthan-Hill et al. (2019), noted that respondents from Brazil indicate their universities need more planning to address the theme. There is a tendency for there to be more and more research groups and research projects related to climate change, mostly because this is a theme that covers the most diverse areas of study and that impacts all regions and socioeconomic contexts (Salvia et al., 2019).

By using the Web of Science database for a search on publications related to climate change research, interesting results can be observed. With the search string "climate change research" and "Brazil", more than 500 references can be found in the whole database lifespan (1945-2020). The first references were published in the 1990s and, as for most research areas, publications presented an exponential growth throughout the years.

As shown in Table 2, with some selected studies as examples, climate change research in Brazil covers a wide range of topics, from education to health, from impacts on urban areas to impacts on the Amazon, and from water-food-energy nexus to weather patterns.

In terms of policies, Brazil has the National Plan for Graduate Studies (in Portuguese: Plano Nacional de Pós-Graduação - PNPG 2011-2020). Encouragement to the multidisciplinary study of climate change is among the plan guidelines, and several environmental issues are among the research topics presented as challenges for Brazil (i.e. water, energy, transportation, agribusiness, and the Amazon region) (CAPES, 2010). Additionally, to support and expedite the examination of patent applications related to environmentally friendly technologies, the government developed the programme Green Patents, aiming to contribute to addressing global climate change. The programme covers issues related to the areas of clean energy, transportation, energy conservation, waste management and sustainable agriculture (Brazil, 2020b).

Brazil has a consolidated international research profile in several areas, including climate change. Similarly to the situation of campus operations, it is common to observe synergies and overlaps with sustainable development topics. Further developments in climate change research in Brazilian institutions depend on availability of financial resources, especially for continuation and practical implementations.

Table 2. Examples of studies related to climate change research in Brazil

Main topic	Title	Authors
Education and awareness	Promoting climate change transformation with young people in Brazil: participatory action research through a looping approach	Trajber et al. (2019)
Water-food-energy nexus	The socio-ecological Nexus+ approach used by the Brazilian Research Network on Global Climate Change	Araujo et al. (2019)
Impacts on Amazon	Impacts of climate change and deforestation on hydropower planning in the Brazilian Amazon	Arias et al. (2020)
Climate change and energy issues	Estimating the impact of climate change on wind and solar energy in Brazil using a South American regional climate model.	de Jong et al. (2019)
Relation with diseases	Climate change and health: An analysis of causal relations on the spread of vector-borne diseases in Brazil	Leal Filho et al. (2018)
Connection with environmental aspects	Marine and coastal environmental education in the context of global climate changes - synthesis and subsidies for Rebentos	Berchez et al. (2016)
Urban aspects	The urban growth of the metropolitan area of Sao Paulo and its impact on the climate	de Lima et al. (2018)
Weather patterns	Changes in precipitation extremes in Brazil (Paraná River basin)	Zandonadi et al. (2016)

3.4 Outreach

In Brazil, the need for universities to meet the principle of inseparability between teaching, research and outreach is reinforced in article 207 of the Federal Constitution (Brazil, 1988). Thus, the performance of these teaching centres expands to also meet the needs of local society. Table 3 presents a brief mapping of the initiatives of Brazilian universities in the aspect of outreach. The actions were divided between projects, courses and events.

In the Brazilian scenario, the outreach pillar promotes environmental awareness initiatives that address the theme of climate change indirectly. At the University of Passo Fundo (UPF), for example, the Ecological Fair promoted on campus serves the academic and regional community and encourages the purchase of local and organic products (Brandli et al. 2019). At the Federal University of Paraná (UFPR), the Ciclovida outreach programme works to raise awareness and encourage the use of bicycles, with its actions focused both on the academic community and in the city of Curitiba, by encouraging interdisciplinary research, academic work, and curricular insertion, and developing events to demonstrate the benefits of using the bicycle as a means of transport and also as a tool to improve the quality of life (Nakamori et al. 2015). Regarding climate change, projects promoted by the Federal University of Minas Gerais (UFMG) and the Federal University of Pernambuco (UFPE) can be highlighted. Of these, the project Climate Change Adaptation: autonomy for communities and urban resilience promoted a unit for the Architecture and Urbanism course (UFMG, 2017), whose objective is to develop actions aimed at increasing the local adaptation capacity of the most vulnerable inhabitants to the adverse effects of climate change.

Several outreach projects involve public school students. The project Social practices for the development of sustainability awareness in public school students, developed by the Federal University of Rio Grande do Sul, involved public primary school students in the discussion about the anthropic action in the environment (UFRGS, 2020a). The project, still in progress, has as expected results the awareness of children through practical activities on sustainable lifestyles and sustainable consumption. Another initiative focused on raising awareness is the project How is Climate and Water at School: Pedagogical Practices in Environmental Education to Combat Climate Change, developed by the University of Brasilia, which promotes the training of teachers and leaders of the region on the role of environmental education in tackling climate change, based on the results of a mapping of pedagogical actions on climate and water developed in elementary schools (UNB, 2018). The project Plant a fruit species from the Amazon and learn its importance in the conservation of biodiversity, put into practice by the Federal University of Amazonas, in the north of the country, distributes Amazon native fruit species to students from a public school and highlights the importance of fruit trees for biodiversity conservation (UFAM, 2018).

Table 3. Examples of outreach projects

Category	Action	University/ Region	Reference
Outreach project	Ecological Fair: a new view on campus	UPF/South	Brandli et al. (2019)
	Ciclovida Program	UFPR/South	Nakamori et al. (2015)
	Climate Change Adaptation: autonomy for communities and urban resilience	UFMG/Southeast	UFMG (2017)
	CLIMA Network - Brazilian Research Network on Global Climate Change, Cities and Urbanization Subnet	UFMG/Southeast	UFMG (2014)
	Social practices for the development of sustainability awareness in public school students	UFRGS/Southeast	UFRGS (2020a)
	Technical and participatory mapping of areas at risk of landslides, erosion and floods in the State of Pernambuco - dialogical interaction	UFPE/Northeast	UFPE (2018)
	How is Climate and Water at School? Pedagogical Practices of Environmental Education to Combat Climate Change, Planaltina (DF)	UNB/Centro-Oeste	UNB (2018)
	Plant a fruit tree from the Amazon and learn its importance in biodiversity conservation	UFAM/North	UFAM (2018)
Outreach courses	Basic Training in Meteorology and Climatology	UFMG/Southeast	UFMG (2018b)
	Learning hydrology for natural disaster prevention - 2	UFRGS/South	UFRGS (2020b)
	Introduction to Photovoltaic Systems, Dimensioning and Installation	USP/Southeast	USP (2020)
	Basic Course of Solar Thermal and Photovoltaic Energy	UFPE/Northeast	UFPE (2020)
	Educational course for generation of electricity from wind power	UFC/Northeast	UFC (2020)
Outreach Events	Challenges of implementing climate policies in Brazil: looking for a transdisciplinary vision	UFMG/Southeast	UFMG (2016)
	Climate Perspectives for Northern Minas Gerais State	UFMG/Southeast	UFMG (2019)

In other universities, the outreach pillar is mainly committed to promoting courses aimed at the general public in order to disseminate knowledge. Courses focused on the environmental theme address renewable energy, prevention of natural disasters and teaching basic concepts about meteorology and climatology. The example of outreach events promoted by the Federal University of Minas Gerais highlighted the debate on the challenges of mitigation and adaptation to climate change in Brazil and addressed the local climate perspectives (UFMG, 2020).

These examples of projects and initiatives show the diversity of the universities' activities and emphasizes the importance of outreach in building a society with knowledge and skills to deal with climate change.

As indicated by UNESCO (2012) in a report on challenges for Brazilian higher education, efforts to support all academic activities – including outreach – demand strengthened collaboration within the country, partnerships between education, science, technology and innovation, and support to international integration. In the history of the higher education system in Brazil, outreach has received less attention – and financial support – in comparison to research, for example (Fernandes et al., 2012). The authors support the need for simultaneous work between research and outreach, ensuring quality education and community engagement. This is especially important in a moment where more private and for-profit institutions have been created – and the high number of students in these institutions (Duarte, 2014) - and consequently threaten the development of outreach and the commitment to real transformation (rather than a superficial one related to profit and low quality) (de Moraes Freire, 2011). Another issue in this context is the focus on publications and academic competition – which lead educators to focus on research and curriculum development rather than community application and practice (Almeida et al., 2012).

4. Conclusions: challenges and potentialities

This working paper aimed to explore the Brazilian context of higher education system and its connection with climate change. The sections reviewed literature on how climate change is approached in curricula, research, campus operations and outreach in Brazil. Even though the Brazilian higher education system can be considered well developed and complex in terms of number of institutions and enrolments, efforts towards climate action are diffuse, do not follow specific and national guidelines, and mostly depend on each institution's planning and resources.
Although the country has a strong legal framework related to environmental education, climate change legislation still addresses educational efforts in a superficial way (Trajber and Mochizuki, 2015). This aspect hinders university efforts towards climate change adaptation and mitigation, given the lack of specific guidelines to support action. Most efforts are unfortunately not consistent and not being pursued further, probably due to development constraints such as lack of resources or change of governance and responsible teams. Even for successful practices, challenges remain in terms of integrating opportunities and efforts to strengthen isolated actions in larger synergies. Another important challenge in the Brazilian context which is also related to isolated activities and continuation is the availability of funding for research, outreach and campus operations initiatives. Different types of institution have different commitments to sustainability and climate change efforts. Community and public universities, for example, tend to have higher allocated budgets for matters related to these aspects, in comparison to for-profit institutions.
Although mostly isolated, existing efforts should be acknowledged, as this paper has done, and future interventions need to be planned to build upon the current strategies and overcome the challenges already experienced. In this sense, some recommendations on future research needs can be presented:

1. inclusion of deeper strategies for climate change adaptation and mitigation in the Brazilian context, as impacts have been increasing across the country;
2. support for participatory and capacity-building initiatives, especially to integrate environmental education practices (which are more commonly applied in the country) to climate-related aspects;
3. development of a national network on climate action for Brazilian universities to share efforts and resources and build an integrated approach – avoiding studies/efforts to become isolated and compartmentalised;
4. possibilities for international and interdisciplinary cooperation – also in light of the 2030 Agenda – to support efforts towards climate action and overcome financial-related challenges.

By advancing in these aspects, it is also possible to have the higher education system contributing more practically to the development of national policies and guidelines, as a deeper understanding of the different approaches to climate action in the country will be fostered.

In addition to these recommendations, the collaboration between educational institutions and education national or regional coordination bodies is particularly important. Higher education institutions can share their experience and knowledge so that guidelines and policies could reflect the wide variety of characteristics, such as institutional profiles, availability of resources, and courses offered. These guidelines should be flexible enough to support all institutions, but also offer a framework for action at all levels.

References

Almeida, L. D., Araújo, M. D., & Guerreiro, M. R. (2012, November). Extensão Universitária no Ensino Superior: o diferencial na qualidade acadêmica. In Conferência do Fórum da Gestão do Ensino Superior nos países e regiões de Língua Portuguesa. Recuperado de http://aforges. org/conferencia2/05documentos. html.

Araujo, M., Ometto, J., Rodrigues-Filho, S., Bursztyn, M., Lindoso, D. P., Litre, G., ... & Assad, E. (2019). The socio-ecological Nexus+ approach used by the Brazilian Research Network on Global Climate Change. *Current Opinion in Environmental Sustainability*, 39, 62-70.

Arias, M. E., Farinosi, F., Lee, E., Livino, A., Briscoe, J., & Moorcroft, P. R. (2020). Impacts of climate change and deforestation on hydropower planning in the Brazilian Amazon. *Nature Sustainability*, 1-7.

Berchez, F. A. S., Ghilardi-Lopes, N. P., Correia, M. D., Sovierzoski, H. H., Pedrini, A. D. G., Ursi, S., ... & Brotto, D. S. (2016). Marine and coastal environmental education in the context of global climate changes-synthesis and subsidies for ReBentos (Coastal Benthic Habitats Monitoring Network). *Brazilian journal of oceanography*, 64(SPE2), 137-156.

Berchin, I. I., Sima, M., de Lima, M. A., Biesel, S., dos Santos, L. P., Ferreira, R. V., ... & Ceci, F. (2018). The importance of international conferences on sustainable development as higher education institutions' strategies to promote sustainability: A case study in Brazil. *Journal of Cleaner Production*, 171, 756-772.

Brandli, L.L.; Salvia, A.L.; Dal Moro, L.; Tibola da Rocha, V.; Mazutti, J. & Reginatto, G. (2019) How can ecological fairs increase sustainability in a university campus?. *International Journal of Sustainability in Higher Education*, 20 (3), 515-529.

Brazil (1981) Lei nº, de 31 de agosto de 1981. Dispõe sobre a Política Nacional do Meio Ambiente, seus fins e mecanismos de formulação e aplicação, e dá outras providências [National Environment Policy, purposes and formulation and application mechanisms].

Brazil (1988) Constituição da República Federativa do Brasil [Constitution of the Federative Republic of Brazil].

Brazil (1999) Lei nº 9.795, de 27 de abril de 1999. Dispõe sobre a educação ambiental, institui a Política Nacional de Educação Ambiental e dá outras providências [Provides for environmental education, institutes the National Environmental Education Policy and provides other measures]. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, no 79, Seção 1, p.1-3, 28 Apr. 1999.

Brazil (1996) Lei nº 9.394, de 20 de dezembro de 1996. Estabelece as diretrizes e bases da educação nacional. [Establishes the guidelines and bases for national education]. Diário Oficial [da] República Federativa do Brasil, Brasília, DF, 20 Dec. 1996.

Brazil (2008) Plano Nacional sobre Mudança do Clima [National Plan on Climate Change]. Governo Federal: Brasília. 132 pp.

Brazil (2009) Lei nº 12.187/2009 - Institui a Política Nacional sobre Mudança do Clima - PNMC e dá outras providências [Institutes the National Policy on Climate Change - PNMC and takes other measures].

Brazil (2012) Conselho Nacional de Educação/Ministério da Educação. Resolução nº 2, de 15 de junho de 2012. Estabelece as Diretrizes Curriculares Nacionais para a Educação Ambiental [Establishes the National Curriculum Guidelines for Environmental Education].

Brazil. (2013). PL 5203/2013 Bill. Available at: https://www.camara.leg.br/proposicoesWeb/prop_mostrarintegra?codteor=1067915&filename=PL+5203/2013 (last accessed 08/03/2020).

Brazil. (2016). Plano Nacional de Adaptação à Mudança do Clima [National Plan for Adaptation to Climate Change]. Ministry of the Environment. Brasília: MMA. 12 p.

Brazil. (2020a). Legislative Activity - Draft Laws and Other Propositions. PL 5203/2013 Bill. Available at: https://www.camara.leg.br/proposicoesWeb/fichadetramitacao?idProposicao=568729 (last accessed 08/03/2020).

Brazil. (2020b). Patentes Verdes, available at: https://www.gov.br/inpi/pt-br/servicos/patentes/tramite-prioritario/projetos-piloto/Patentes_verdes

Caetano, F. J., Oliveira, C. M., Araújo, M. F., & Rêgo, M. C. (2018). Towards Climate Change Awareness Through Distance Learning—Are Young Portuguese and Brazilian University Students Vigilant?. In *Climate Literacy and Innovations in Climate Change Education* (pp. 261-273). Springer, Cham.

CAPES (2010). "Plano Nacional de Pós-Graduação - PNPG 2011-2020", available at: https://www.capes.gov.br/plano-nacional-de-pos-graduacao

CAPES. Coordenação de Aperfeiçoamento de Pessoal de Nível Superior. (2017). Documento de Área: Engenharias 1. Available at: https://www.capes.gov.br/images/Documento_de_%C3%A1rea_2019/ENG1.pdf. Last accessed: 20 Apr. 2020.

Carlos, S. D. M., Cunha, D. A. D., & Pires, M. V. (2019). Conhecimento sobre mudanças climáticas implica em adaptação? Análise de agricultores do Nordeste brasileiro. *Revista de Economia e Sociologia Rural*, 57(3), 455-471

Cooper, O., Keeley, A., & Merenlender, A. (2019). Curriculum gaps for adult climate literacy. *Conservation Science and Practice*, 1(10), e102.

Correia, P. R. M., Valle, B. X., Dazzani, M., & Infante-Malachias, M. E. (2010). The importance of scientific literacy in fostering education for sustainability: Theoretical considerations and preliminary findings from a Brazilian experience. *Journal of Cleaner Production*, 18(7), 678-685.

Costa, M. L., Freire, M. R., & Kiperstok, A. (2019). Strategies for thermal comfort in university buildings-The case of the faculty of architecture at the Federal University of Bahia, Brazil. *Journal of environmental management*, 239, 114-123.

Cross, D., Thomson, S., & Sibclair, A. (2018) Research in Brazil: A report for CAPES by Clarivate Analytics. Available at: http://www.sibi.usp.br/wp-content/uploads/2018/01/Relat%C3%B3rio-Clarivate-Capes-InCites-Brasil-2018.pdf. Last accessed 18 Jan. 2021.

de Jong, P., Barreto, T. B., Tanajura, C. A., Kouloukoui, D., Oliveira-Esquerre, K. P., Kiperstok, A., & Torres, E. A. (2019). Estimating the impact of climate change on wind and solar energy in Brazil using a South American regional climate model. *Renewable energy*, 141, 390-401.

de Lima, G. N., & Rueda, V. O. M. (2018). The urban growth of the metropolitan area of Sao Paulo and its impact on the climate. *Weather and climate extremes*, 21, 17-26.

de Moraes Freire, S. (2011). Desafios da extensão universitária na contemporaneidade. Revista Conexão UEPG, 7(1), 8-15.

Duarte, J. D. S. (2014). As contribuições da extensão universitária para o processo de aprendizagem, a prática da cidadania e o exercício profissional (Doctoral dissertation, Dissertação. Programa de Pós-graduação em Educação. Universidade Católica de Brasília. Brasília).

Fahey, S. J. (2012). Curriculum change and climate change: Inside outside pressures in higher education. *Journal of Curriculum Studies*, 44(5), 703-722.

Fernandes, M. C., Silva, L. M. S. D., Machado, A. L. G., & Moreira, T. M. M. (2012). Universidade e a extensão universitária: a visão dos moradores das comunidades circunvizinhas. Educação em Revista, 28(4), 169-194.

Finlay, J., & Massey, J. (2012). Eco-campus: Applying the ecocity model to develop green university and college campuses. *International Journal of Sustainability in Higher Education*.

Fissi, S., Romolini, A., Gori, E., & Contri, M. The path toward a sustainable green university: The case of the University of Florence. *Journal of Cleaner Production*, 279, 123655.

Hesselink, F.; van Kempen, P. P.; Wals, A. E. (2000). *ESDebate: International debate on education for sustainable development*. IUCN (International Unioin for Conservation of Nature and Natural Resources), Gland, Switzerland and Cambridge, UK. 64p.

Jacobi, P. R. (2014). Mudanças climáticas e ensino superior: a combinação entre pesquisa e educação. Educar em Revista, (SPE3), 57-72.

Jacobi, P. R., & Sulaiman, S. N. (2016). Governança ambiental urbana em face das mudanças climáticas. *Revista USP*, (109), 133-142

Jickling, B. and Sterling, S. (2017). Post-Sustainability and Environmental Education: Framing Issues. In B. Jickling and S. Sterling (Eds.), Post-Sustainability and Environmental Education. Re-imagining Education for the Future (pp.1-11). Springer Nature AG, Cham, Switzerland.

Johnston J.D. (2019) Climate Change Literacy to Combat Climate Change and Its Impacts. In: Leal Filho W., Azul A., Brandli L., Özuyar P., Wall T. (eds) Climate Action. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-71063-1_31-1

Junges, A. L. (2019). Aquecimento global: uma questão sociocientífica a ser discutida na formação de professores de física da educação básica. (Doctoral dissertation).

Layrargues, P. P. et al. Diagnóstcos de percepção ambiental: o que pensam os alunos da Faculdade UnB Planaltina sobre gestão ambiental e sustentabilidade universitária. In: Catalão, V. M. L. et al. (Org.). Universidade para o século XXI: educação e gestão ambiental na Universidade de Brasília. Brasília: Cidade Gráfica e Editora, 2011. p. 87-98.

Leal Filho, W., Bönecke, J., Spielmann, H., Azeiteiro, U. M., Alves, F., Lopes de Carvalho, M., & Nagy, G. J. (2018). Climate change and health: An analysis of causal relations on the spread of vector-borne diseases in Brazil. *Journal of Cleaner Production*, 177, 589–596.

Leal Filho, W., Mifsud, M., Molthan-Hill, P., J Nagy, G., Veiga Ávila, L., & Salvia, A. L. (2019). Climate change scepticism at universities: A global study. *Sustainability*, 11(10), 2981.

Mandai, S. S., & da Rocha Brando, F. (2018). Experiences in sustainability of two public universities in different contexts: The University of Copenhagen and the University of São Paulo. In Towards Green Campus Operations (pp. 653-668). Springer, Cham.

Marengo, J. A., Nobre, C. A., Chou, S. H., Tomasella, J., Sampaio, G., Alves, L. M., ... & Kay, G. (2011). Dangerous Climate Change. A Brazil-UK analysis of climate change and deforestation impacts in the Amazon. 55pp.

Marinho, M., do Socorro Gonçalves, M., & Kiperstok, A. (2014). Water conservation as a tool to support sustainable practices in a Brazilian public university. Journal of Cleaner Production, 62, 98-106.

Meira Cartea P.Á. (2019) Climate Change and Education. In: Leal Filho W., Azeiteiro U., Azul A., Brandli L., Özuyar P., Wall T. (eds) Climate Action. Encyclopedia of the UN Sustainable Development Goals. Springer, Cham. https://doi.org/10.1007/978-3-319-71063-1_27-1

Melo, E. F. R. Q., Frandoloso, M. A. L., & Melo, R. H. R. Q. (2019). Green Campus and Environmental Preservation on a Brazilian University. In Sustainability on University Campuses: Learning, Skills Building and Best Practices (pp. 191-208). Springer, Cham.

MMA. Ministry of the Environment (2019) Brasil perto de cumprir meta de redução de CO2 em 2020, https://www.mma.gov.br/informma/item/15650-brasil-perto-de-cumprir-meta-de-redu%C3%A7%C3%A3o-de-co2-em-2020.html

MMA. Ministry of the Environment (2019). Linha do tempo das medidas envolvendo Mudanças Climáticas, https://www.mma.gov.br/component/k2/item/15164-linha-do-tempo-das-medidas-envolvendo-mudan%C3%A7as-clim%C3%A1ticas.html (last accessed 3/20/2020).

MMA. Ministry of the Environment (n.d). Fundo Nacional sobre Mudança do Clima https://www.mma.gov.br/clima/fundo-nacional-sobre-mudanca-do-clima.html

Molthan-Hill, P., Worsfold, N., Nagy, G. J., Leal Filho, W., & Mifsud, M. (2019). Climate change education for universities: A conceptual framework from an international study. *Journal of cleaner production*, 226, 1092-1101.

Nakamori, S., Belotto, J. C. A., Junior, M. F. F., & Oliveira, A. G. (2015). A contribuição da academia para mobilidade urbana sustentável por meio do programa de extensão universitária da UFPR–ciclovida. Revista Políticas Públicas & Cidades-2359-1552, 3.

National Geographic (2020). Brasil já sente impactos das mudanças climáticas e situação pode se agravar, https://www.nationalgeographicbrasil.com/meio-ambiente/2020/02/brasil-ja-sente-impactos-das-mudancas-climaticas-e-situacao-pode-se-agravar Last accessed: 20 Apr. 2020.

Nerini, F. F., Sovacool, B., Hughes, N., Cozzi, L., Cosgrave, E., Howells, M., ..., & Milligan, B. (2019). Connecting climate action with other sustainable development goals. *Nature Sustainability*, 2(8), 674-680.

Neves, C. E. B. (2015). Demand and supply for higher education in Brazil. In Higher Education in the BRICS Countries (pp. 73-96). Springer, Dordrecht.

Nexo (2017). Desastres Naturais no Brasil: um ciclo de tragédias anunciadas, https://www.nexojornal.com.br/ensaio/2017/Desastres-Naturais-no-Brasil-um-ciclo-de-trag%C3%A9dias-anunciadas Last accessed: 20 Apr. 2020.

Pavlova, M. (2011). Environmental education and/or education for sustainable development: What role for technology education. Griffith Research Online https://core.ac.uk/download/pdf/143904256.pdf

Perkins, K. M., Munguia, N., Moure-Eraso, R., Delakowitz, B., Giannetti, B. F., Liu, G., Nurunnabi, M., Will, M. & Velazquez, L. (2018). International perspectives on the pedagogy of climate change. *Journal of Cleaner Production*, 200, 1043-1052.

Rebelatto, B. G., Salvia, A. L., Reginatto, G., Daneli, R. C., & Brandli, L. L. (2019). Energy efficiency actions at a Brazilian university and their contribution to sustainable development Goal 7. *International Journal of Sustainability in Higher Education*.

Ribeiro, J. M. P., Autran, A., Santa, S. L. B., Jonck, A. V., Magtoto, M., Faraco, R. Á., & de Andrade, J. B. S. O. (2020). Identifying and Overcoming Communication Obstacles to the Implementation of Green Actions at Universities: A Case Study of Sustainable Energy Initiatives in South Brazil. In Universities as Living Labs for Sustainable Development (pp. 103-119). Springer, Cham.

Ribeiro, J. V. (2015). Representações sociais das mudanças climáticas globais: um estudo de caso com bacharelandos do curso de direito da Universidade de Cuiabá. Master dissertation, University of Cuiabá.

Rocha V.T., Brandli L.L., Mazutti J., Moro L.D., Gasperina L.D., Kalil R.M.L. (2020a) Teacher's Approach on Climate Change Education a Case Study. In: Leal Filho W., Tortato U., Frankenberger F. (eds) Universities and Sustainable Communities: Meeting the Goals of the Agenda 2030. World Sustainability Series. Springer, Cham. p. 617-642.

Rocha, V. T., Brandli, L. L., & Kalil, R. M. L. (2020b). Climate change education in school: knowledge, behavior and attitude. International Journal of Sustainability in Higher Education.

Salvia, A. L., Leal Filho, W., Brandli, L. L., & Griebeler, J. S. (2019). Assessing research trends related to Sustainable Development Goals: Local and global issues. *Journal of cleaner production*, 208, 841-849.

Santos, M. R. D. S., Vitorino, M. I., & Pimentel, M. A. D. S. (2017). Vulnerabilidade e mudanças climáticas: análise socioambiental em uma mesorregião da Amazônia. *Revista Ambiente & Água*, 12(5), 842-854.

Semesp Institute (2019). Mapa do Ensino Superior no Brasil 2019 [Map of Higher Education System in Brazil 2019]. Available at: https://www.semesp.org.br/pesquisas/mapa-do-ensino-superior-no-brasil-2019/.

Silva, C. M. L. F., Costa, F. A., & Borba, G. L. (2016). A educação em Mudanças Climáticas: uma abordagem interdisciplinar. [Climate Change Education: an interdisciplinary approach]. *Holos*, 4, 176-188.

Silva, L. A. D. S. (2017). Carona dinâmica como medida de mobilidade sustentável em Campus universitário (Master's thesis, Universidade Federal de Pernambuco).

Stallivieri, L. (2007). O sistema de ensino superior do Brasil características, tendências e perspectivas, 2006. Universidade Caxias do Sul.

Trajber, R., & Mochizuki, Y. (2015). Climate change education for sustainability in Brazil: A status report. *Journal of Education for Sustainable Development*, 9(1), 44-61.

Trajber, R., Walker, C., Marchezini, V., Kraftl, P., Olivato, D., Hadfield-Hill, S., ... & Fernandes Monteiro, S. (2019). Promoting climate change transformation with young people in Brazil: participatory action research through a looping approach. *Action Research*, 17(1), 87-107.

UFAM. Federal University of Amazonas (2018). Dean of Extension. Extension Actions Catalog 2018. Available at: http://edoc.ufam.edu.br/bitstream/123456789/858/83/Cat%c3%a1logo%20de%20Extens%c3%a3o%202018.pdf. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2014). Extension Information System. Project - 402343 - CLIMATIC Network - Brazilian Network for Research on Global Climate Change, Cities and Urbanization Subnet. Available at: https://sistemas.ufmg.br/siex/AuditarProjeto.do?id=57584. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2016). Extension Information System. Event - 202397 - Challenges of implementing climate policies in Brazil: looking for a transdisciplinary vision. Available at: https://sistemas.ufmg.br/siex/AuditarEvento.do?id=60961. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2017). Extension Information System. Project - 402971 - Climate Change Adaptation: autonomy for communities and urban resilience. Available at: https://sistemas.ufmg.br/siex/AuditarProjeto.do?id=61863. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2018a). Extension Information System. Project - 403434 - Promotion of research on mitigation and adaptation to climate change, low carbon economy and ecosystem services. Available at: https://sistemas.ufmg.br/siex/AuditarProjeto.do?id=60201. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2018b). Extension Information System. Course - 102405 - Basic Training in Meteorology and Climatology. Available at: https://sistemas.ufmg.br/siex/AuditarCurso.do?id=54439. Last accessed: 28 Apr. 2020.

UFMG. Federal University of Minas Gerais (2019). Extension Information System. Event - 203936 - Climate Perspectives for Northern Minas Gerais State. Available at: https://sistemas.ufmg.br/siex/AuditarEvento.do?id=63222. Last accessed: 28 Apr. 2020.

UFPE. Federal University of Pernambuco (2018). Dean of Extension and Culture. Technical and participatory mapping of areas at risk of landslides, erosion and floods in the State of Pernambuco - dialogical interaction. Available at: https://www.ufpe.br/documents/38978/1852695/

UFPE. Federal University of Pernambuco (2020). Dean of Extension and Culture. Basic Course on Solar Thermal and Photovoltaic Energy. Available at: https://www.ufpe.br/proexc/cursos/-/asset_publisher/2PDxMHCzx5c9/calendar/id/2719439?inheritRedirect=false&redirect=https%3A%2F%2Fwww.ufpe.br%2Fproexc%2Fcursos%3Fp_p_id%3D101_INSTANCE_2PDxMHCzx5c9%26p_p_lifecycle%3D0%26p_p_state%3Dnormal%26p_p_mode%3Dview%26p_p_col_id%3Dcolumn-4%26p_p_col_count%3D1. Last accessed: 28 Apr. 2020.

UFRGS. Federal University of Rio Grande do Sul (2020a). Dean of Extension: Extension Actions Catalog. Social practices for the development of sustainability awareness in public school students. Available at: https://www1.ufrgs.br/extensao/catalogo/vis_acao.php?CodAcaoExtensao=42187. Last accessed: 28 Apr. 2020.

UFRGS. Federal University of Rio Grande do Sul (2020b). Dean of Extension: Extension courses. Learning hydrology for natural disaster prevention - 2. Available at: https://www1.ufrgs.br/extensao/catalogo/vis_acao.php?CodAcaoExtensao=42628. Last accessed: 28 Apr. 2020.

UNB. University of Brasília (2018). Catalog of programs and extension projects (2018-2019). Available at: http://dex.unb.br/catalogos-de-peacs?download=923:catalogo-peacs-2018.pdf. Last accessed: 28 Apr. 2020.

UNDP (n.d.) Climate Change Adaptation – Brazil, https://www.adaptation-undp.org/explore/latin-america-and-caribbean/brazil

UNESCO (2010). Climate change education for sustainable development: the UNESCO climate change initiative. 19p. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000190101. Accessed: 10 mar. 2020.

UNESCO. (2012). Desafios e perspectivas da educação superior brasileira para a próxima década: 2011-2020. Available at: https://unesdoc.unesco.org/ark:/48223/pf0000218964 Last accessed: 1 Mar. 2021.

UNESCO (2014), "Mudança climática em sala de aula: curso da UNESCO Para professores secundários (fundamental II e ensino médio) sobre educação em mudança climática e desenvolvimento sustentável (EMCDS)", United Nations Educational, Scientific and Cultural

Organization. Available at: www.unesco.org/new/pt/brasilia/about-this-office/single-view/news/climate_change_in_the_classroom/

UNESCO. (2017), "Education for Sustainable Development goals: Learning objectives". Available at https://unesdoc.unesco.org/ark:/48223/pf0000247444 Last accessed: 2 Mar. 2021.

UNESCO (2020), "Research and development spending", available at: http://uis.unesco.org/apps/visualisations/research-and-development-spending/ UNFCCC. United Nations Framework Convention on Climate Change. Convention on Climate Change. Ministry of Science and Technology / Ministry of Foreign Affairs. 1995. Available at: https://cetesb.sp.gov.br/proclima/wp-content/uploads/sites/36/2014/08/convencaomudancadoclima.pdf. Last accessed: 27 Apr. 2020.

Unisinos. Universidade do Vale do Rio dos Sinos (2020). ISO 14001: Preservação do meio ambiente. Available at: http://www.unisinos.br/institucional/meio-ambiente/iso-14001. Last accessed: 28 Apr. 2020.

USP. University of São Paulo (2020). Extension Courses and Activities. Available at: https://uspdigital.usp.br/apolo/apoListarCursoModalidadeTipo?id_modalidade=4. Last accessed: 20 Apr. 2020.

Wachholz, S., Artz, N., & Chene, D. (2014). Warming to the idea: university students' knowledge and attitudes about climate change. *International Journal of Sustainability in Higher Education*.

Zandonadi, L., Acquaotta, F., Fratianni, S., & Zavattini, J. A. (2016). Changes in precipitation extremes in Brazil (Paraná River basin). *Theoretical and applied climatology*, 123(3-4), 741-756.

Climate-U
Transforming Universities
for a Changing Climate

About Transforming Universities for a Changing Climate

Climate change is the most significant global challenge of our time, and many of its effects are felt most strongly in the poorest communities of the world. Higher education has a crucial role to play in responding to the climate crisis, not only in conducting research, but also through teaching, community engagement and public awareness. This study contributes to our understanding of how universities in low and middle-income countries can enhance their capacity for responding to climate change, through a focus on the cases of Brazil, Fiji, Kenya and Mozambique. In doing so, it contributes to the broader task of understanding the role of education in achieving the full set of Sustainable Development Goals.

Our partners

GCRF Global Challenges Research Fund

UKRI UK Research and Innovation

UCL

USP THE UNIVERSITY OF THE SOUTH PACIFIC

KENYATTA UNIVERSITY

UPF UNIVERSIDADE DE PASSO FUNDO

UNIVERSIDADE EDUARDO MONDLANE

The Association of Commonwealth Universities