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Climate change and the role of universities: the potential of land-based teacher education and agroecology

As mudanças climáticas e o papel das universidades: potencialidades a partir da formação de educadores do campo e da agroecologia

Cambio climático y el papel de las universidades: potencialidades a partir de la formación de educadores de campo y agroecología

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Abstract: This article provides a critical reflection on climate change in contemporary times, addressing the responses made by universities through land-based teacher education courses with a agroecology approach. It draws on historical dialectical materialism, with reference to land-based higher education and the Transforming Universities for a Changing Climate project. Significant possibilities are identified for the critical development of educators with an understanding of agroecology linked to the material production of life in the farming territories.

Keywords: Climate change; university; land-based education; teacher education; agroecology.

Resumo: *O artigo traz reflexões críticas sobre mudanças climáticas na atualidade, expondo aportes a seu combate vindos de universidades, via processos de formação de educadores gerados em Licenciaturas em Educação do Campo que tem a Agroecologia como matriz formativa. Ancora-se no Materialismo Histórico Dialético, com acúmulos produzidos nas pesquisas Educação Superior do Campo e Transforming Universities for a Changing Climate. Observaram-se relevantes potencialidades na formação crítica de educadores com a compreensão da Agroecologia vinculada à produção material da vida nos territórios camponeses.*

Palavras-chave*: Mudanças Climáticas; Universidade; Educação do Campo, Formação de Educadores; Agroecologia.*

***Resumen**: El artículo trae reflexiones críticas sobre el cambio climático en la actualidad, exponiendo aportes a su lucha desde las universidades, a través de procesos de formación de educadores generados en Licenciaturas en Educación Rural que tienen como matriz formativa la Agroecología. Está anclado en el Materialismo Histórico Dialéctico, con acumulaciones producidas en las investigaciones Educação Superior do Campo y Transformando las Universidades para un Clima Cambiante. Se observaron potencialidades relevantes en la formación crítica de educadores con la comprensión de la Agroecología vinculada a la producción material de vida en los territorios campesinos.*

***Palabras clave**: Cambio Climático; Universidad; Educación Rural, Formación de Educadores; Agroecología.*

INTRODUCTION

This article addresses the global challenge of climate change, reflecting critically on the intensification of its impacts in Brazil and the world in contemporary times, and questioning the mechanisms adopted for addressing it, especially those involving commercialisation of forests, ecosystems and agriculture. Through a broad reflection on the problems associated with climate change, involving questions of an economic, political and social nature, we acknowledge the central importance of education, and specifically the university. The focus here in particular is on the role of teacher education as an essential strategy in addressing the climate crisis through collective shifts in understanding and actions linked to sustainability of life, nature and humanity.

In its methodology, the article is grounded in historical dialectical materialism, drawing on research conducted on land-based education developed as part of the *Rede Universitas* network in Brazil, composed of researchers of higher education policy from across the country, and from the *Transforming Universities for a Changing Climate – (Climate-U)* project, composed of researchers from Brazil, Fiji, Kenya, Mozambique and the UK focusing on the impact of higher education on climate action and sustainable development.

The article comprises three complimentary sections: the first presents the broad backdrop to the climate crisis and its resolution in Brazil and globally, involving systems of production, land distribution and environmental destruction. The second reflects on the strategic role of the university in shaping our understandings and collective actions in relation to climate change. Finally, the third section addresses the importance and contributions of university-based teacher education for climate action, focusing on the experiences of land-based teacher education courses in Brazil, grounded in ideas of agroecology.

THE CLIMATE EMERGENCY IN BRAZIL AND THE WORLD

Widespread wildfires and floods, melting of ice and sea level rises, loss of species and acidification of the oceans have become increasingly frequent and intense throughout the world in the context of increases in planetary temperatures. These ever more severe impacts have stemmed from human activities of fossil fuel burning and deforestation, impacting all regions of the world. A continuation of this anthropocentric relationship with nature, exploiting its riches and converting them into commodities in a market system, will exacerbate these environmental impacts and changes in climate, reaching critical levels and the irreversible loss of biodiversity.

Strangely, the above is taking place in a landscape in which humanity has already produced many alternatives for social development in keeping with the sustainability of the diverse forms of life on the planet. We are no longer solely reliant on fossil fuels – derived from oil, coal and natural gas – for energy production, nor is there necessity for the clearing of forests for cattle rearing and agriculture, the implantation of massive infrastructure projects, and logging, land grabbing and mining often carried out illegally and without regard for territorial rights.

These issues have brought the climate debate to the forefront in Brazil and beyond in contemporary times. An example is the manifesto for the 26th Conference of Parties (COP) held in Glasgow, UK, produced by Brazilian civil society organisations, social movements, trades unions, organisations, forums, networks, activists and researchers, together known as the Belém Charter group. This group questioned the excessively technical and financial focus of the meeting, neglecting deeper questions of the organisation of society and relations of economic and political power, expressed through a series of agendas and mechanisms in the interest of national and international actors, and which are causing devastating impacts on the expropriation and exploitation of territories, depletion of natural resources, and physical and symbolic violence on populations and ways of life (Grupocartadebelem, 2021). The manifesto questions the approach taken to reducing greenhouse gas emissions, with the proposals of nature-based solutions (NbS) including promotion of monoculture of eucalyptus and biofuels, transforming agriculture into a significant opportunity for large-scale mitigation associated with the market in soil carbon. In the understanding of this group, these mechanisms use forests, ecosystems and agriculture as market instruments for financing climate action, representing therefore a process of reconfiguration of forms of accumulation. They promote new dynamics of plundering, which present themselves as mechanisms of compensation but which in practice perpetuate

injustices and threaten environmental integrity; they create new enclosures to the spaces of life, reducing nature to a service provider for the benefit of companies and markets (Grupocartadebelem, 2021).

Brazil has around 28,354 million hectares dedicated to agriculture and grazing, corresponding to 34% of the national territory, positioning it amongst countries that have the largest extension of agricultural land in the world (along with China, USA and Australia)[1]. In order to support this activity, there is concrete evidence of the encroachment of the agricultural frontier on forests, public lands and the territories of indigenous peoples and traditional communities. According to data from the Ministry of Economy, Industry, Trade and Services[2], in 2018 the country reached a proportion of 49% of its exports for primary products, including beef and soya.

Data recently released by Imazon reveals that Brazil continues to be the world's largest site for deforestation, being the country with the highest rates between 2010 and 2015: around 984,000 hectares[3]. Between August 2018 in March 2019, there was an increase of 24% in deforestation compared to the same period of the previous year, with 58% occurring in private lands[4], destroying 20% of the Amazon region and 50% of the scrubland biome[5]. In terms of wildfires, GRAIN/ Grupo Carta de Belém (2019) registered an increase of 71% from January to August 2019, compared to the same period in 2018, the highest rate since 2008, with 49% occurring in the Amazon region and 32% in the scrubland.

Preliminary data from the agricultural census of 2017 show the increase of 5% in the private use and occupation of land, equivalent to an increase of 16.5 million hectares (the size of the entire Brazilian state of Acre), resulting in the occupation of 41% of the land area of the country in agricultural holdings, with a reduction of 2% in the number of farms in the same period, unequivocal evidence of the increase in the concentration of land in the country[6]. According to the Gini coefficient for land distribution, Brazil is the fifth placed country in Latin America,

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1 Tabela Grain, 2019 IN: https://grain.org/en/article/6278-brasil-pacto-contra-a-biodiversidade-e-os-territorios-dos-povos , cited by http://mapbiomas.org/map#coverage and FAOSTAT, 2016, http://www.fao.org/faostat/en/#data/EL .

2 Cited by GRAIN/Grupo Carta de Belém, 2019.

3 Global Forest Resources Assessment 2015. FAO, How are the World's Forests Changing? (Second edition) Roma, 2016. Table 3: Top ten countries reporting the greatest annual net loss of forest area, 2010–2015, p. 17.

4 https://k6f2r3a6.stackpathcdn.com/wp-content/uploads/2019/04/SAD-marc%CC%A7o-2019_impressaopessoal.pdf .

5 According to Relatório Planeta Vivo 2018 (Living Planet Report) of WWF, launched globally on 24 October 2018. https://www.wwf.org.br/natureza_brasileira/especiais/relatorio_planeta_vivo_2018/ .

6 https://censos.ibge.gov.br/agro/2017/resultados-censo-agro-2017.html .

after Paraguay, Chile, Colombia and Venezuela: an unenviable accolade, given that the region has the highest global inequalities of land ownership, with only 1% of owners controlling 51.9% of land; in other words that 1% of the population controls more than the remaining 99%[7].

In addition to this, there is a trend of growth of large rural properties in Brazil not only in number but also in area, with the increase between 2006 and 2007 of more than 3287 farms of a thousand hectares or more, increasing their occupation by more than 16.3 million hectares, thereby raising the participation of these large businesses from 45% to 47.5% of the total area occupied in this period[8]. Furthermore, the data reveal that it is in private areas in which there is the most deforestation in the country. Private properties occupy 190 million hectares and represent about 1/3 of the 532.5 million hectares of forests and grasslands of Brazil (62.6% of the national territory)[9]. In the last 30 years, private areas lost around 20% of native vegetation cover, in contrast to conservation areas and indigenous lands which lost just 0.5% in the same period.

These figures pose a challenge to the rural landowner organisations, which advance in their capture of the Brazilian state, in partnership with mass media, with their repeated arguments that Brazil is one of the countries which most protects its forests, and that there are too many nature reserves and indigenous lands, thereby making it necessary to reduce them to allow the advancement of progress and development of the country. Behind this discourse there is the real intention of the rural landowning organisations to reduce the extension of protected public areas and to advance the disappropriation of the territories of indigenous peoples, *quilombolas*[10], small-scale extractivists and subsistence farmers. This position has the agreement of the majority of the Brazilian population, which has been led to believe that the development of the country is being driven by agricultural, mining and hydroelectric enterprises, and that to continue forward it is necessary to overcome the legal and institutional obstacles that protect extensive territories, occupied by a small and not very entrepreneurial population.

As a consequence of this model of development defended by the agricultural, mining and hydroelectric business, and anchored in the expansion of the agricultural frontier and the introduction of cattle and crops, principally soya,

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7 Oxfam, Relatório Terra, Poder e Desigualdade na América Latina, november 2016, available at:https://www.oxfam.org.br/sites/default/files/arquivos/terra_desigualdade-resumo_executivo-pt.pdf .

8 https://agenciadenoticias.ibge.gov.br/agencia-sala-de-imprensa/2013-agencia-de-noticias/releases/21905-censo-agro-2017-resultados-preliminares-mostram-queda-de-2-0-no-numero-de-estabelecimentos-e-alta-de-5-na-area-total .

9 http://mapbiomas.org/infograficos-2018/brasil.jpg .

10 African Brazilian communities

and with grabbing of public land and water, there has been in the Amazon region an increase of 34% in fire outbreaks, of 55% in the rate of deforestation, and 11% more rain, between the months of January and August 2019, compared with the same period of the previous three years (2016-2019), according to data of GRAIN/ Grupo Carta de Belém (2019).

The acceleration of deforestation of the Amazon rainforest, according to Carlos Nobre (2020), reached the elevated level of 17%, meaning that the rainforest is close to the point of no return, if it continues at this rhythm and reaches 20% or 25%. In fact, the intensification of forest fires in 2019 has increased the risks of desertification of ecological regions such as the Amazon, the Pantanal and the scrubland, and the expansion of the Brazilian industrial complex with its infrastructural logistics places at risk the lives and territories of indigenous peoples, *quilombolas*, river dwellers, and small-scale extractivists and farmers in all of the Brazilian biomes. This backdrop requires special attention both to the polarisation of the demarcation of indigenous and quilombola lands, and to invasions on their territories, particularly with the destruction of areas of common use.

It is therefore important to recognise that the problems related to climate change and strategies for addressing it involve economic, political and social spheres, demanding the application of different measures relating to the productive system and questions of land ownership and the natural environment. It is impossible to continue tolerating the social injustice, environmental destruction and extermination of biodiversity, provoked by the financialization and privatization of nature and common goods.

Education and with it the appropriation of scientific knowledge and technological innovations are essential for addressing the causes of the climate crisis and for the collective global-local changes necessary for the sustainability of humanity and all forms of life. It can foster a deeper change in human understandings and actions. The following section will reflect on the strategic role and contributions of the university for rethinking the pathways of our collective understandings and actions for addressing climate change.

THE ROLE OF THE UNIVERSITY IN ADDRESSING CLIMATE CHANGE

Three elements of the climate crisis outlined above are highly relevant for the role of higher education. In the first place, it is clear that climate change is a political, and not just a technical issue. Some solutions have been proposed that involve direct interventions in the natural environment – for example, geo-engineering that attempts to partially block the sun's rays and thereby reduce temperatures, or to

capture and store carbon from the atmosphere. While technological innovations will doubtless be part of a successful response, it is clear that they cannot be the totality. In an unjust political and economic system, and one in which the private trumps the public, it is unlikely that technology will be utilised in in an equitable way, nor in one oriented towards the public good. As argued persuasively by Naomi Klein (2014; 2019) amongst others, climate action is now one with social justice action. The struggles of marginalised populations around the world for justice must inevitably involve climate change, and the quest for environmental sustainability must involve political and economic transformations.

A second key dimension of climate action is that it involves all segments of society and human experience. The connection with the above point is that a technical solution in only one sphere is unlikely to be successful as climate change is rooted in contemporary human civilisation and way of life, stemming back to the earliest exploitation of the natural environment by human beings, and intensified through the rise of capitalism and the Industrial Revolution. Moving to a carbon neutral world involves changes in our individual lives and collective structures, and embedding across cultural, social, economic and political spheres.

Thirdly, climate change has an important epistemic dimension, and one that is highly contested. Climate scientists from the 1980s began to put through reports of rising temperatures as a result of greenhouse gas emissions, reaching a near consensus in the following decades. Yet with the exception of those living 'at the sharp end' – for example in low-lying island states – the evidence and impact of climate change are not constantly visible, leading to many to ignore or even deny the crisis. Climate denial (and more recently delay) has been deliberately fostered by fossil fuel companies, who rightly see a major threat to their profitability. Climate change, therefore, is a highly contested issue, both through outright denial, and also in the wide range of possible courses of action available even to those who accept it.

The characteristics above place the university at front and centre of responses to the crisis. As an institution which concentrates most academic research globally, it is at the forefront of documentation and analysis of the causes and impacts of anthropogenic global warming. And in its responsibility for educating increasingly large proportions of young people around the world, it has a central role in raising awareness of the issue and equipping people for effective action. Yet the political, multisectoral and epistemically contested nature of climate change mean that not any university response will do. The concentration of high-level scientific research in a few globally elite universities, and the transmission of inert information on climate change to the masses will be entirely inadequate as a response.

A systematic review of literature (Nussey al. forthcoming) carried out by the *Transforming Universities for a Changing Climate* project (Climate-U) indicates that, despite the growing body of evidence on responses of universities to the climate crisis, there are some marked skews. First, the majority of literature published on the topic in major journal databases focuses on a small number of countries, most notably the USA, Canada, Australiaand the UK. Second, most of the literature relates to greening the campus, curriculum/teaching and learning, and some aspects of community engagement, with little on political mobilisation, governance or research agendas – all important parts of the higher education response. And within the pedagogical literature, there is a predominance of narrow information transmission and behaviour alteration approaches in climate change education. While the results of a systematic review may provide evidence of research bias and publication bias, rather than characterising practice, it is indicative of the approaches that are dominant around the world, particularly in English-speaking countries.

What might a university response look like, if not restricted to knowledge transmission and elite science? It is crucial to look at the university holistically, encompassing all of its diverse functions. These can be viewed in terms of five modalities (McCowan 2020): education (through the teaching of undergraduate and graduate students), knowledge production (research, scholarship and innovation), service (community engagements, secondments and consultancy), public debate (activism of staff and students, public information and serving as an arena for debate) and campus operations (the direct environmental impact of the university as institution). All of these modalities are crucial in their own right, but can also positively influence each other through their interactions in the university sphere.

In terms of its teaching, the university would need to draw on Freirean principles of critical pedagogy to foster transformative action through an understanding of the political dimensions of the climate crisis (McCowan 2021; forthcoming). The curriculum and the knowledge environment of the university more broadly would need to display an ecology of knowledges (Santos 2015), ensuring a genuine dialogue between diverse knowledge traditions, cultures and languages around the world. These principles also need to filter into teacher education, and to the engagements between universities and schools (Reimers 2021). Connected with this point, broad accessibility of the university to all populations is essential, ensuring just distribution of opportunities for studying in higher education but also diversity of student and staff bodies. A new form of engagement with communities is also needed, particularly local populations which are often ignored by the university. For this end, the participatory action research model developed by Climate-U (2021) has countered extractive and disempowering approaches to community engagement by seeking a genuinely horizontal and collaborative relationship, and coproduction of

knowledge. Ultimately then, the responses from higher education will need either to be in the form of the *multiversity* (in Santos's [2017] terms), or alternatively the *subversity*, challenging the mainstream from the fringes.

None of these forms of practice is straightforward to achieve. In particular, this is because of a rather unconducive environment at the global level for higher education policy, diverting it from its public good mission (Unterhalter et al. 2019; Marginson 2011; McCowan 2019). There are the ongoing processes of marketisation involving the introduction of tuition fees in public systems, the growth of the for-profit private sector and commercialisation of research and community engagement. National and international rankings have also fostered status competition that causes universities to focus on elite research and exclusive admissions policies, to the detriment of public benefit and local relevance. Finally, there are incipient processes of unbundling that threaten to fragment the functions of the university and the components of the teaching and learning process. Given this backdrop, even greater efforts are needed to protect the generative role of universities in relation to the climate emergency.

Much of the attention to sustainable development in higher education over recent years focuses on coherence, coordination and alignment (McCowan et al. 2021). Lamenting the fragmented nature of the university as institution, many university leaders and policymakers have attempted to ensure that all parts of the university fall into line with the sustainability agenda. While these initiatives are laudable in many ways, it is misguided to think that the university can always speak with one voice, in principle and in practice. Some diversity and even messiness is important in fostering innovation, as well as protecting academic freedom, and grassroots and bottom-up initiatives. The dilemma of within or beyond the university then (McCowan & Dietz 2022) does not need to be quite as stark as it at first appears. It may even be possible to create the 'subversity' within the mainstream university. Indeed, nurturing these pockets of resistance and experimentation may be our best chance for transforming higher education and addressing the climate crisis. It is one of these pockets of counterhegemonic practice that will be analysed in the sections that follow, in the form of land-based education.

THE POTENTIAL OF LAND-BASED TEACHER EDUCATION AND AGROECOLOGY

This section will reflect on the development of public policy for land-based education[11] in the context of teacher education provided by public universities in Brazil. It considers the possibilities of enabling people to contribute to addressing the problems arising from climate change, based on the experience of the land-based teacher education courses, grounded in agroecology.

Land-based teacher education courses[12] (LBTECs) were conceived with the objective of forming educators currently working in small-scale farming communities in a higher education setting, and also for preparing the youth who will be the next generation of teachers. These courses are focused on rural schools, with emphasis on the construction of new forms of school organisation and pedagogical methods for lower and upper secondary education (MOLINA e SÁ, 2011). The pedagogical approach of land-based education has a deep link with the historical project of the working class and an intrinsic commitment to contribute to the construction of the territorial project of small-scale farmers, in which popular land reform is an essential element, a structural condition of the deconcentration of large estates and an essential basis for transforming society.

In the 15 years since this policy began in 2007 as a pilot project in only four universities, the LBTECs have been implemented in 33 public higher education institutions, and a total of 45 permanent courses (since some universities have more than one campus) (MOLINA, 2020). In these courses, which are present in all five of the regions of Brazil, there are 7300 students enrolled, with 585 lecturers contracted to teach. There are already dozens of research studies on graduates of the LBTECs (MOLINA 2, 2021) showing that they have been capable of including a wide range of students from small-scale farming backgrounds in Brazil. These studies confirm that the graduates of these courses include students settled as part of the land reform programme, those in temporary camps, river dwellers, *quilombolas*, small-scale extractivists, fishing communities, as well as indigenous peoples of different ethnicities in certain courses. Precisely because they bring together students from different backgrounds, from a diversity of biomes, cultures,modes of production, lives and relationships with nature, but with a common struggle to continue their rural lives, the LBTECs require of their teachers an ever greater approximation with these populations and their territories. The process involves jointly constructing

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11 *Educação do campo* in Portuguese. Alternative translations of 'rural education' and 'countryside education' have not been used as they do not capture the relationship of the worker with the land contained in the Portuguese expression.

12 Licenciaturas em Educação do Campo in Portuguese

social, economic, environmental, cultural and political strategies which will allow the students to resist the increasingly intense and violent expropriation that they suffer, practised by the hegemonic model of organising agriculture. One of the specificities of these courses is the promotion of teacher education by broad areas of knowledge rather than specific disciplines (CALDART, 2011; MOLINA e PEREIRA 2021), equipping them for multidisciplinary teaching in rural schools, in the areas of art, language and literature, human and social sciences, mathematics, and finally natural sciences, which is the main focus of this article.

The LBTECs were established to form educators who, through their praxis in rural schools, will enable rural populations to resist the intense process of deterritorialization which has been imposed on them by agribusiness. This hegemonic model of organising agriculture contributes rapidly to environmental destruction, as extensively shown in the first section of this article, in its thirst for conquering ever more lands, for the implantation of its infinite monocultures, devastating the soil, the plants, water, health and human life, with the widespread use of dangerous pesticides and fertilisers .

In contrast to this, the rural populations have a different relationship with nature, treating it as a living being, worthy of respect and care. The LBTECs were created precisely to be part of and contribute to the construction of the territorial project of the small-scale farmer, who sees the land as a space of production of life, of new social relations, of a fair and ethical relationship between humans and nature. Using agroecological practices oriented towards sustainability and food sovereignty, and putting agroecosystems centre stage, the rural populations, schools and teachers, formed with a different perspective, can offer real and concrete contributions to overcoming what Marx called the 'metabolic rift', of the pattern of relationship between humans and nature which holds it as thing and object, considering it only a space of business and production of surplus. In other words, they are finding ways to recuperate the rupture of interdependence between productive activity and environmental conditions for the maintenance of life, a rift of metabolism between human and nature that has not yet been overcome, as emphasised by VAZ PUPO (2018).

Land-based education can contribute concretely to addressing the environmental crisis through forming educators who understand the intrinsic relationship of chemistry, physics and biology in the socio-metabolic processes of the organisation of agricultural production, and who are capable of teaching the students in rural schools to establish in their territories other practices of organising production, based on an understanding of agroecosystems. Precisely due to the formative perspective of the philosophy of praxis (VAZQUEZ, 2011; MOLINA e BRITO, 2017), land-based education does not only contribute by developing a

critical understanding of reality. Instead it is concerned with promoting educational processes that equip students to understand *and* transform the reality in which they find themselves. All of the work focuses on the principle of praxis as a mode of knowledge which articulates theory and practice, knowledge and reality, in a single movement (MOLINA, 2017).

Agroecology, which underpins the curricular framework for the LBTECs, has been defined by CALDART (2021, p. 357) as:

> a living process of cultural and scientific systematisation of the historical transformation of agriculture from its foundations, in other words, its farming population.... Agriculture is the cultivation of the land for the production of food which is a vehicle for and preserver of life – human life and the life of nature of which the human being is a part. At its base, agroecology brings together practices, diverse scientific knowledge, social relations, political struggles and educational practices. It has an indigenous and rural origin. It brings together science and ancestral memories of the cultivation of the land and the relationship of the human being with nature, to form another paradigm of advancing the productive forces of agriculture.

With this understanding of agroecology, its fundamental role in land-based teacher education is clear, in that not only can it make a profound difference in the teacher education courses themselves, but also to the pedagogical practices of these teachers in rural schools, with repercussions in the transformation of their communities. Aligned with this view, PUPO afirms that:

> considering the centrality of modes of appropriation of ecosystems, we can choose agroecology, both as a sociotechnical organisation for food production as a scientific discipline, and also as a necessary link between natural sciences and land-based education. It is configured as a response to the long-term material and symbolic expropriation of rural peoples. To express the continuing process of updating of biocultural memory, agroecology has shown its ability to unveil and construct agrarian systems aligned with the universal metabolism of nature, while being circumscribed by the relative autonomy of its experiences. It defines itself as the area of human knowledge which integrates natural and human sciences, whose knowledge necessarily stems from the protagonism of its technicians, educators and farmers (2018,884).

The 15 years of experience of these LBTECs and the intense process of knowledge production which has accompanied it (MOLINA et al, 2019) shows its potential for becoming increasingly concrete, with different expressions of transformation of use of scientific knowledge in the field (MARQUES, 2021).

The transformation from potentiality to act has been made possible by the articulation of the diverse elements that make up subject-based teacher education, namely: the conception of interdisciplinarity based on materiality; the centrality of

the contradictions of reality of the students' territories, and their connection with science, based on the pedagogy of alternation (HAGE et al, 2021); the linking of these students, knowledge and territories to the struggles of rural worker movements, with the promotion of protagonism and self-organisation of these future educators in their communities in land-based schools; and the absolute necessity of the insertion of agroecology as an underlying framework for these educational processes.

There are relevant doctoral theses on the outcomes of science teacher education in LBTECs documenting these transformations with focus on the different dimensions of this rich process. Some of these address the changes that take place in the universities themselves when they welcome the rural cohort for the teacher education courses, others address directly the rural schools and the territories in which they are located (COAN; 2020; CARCANHOLI; 2019; DALMOLIN; 2020; VAZ PUPO, 2018). What these studies show is that the educational intentions of the LBTECs have managed to become concrete, despite the extensive challenges faced in their institutionalisation.

One of the important pieces of research which confirms the potentialities of the LBTECs in the area of natural sciences, is the thesis of COAN (2020). The research analysed the processes of land-based teacher education in Erechim, in the Federal University of the Southern Frontier. The focus of the work was to understand how the pedagogical model of the course influences the formation of science teachers from a critical transformative perspective. The results show the development of praxis proposed by the LBTECs, via articulation between theory and practice based in the pedagogy of alternation, and the centrality of the collective work of teaching in advancing interdisciplinary practice in higher education. The work in question asserts that this critical transformative perspective encountered by science teachers in the Erechim LBTECs has developed dynamism through the constant process of action-reflection-action on pedagogical practice. In this dynamic, the unveiling of contradictions present in the students' realities becomes the central focus of the pedagogical process, from which the academic-scientific knowledge then develops. To understand reality, the teacher collective expands its understanding of the need for a counterhegemonic rural strategy. (COAN, 2020).

Other precious examples of how the changes promoted by teacher education in broad areas of knowledge promoted by the LMTECs contribute to the promotion of new agroecological practices in rural schools come from the the graduating students of these courses. There has been a significant evolution of final dissertations, focusing on the relationship between agroecology and rural education in various higher education institutions, in which the potential and advances of this relationship are outlined as well as the challenges, for example in the works

of Silva, 2021; Lima, 2020; Pagnusatti; 2018. A good example of these changes comes from a student of the LBTEC at the Federal University of Santa Catarina, in which she describes the strategies used to work with students in the school in which she was teaching. In a historical review of work with tobacco in the region, she uncovers how the advance of the logic of capital in the organisation of agricultural production of this crop is leading farmers towards monoculture and destruction of the environment and of their own physical and emotional health. She traces a rich and intricate process of learning drawing on a Freirean thematic approach, revolving around the significant statement from a student: "In my family tobacco causes death". Concerning this experience, the student in question states:

> Given the disciplinary nature of the teacher education, in this case in natural sciences and maths, the theme allowed us to approach some questions in a contextualised way, like for example the economic, social and environmental focus. It's important to emphasise that working in a disciplinary way allows us to contextualise more broadly some themes, allowing a greater integration of the knowledge and perhaps facilitating the understanding of them. (...) Defragmenting knowledge is providing opportunities for people to understand the context in which they live, and to feel part of it, seeking in that way to be protagonists of their reality. In this perspective, we chose as a focus of our work the economic question, as the intention was to address production and consumption of tobacco.(...) To set in motion the problematisation on this theme, we decided to contextualise on a timeline the use and production of tobacco. It's important to highlight that the way in which we approached these questions, in bringing this information to the table, provoked moments of great reflection amongst the students, in particular making us think about the diverse questions which involve agribusiness and its ramifications. It's important to highlight that this problematic was related with the teaching of certain specific concepts, such as in the area of natural sciences, in biology: genetics (genotype, phenotype, chromosomes, DNA), biotechnology, genetic improvement, genetic engineering, genetic mapping, cloning, genome project, genetically modified organisms; in chemistry, alkaloids, chemical functions (organic function, nitrogenated organic function, amines); in physics, energy (the difference between thermal energy and electrical energy, electrical power, heat emmission – conduction, irradiation, convection – thermodynamics); and in the area of mathematics: financial mathematics – profitability, the rule of three, information processing, percentages. (BUSS, 2018. P.54)

The richness of the experience and the narrative show advances in understanding of teaching practice and interdisciplinary work, with the perspective of developing the production and socialisation of scientific knowledge in school so as to contribute to the unveiling and overcoming of social contradictions.

CONCLUSIONS

In the first section a broad backdrop was traced for understanding climate change and of the proposals for addressing it in Brazil and the world, including questions relating to the productive system, large land estates and environmental questions. In section 2, drawing on the contributions of the Climate-U project, it was seen that the response of the university has not yet been sufficient in terms of the five relevant roles that it can play in addressing a challenge of such seriousness. Addressing the climate crisis requires a civilisational shift, involving all of the dimensions and habits of human life, including deep changes of behaviour. While technological innovations are important and necessary, they will never represent a solution on their own.

In order to explore the possibilities of universities in carrying out these roles, section 3 of this article presented a concrete experience of higher education for rural workers in Brazil – land-based teacher education courses – and their potential for promoting agroecology, with emphasis on the challenges and opportunities of the work carried out through teacher education in science. Through a brief review of the challenges of implementation of these courses and the underpinning framework, via subject areas, it was possible to see particularly in natural sciences the relationship with the rural workers and with the concrete challenges faced by them in their biomes and modes of material production of life. The courses also provoked questioning on the part of the higher education lecturers, making them reassess their practices and the formation of rural peoples through their meetings with them and the diversity of material modes of production present in their biomes and territories. The dialogue of knowledges contributes to resignifying these practices in higher education.

The various research studies on the LBTECs, in the area of natural sciences, have confirmed the potential of these courses in terms of bringing universities closer to the roles that they must have in the climate crisis, working to promote new levels of consciousness and praxis, both in higher education and basic education, to overcome the hegemonic model of organising agriculture, through the widespread dissemination of agroecological practices and the maintenance of ecosystems.

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