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Into the Mine

Wicked Reflections on Decolonial Thinking and Technologies

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ABSTRACT

Our global livelihoods are intrinsically tied to mining. The technologies we use, as currently designed, are not possible without the minerals and metals that are an essential part of several of their components. As a result, HCI research and applications are tightly dependent on mining, including the negative environmental and social impacts resulting from it. This paper aims to describe and reflect on this problematic entanglement as a "wicked cycle." We present a dilemma faced by communities living near mining sites in the Amazon, which are affected by the ecological impacts of mining and rely on digital technologies made with such mines' products, including telecommunication technologies, to effectively and successfully advocate for and realise their own local visions of development. We promote a discussion built on concepts from decolonial thinking and critical sustainability. With this paper, we want to create space and necessity to acknowledge our complicity as HCI researchers in this dilemma and propose a series of questions to reflect on our part in these specific, and other, wicked cycles.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; **HCI theory, concepts and models**.

KEYWORDS

mining, wicked problems, decolonial, ecofeminism, Amazon rainforest

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1 INTRODUCTION

"If we suggest that technology or markets have problems or limits, some will consider us to be heretics, and they will say that we are anti-technology."
— Donella Meadows [80, p. 205]

The times we live in can be described as the mineral age, as global livelihoods depend on them [62]. Due to the importance of minerals and metals, our research has focused on examining mining, its practices, and its disastrous impact on nature, including humans (see e.g., [9, 62] for an overview). Mining can take place in two different types of practices: large-scale mining and what is called Artisanal and Small-scale Mining (ASM). The latter are often but, importantly, not always informal and illegal. ASM is often associated with precarity, as it is for example carried out as a *side business* for subsistence farmers in Latin America to diversify their income [11, 27]. It thus presents a critical income strategy for unemployed, underemployed, or otherwise impoverished people [62]. However, the precarity that leads people to engage in ASM, also extends to ASM as a practice itself. It is often done under hazardous conditions with inappropriate equipment and insufficient (or nonexistent) safety measures, presenting tremendous health risks for miners, including mercury poisoning.

Research shows damage in both the environment and populations who live and work in communities close to or dependent on the mines [32, 127]. Moreover, in Brazil, for example, the suicide rates in areas with extraction of minerals are higher than those of the Brazilian population in general [36, 108]. Both ASM and large-scale mining have disastrous effects on nature. These effects include deforestation [61], resulting in erosion of land which - together with toxic leftovers - makes reforestation difficult [92, 111]. Mining is also severely damaging to water resources, not only through heavy metals (mostly, mercury and cyanide) poisoning water bodies, but also acid draining which affects waterways and groundwater. Dam collapse has also become more frequent in Brazil, causing the death of people, soil, and water. For Shirley Djukurnã Krenak, the damage is also spiritual: "the whole spirit of the water was murdered. We still mourn the death of Watu river today" [69]. The large amounts of water which are needed for mining efforts also drain local water resources. This is the case even when the water is fed back into the

environment as part of the mining process, which further heightens the risk of contamination. Mercury does not only affect the water quality but also that of land and air, accumulating in all organisms, especially top-level predators including humans [75, p. 155]. Communities with mining operations nearby are also impacted. Their health and their living conditions are affected by the short and long-term consequences of air, ground, and water pollution from these mining activities, along with land subsidence, landslides, and water run-offs in their territory [Ibid.]. Also, communities, mostly Indigenous, in these locations are often left facing risks of attacks and violence, associated frequently with mining and large-scale extractivist projects, when attempting to defend their territories [112]. The environmental impacts last hundreds, if not thousands of years [62], and affected areas are not easily recovered even where environmental rehabilitation was intended.

HCI research and design is directly implicated in these matters of mining. A wide variety of metals and minerals are used when building digital technologies such as semiconductors, capacitors, and hard drives. These include aluminum, gold, niobium and tantalum. Niobium and Tantalum, for example, have become especially important (and infamous) for the production of digital technologies. They are extracted from coltan ore. Coltan is primarily mined in the Democratic Republic of Congo (DRC), but large reserves (40% of the world's resources) can also be found in Latin America including the Amazon region [121].

Studies that directly investigate the connection between mining and the global computing industry have predominantly focused on the role of coltan mining in fueling armed conflicts and violence in the DRC [77], and the centrality of coltan for the digital age [118]. They detail, for example, how increased demand for Sony's Playstation games console in the U.S. directly led to growing violence in the DRC over increasingly profitable coltan mines, a key component of the game console [77]. These studies illustrate the manifold ways in which the computing economy (including HCI research) is interwoven with, and directly dependent on, mineral extraction and its associated atrocities such as violence in the DRC and the destruction of the environment and human livelihoods in the Amazon Region. We appreciate the advances in industry and research addressing some of these issues, such as commitments to avoid the use of conflict minerals and metals, contributing to the recyclability of devices, among others by Apple [3] or Intel [59]. We also appreciate there is an extensive history of HCI research and interventions into sustainability issues. However, we believe HCI as a field has not sufficiently addressed, and critically engaged with, its dependence on mining and the associated destruction.

Building on these concerns, Nardi and O'Day [88] have written extensive reflections on the impacts of technologies on our environments and communities. This has been seismic work, and building on it, an important question arises: how can we, as technology researchers, address this? Especially since, as HCI researchers, our main practice is to design, develop, and evaluate new technological solutions and their appropriations and use within communities, workplaces, or homes. As a field of study, we like to intervene when we see potential for technologies to *solve* particular issues or problems. Even when we are not working in this solution-oriented way (see e.g., [20]), we develop technologies to explore issues, to discuss topics, or to facilitate community-development. The solutions-driven approach to our research is particularly evident when we work in the "Global South." There is temptation for the HCI community to propose technological solutions to problems of global inequality, and it is especially perverse in light of the devastating impact of technology production. When using a decolonial lense to look at this work, we can start to see that we are addressing long-standing issues which, at least partially, arise from the growing of globalized economies by and for the Global North.

1.1 Our Contribution

Building on concepts of decolonial thinking [53, 83, 100], we problematize further HCI's dependency on mining and the associated environmental and social atrocities. We describe this deeply problematic entanglement, while considering the research already done, as a "wicked cycle," in which HCI efforts to address and overcome these atrocities contribute to their existence. To do this, we present and theoretically unpick a unique dilemma that is representative of many other ecological and social crises: communities living near mining sites in the Amazon are experiencing the impacts of ecological disasters which, mining and specific notions of *development* bring on. But to advocate against mining, or for their own visions of development, they require telecommunications technologies. Such technologies are leveraged rather successfully, making them powerful and effective tools in the communities' struggle for their own version of *development* and against environmental destruction. Yet, the reliance of these technologies on the use of minerals found in the mines that are causing the problems in the first place creates a tension between their production and their deployment. With this paper we aim to explore this tension which we label a wicked cycle and introduce concepts and ideas from different decolonial thinking traditions that offer a variety of perspectives on this tension.

1.2 Process and outline of the paper

This paper stems from the first author's long-term engagement with a rural Amazonian community. Even though the work of the first author one with the community dealt with difficulties associated with development and the role of digital technologies, a concern for mining was never the explicit focus, the concerns addressed here emerged much later. However, this is not an empirical or ethnographic paper, and as such does not provide detailed empirical findings. Instead, it is a critical reflection initiated by an observation made in the community.This observation, shaped by the first author's experience and long-standing relationship, serves as the starting point for us to explore the issues mining poses for HCI. Through a decolonial lense we provide several positions in relation to this challenge which could serve as starting points for our HCI community to develop responses. We arrived at these reflections through a series of collaborative and shared reading, discussions, and writing.

In the paper, we will first explore different perspectives on extractive mining, technologies, and their complicated relation to the lives of people and communities in the Amazon rainforest. We do this by exploring decolonial thinking and linking this to existing research in HCI of designing in existential crisis. Second, we

present a look at the role mining plays in the Brazilian Amazon, particularly the Pará region, where the first author has carried out many years of collaborative work. While the paper does not aim to represent a deep ethnographic account, we draw on these long-standing relationships, and present a pressing dilemma that is faced by a specific community in Pará, which has been shared with us by our friends living there. To conclude, we present a discussion on the importance of decolonial thinking for our discipline, and bring proposals of alternative theories that can be helpful for us as HCI researchers in understanding our complex role in the world. We conclude with our thoughts on how using this way of thinking has allowed us to reflect on this knotty dilemma, and advocate for other researchers to take time to reflect and understand their own complicity in this issue as well.

2 FROM WICKED PROBLEMS TO WICKED CYCLES

The notion of wicked problems has been around for over four decades [107]. They appeared in response to *engineering approaches* to policy-making, where problems are seen as "definable and solutions are verifiable" [56, p. 102], but are not necessarily corresponding to current global phenomena and dynamics. Thus, wicked problems have no definitive formulation nor solution(s) [107]. They are complex, unique, non-linear, with multiple causes and actors involved (hence, with high levels of divergence in knowledge and values) and not necessarily solely relying on *scientific certitude* [56, 91, 107]. Wicked problems are often not isolated, but are interlinked with each other (e.g., mining and technology use) which has resulted in the coining of the term *super wicked problems*, where climate change (or the climate crisis) is seen as the most representative example [71]. Based on this interconnected nature of various wicked problems, we see these individually complex issues not just as interlinked, but as developing into wicked cycles. This relates to, for example, when one wicked problem (such as mining in the Amazon) is part of, and affected by, other wicked problems such as the climate crisis, which in turn then exacerbates other issues (for instance, negative impacts on peoples' livelihoods). Instead of realizing this and making change though, in a wicked cycle, these processes and impacts continue indefinitely, and are further exacerbated through western notions of capitalism (e.g., the making and use of new technologies, which in turn requires additional mining in the Amazon).

In the following sections, we bring together two disparate but intertwined wicked problems: (1) environmental destruction and its effects on indigenous communities in the Amazon; and (2) the need for communication technologies and infrastructures of these same affected communities to continue the fight for their rights and environmental protections. We hope, throughout the paper, to make clear how they are not independent problems but how they perpetuate one another, turning the individual wicked problems into a wicked cycle.

2.1 On modernity/coloniality and technologies

The global, multiple and heterogeneous, structures of coloniality did not vanish with the "juridical-political decolonization of the periphery" Grosfoguel [53]. This means colonial dynamics are still in place even though legally binding colonial rule is no longer present. Such a perspective is also supported by other decolonial thinkers in Latin America [53, 83, 100]. This is further impacted by universalism being pushed as the dominant conceptual notion through which Western structures of life and knowledge have hegemonically been established around the globe, forming what is known as the *colonial matrix of power* [100]. Grosfoguel describes how this process of on-going coloniality has sustained old hierarchical structures which follow the dynamics of current capitalist accumulation processes and global division of labor [53]. This continuous reinforcing of hierarchies creates a condition of coloniality, where coloniality is seen as constitutive of modernity and often referenced as a combined notion: *modernity/coloniality* [38, 84, 100]. Modernity/coloniality is understood as the general state of the world, in which judicial colonialism is over, but has structured the world as we see it today. Modernity is coloniality. The essence of this paper is about the global economic cycles of mining and the development of more and more new technologies - because of this, the issue of modernity is central to our argument and we have chosen to use the dual-use of modernity/coloniality throughout.

Colonialism and the colonial matrix of power have structured the world and the global economic system into *centers* and *peripheries*, as explained in Wallerstein's World System Analysis [126]. The centers are countries focused on high-wage and high-skill production, and the peripheries of the world focus on labor-intensive, low-wage, and low-skill production and exploitation of raw materials. This structure has been developing since at least the first century of colonisation in Latin America (from the end of the 1400s to the end of 1800s). Until the year 1660, 185,000 kilos of gold and 16 million kilos of silver (not including smuggled goods that escaped counting) landed at the Port of Spain, exceeding three times the total European reserves ([54] as cited in [48]). This exportation continued for five hundred years during the colonial era and has left its impacts on our contemporary world as a part of modernity/coloniality [9]. During the colonial times, mercury was already used to discover silver and gold within the earth. According to Maria da Conceição Tavares [122] these economic dynamics enable *growth outward*. This means, for example, that countries in Europe (the center) use their primary products to grow inward, using their internal and external natural resources for internal growth. At the same time, countries in the periphery would use their primary products to be used for growth outwardly, exporting their natural resources to the center, while importing most of the technological goods which are also produced by the center (perhaps from their same resources that they first exported). Several Latin American countries have gone through phases and developments such as these, resulting in unbalanced power-relations in the physical and our current digital world.

Others [15, 18, 47] argue that a lack of technologies and/or access to knowledge may be part of the cause for poverty at the systemic rather than individual scale, and that access to technologies can, in turn, reduce issues like poverty. Furthermore, the positioning strategies of the Global North and their one-size-fits-all, center-focused, and techno-solutionistic approaches, market them as being successful around the world, including Latin America. However, for Vieira Pinto [125], technology transfer from one community to another can also be a mistake, similar to how importing technology

does not directly lead to development. Bringing this approach to technologies together with an understanding of "growth outward" helps us see that countries in the center try to develop countries in the periphery with technologies that aim to solve local problems, even if those problems were caused by the exploitation of local resources to build those same technologies in the first place.

This also directly links to the mining of minerals and metals in the periphery destined for technological advancement in the center, which impacts industry, research, and academic HCI practices. HCI has started to grapple with issues of colonialism theoretically through explorations of post-colonial computing [60] and decolonial computing [4], but have also started to apply some of this thinking in various countries such as Bangladesh [120]. Building on this, and by looking into mining as part of modernity/coloniality through the lenses of decolonial thinking, helps us get a more context-based and grounded perspective of it. It allows us to explore the power relations embedded, not only among humans but with the natural environment, along with its (direct and indirect) dynamics and effects. It also allows us, for example, to understand more carefully where technology production is placed within this ecology. Lastly and importantly though, it helps us reconfigure our roles as HCI researchers in modernity/coloniality.

To tackle technology's role in coloniality, Varsavsky proposes to first define the kind of society we want to live in: a *people-centered* or *business-centric* one [124]. Each of these societies then must have their own technological style, if we want to get out of the problem represented by Western, solutions-oriented and capitalist technological practices (which may include cultural domination, economic dependence, or environmental pollution, etc.). Instead of relying on inward and outward growth, he suggests for the periphery to design their own technologies and technology-related and -oriented policies [Ibid.]. Vieira Pinto, in 1973, defended that "whatever the degree of development, every social group has enough technology to face nature and obtain from it the necessary production to live" [125, p. 297]. He believed that cultural diversity contains the intellectual and creative conditions to incorporate modern science and create their own advanced technology, no matter how crude the technological stage may seem.

2.2 Crisis, Tensions, and Making Space

To better grapple with multifaceted impacts of mining in the Amazon rainforest, we also need to engage with critical research in HCI for sustainability. We do not attempt to present answers to the questions raised and being dealt with in this community by presenting our reading of decolonial thinkers; rather this is our way of holding tensions and "staying with the trouble" [55] presented by these extensive bodies of work.

HCI has a strong history of sustainable computing research, exploring how computing and design can contribute to sustainability and unsustainability. For example, Mankoff et al. [76] distinguish between sustainability *through* design and sustainability *in* design. On the one hand, sustainability *through* design includes attempts to influence people and persuade them to adopt more sustainable behaviors such as reduced energy consumption and encourage carpooling [Ibid.]. Such approaches have been criticized for focusing on individual behavior and reliance on simple heuristics for (un)sustainable behavior such as the number of car trips someone may take. However, researchers have pointed out that (un)sustainability and climate change or other non-individualistic climate change issues are social or systemic challenges. Individual behavior change targeting simple heuristics is unlikely or even unable to address these bigger issues appropriately.

Researchers are asking for a change of scale in this subfield of HCI [44]. Climate change issues are more complex than these kinds of simple heuristics make them seem; what might on the surface seem like an appropriate behavior can have unintended negative consequences [117]. Sustainability through design perceives the design of technologies as an appropriate response to sustainability issues, even in the face of planet-wide destruction and the real possibility of the *end of the world* as we know it, perceiving this to be a call for *imminent action* by the HCI community [46].

On the other hand, sustainability *in* design addresses questions of how the design of technologies directly contributes to unsustainability and environmental destruction and how this can be minimized. Studies under this umbrella research the negative consequences to the environment based on our technology use and its design. Research on this includes, for example, energy use of digital technologies and looking for ways to reduce these consequences [128]. Others have explored topics like designing with waste [37].

Several authors have taken more critical stances regarding the supportive role of HCI research and design in matters of (un) sustainability, climate change, and ecological destruction. [116], for example, have criticized HCI's bias towards novelty as being in direct conflict with sustainability goals. Pointing to the complicity of HCI in contributing to unsustainability and environmental destruction, authors have pointed out that implications for HCI can relate to not designing technologies at all, or even to remove technologies from settings and contexts [17]. By taking the systemic nature of ecological unsustainability and its disastrous consequences seriously, others have explored what the role of design can be when experiencing existential crisis [72, 73] or the possible end of the world [46]. These authors argue that doing so, while also being very mindful not to provide *quick fixes*, requires for us to break with some central tenets of HCI: such as our focus on users as different from us designers, breaking with a focus on humans (or animals, for that matter) altogether, and instead to pay attention to ecological-technical interaction. This way of working, they argue, is necessary in the Anthropocene, where all beings are affected by human technology without having a choice. We align ourselves with these concerns and expand on them by highlighting a specific tension at the foundation of our profession and craft. The violence and destruction caused by the mining of minerals and metals, and our dependence on them to build our computing infrastructures.

Overall, research on sustainability and issues related to colonialism and coloniality has grappled with its effects, such as issues of environmental destruction around the world in a large array of contexts, countries, and uses of technologies. In this paper, we are using a decolonial lens to explore the space where both of these discourses meet: technology and their design processes in a time of existential crisis [72, 73].

We want this paper to give us space to hold tensions on the environmental destruction dilemmas we are faced with and our

complicity with them. As HCI researchers, we use and also research the design and development of novel digital technologies. But in this paper we also embrace the uncertainty in HCI research [119], hold tensions of our own histories and the discomfort of our complicity in the violence perpetuated in Indigenous and otherwise marginalised communities who live in the places where ecological crises are most likely to strike.

3 THE DILEMMA: MINING, TELECOMMUNICATION, AND COMMUNITY NEEDS

The destruction in the Amazon is part of the foundation for the development thriving outside of it. Communities in the Amazon region are affected by a series of issues including government negligence, invasion of their land, deployment of big enterprises, and deforestation [112]. During 2019, fires destroyed 9700 km2 of the Amazon Rainforest in Brazil – an increase of 30% over recent years [40]. By May 2020, this number was doubled [82], by the end of 2020 rose again by 9.5% [1], and by March 2021 deforestation was considered the highest in 10 years [7]. The majority of the fires were man made, to convert rainforest into economically usable land.

At the same time fewer inspectors work in the Amazon since the Brazilian government decreased environmental controls [19]. There are now fewer than 700 environmental inspectors in an area that is bigger than the land of the European Union [51]. Such environmentally destructive practices and government controls are spurred on by a rhetoric of *development* associated with Brazilian President Jair Bolsonaro. His government aims to open protected and Indigenous forest for mines [66] and argues that this development will bring jobs and reduce poverty, which in turn, he suggests, will somehow decrease deforestation [96]. In 2019, Bolsonaro proposed a mining bill that if approved would affect, counting only the current mining requests, between 47% to 87% of Indigenous lands [12, 103, 112]. Many of the people living in those areas fear for their lives and livelihoods, as with the destruction of their land comes the end of their way of life [74, 102].

Furthermore, in 2019, it was also reported that the violence due to illegal mining and its occupations has increased considerably (more than doubled) compared to 2018 [26]. Violence also occurs in several mining companies investigated, not only for environmental crimes, but also for keeping workers in situations similar to slavery [8]. In 2021 the covid-19 pandemic is yet another crisis that exacerbates these concerns. At this time, the Indigenous Tembés community calls attention to the fact that if they stay, they are killed by the invaders, and if they go to the city, they are killed by COVID-19 [89].

In the Amazon region and over the period of more than half a century, these catastrophes however are not only caused by deforestation and legal large-scale mining [24, 41, 98], which occupies 17% of the Amazon rainforest. They are augmented further by illegal ASM, which occupies 17% of protected areas and 10% of indigenous lands [79, 101]. The Amazon has almost five thousand identified locations where illegal mining is practiced [6] with a particular focus on the extraction and search for precious minerals and metals. During the Covid-19 pandemic, 72% of the illegal ASM took place in protected areas [2, 42]. This kind of illegal and small-scale mining remains a main economic activity and functions as motivation for the migration of people [123]. Bad living conditions for these migrant workers in areas where ASM occurs, mean that these areas often also become centers for the spread of diseases like malaria, leishmaniasis, hepatitis, tuberculosis and HIV [45]. In South Africa, for example, it was found that the migration of miners and their spending of long times away from their homes increased their likelihood of contracting and ultimately spreading HIV [28]. Similarly, in the Amazon an increase in sex work has been found, resulting in the migration of people of all genders to the mine, which could explain the increase of HIV infection among those living near them [45, 123].

Mining in the Amazon region not only broke deforestation records in the last two years [85], but has also caused wide-spread mercury contamination. Fish, even those sold far away from the contaminated areas, were found with high levels of mercury [10, 29, 64, 97]. This contamination has caused clinical and neurological impacts associated with exposure to mercury levels in populations in the whole Amazon through water, air, or the high levels found in the fish that are eaten by the locals [112].

3.1 Ribeirinho Communities in Acará

The Amazon rainforest is home to a large number of communities, including several hundred Indigenous ethnicities, *quilombolas* (communities of former slaves), *ribeirinhos* (communities living alongside the rivers who are not Indigenous, even though they follow some similar traditional ways of life), and other traditional communities. They are communities affected by government negligence, increased incursion by outside capitalist enterprise, and under increasing pressure to become *modern* (reflected in the deforestation and development agenda pursued by the government - see e.g, [21, 52, 95]). Modernisation and the rhetoric of development that frequently accompanies economic incursion, is certainly not universally accepted within the communities. Rather, for many, it holds potentially disastrous consequences. Nevertheless, modern technologies such as smartphones and the internet continue to reach remote communities in the region: creating new opportunities and new challenges for the environment and the diverse communities living there.

For several years, the first author worked with members of a specific ribeirinho community in the Brazilian state of Pará, called Boa Vista do Acará – based along the shores of a river. As mentioned above, ribeirinhos are part of the Amazon's non-Indigenous rural populations, numbering approximately 951,000 people [35]. They are also one of Brazil's most economically marginalized groups [105]. Despite economic marginalization, they have a rich local culture of herbal traditional remedies and healing rituals, agricultural production, and the processing of local plants such as cassava and açaí.

Fishing is a common stream of income and food for people in the village and wider region. As the organizer of ecological and permacultural workshops with Boa Vista do Acará, the first author was trying to find ways to increase the communitys' autonomy. In conversations with two different friends from this community, one whose house is next to a river and the other who has a *popopo* (a

traditional slow boat) to transport people and goods on the river, the first author heard about the need for help with the construction of fish-farming adaptations in their backyards. They both had already started digging on their land, putting fish into the newly created ponds in an attempt to farm them. However, they had not succeeded. The first author was puzzled: they both had easy access to the river to catch wild fish, so why were they not using that advantage and wanted to farm fish in a pond instead? After further conversations, the first author learnt that, yes, the river was once a rich source of fishing for food and income, but for the last years the large fish had seemingly disappeared and the community was only able to catch very small fish.

3.2 Mining Activities related to Technology Production and its Consequences

The rivers around the community of Boa Vista do Acará and the neighbouring quilombola community Guajará Mirim are connected to the Mucurupi river. This larger river flows along the city of Barcarena. Barcarena, located only about 30km West of Boa Vista do Acará, is home to a Norwegian mining operation with two industrial centers: (1) Alunorte, the largest alumina (the raw material for aluminium) refinery in the world outside of China since 1995; and (2) Albras, the largest producer of primary aluminium (bauxite) in Brazil, which has been feeding domestic and external markets since 1985 [5]. Aluminium is everywhere, with the most common applications being in power lines, telecommunications, high-rise buildings, spacecraft components, or consumer electronics. Manufacturers of electronics are using it primarily for cooling CPU and graphics processors, but newer models of electronics are also using aluminium bodies and casing components [43], specifically because it is 100% infinitely recyclable [13]. Thus, also the computing infrastructure at the center of HCI depends on aluminium mining operations like the one in Barcarena.

However, even though the operation of Barcarena is official and supposedly legal, and does not constitute informal or illegal ASM, it has been connected to various instances of environmental catastrophes. For example, in Barcarena, some confirmed cases of water contamination by toxic metal waste have been identified in the rivers near the city in 2003, 2009 and 2018 [86, 90, 109, 110]. While it is crucial to point out that a clear link to the disappearance of fish in the river of Boa Vista do Acará has not been yet established, it is possible to imagine it as a consequence of the mining operation and the pollution that occurs in Barcarena (see the following for more details [94]). And regardless of official research associated with this, the communities directly around Barcarena have certainly suffered the consequences [16, 49]. As shown in the previous sections, mining embodies the visions of development related to modernity and coloniality and it has been associated with disastrous consequences at both social and environmental levels in various territories in the Amazon region. Despite us not being able to pinpoint evidence for the specific case of Acará due to limitations on available data, the effects documented in other communities in the Amazon are worrisome [106] and more specifically, the livelihood of the community of Boa Vista do Acará as well as their independence and food sovereignty have potentially been negatively affected.

As explained previously, Acará and similar Amazonian communities are under pressure to modernize and *develop*. The inhabitants of Acará have made very clear what kind of development they would want throughout the first author's long-standing collaboration with them [31]. In a passionate speech the first author witnessed in 2016, a young woman stated that, as a community, they want to continue their way of life, to maintain their practices while also living relatively independent of the nearby city. However, it has become harder and harder to keep this independence since people are driven to look for work in the city or even further away, pressured to do so, for example, by the disappearance of fish.

To relieve their pressures somewhat, the community have been looking towards digital technologies, especially to improve their internet access for information, knowledge, and routes to advocacy in local government. Furthermore, they are hoping technologies will ease access to healthcare and education for their children, as well as to generate possible new income streams or to promote and increase the sales of their goods. To support them in this effort, the first author has previously collaborated by connecting the village of Acará to the internet network of the federal university in the area [70].

Together, the community and the first author started an organization called co-Nectar[1] in 2016, which manages the collaboration with the university as well as the local infrastructure. The organization attempts to further expand this community network to neighbouring towns, villages, and communities. People in Acará have since changed their economic practices. For instance, they have gone from selling agricultural products wholesale to sell these to individual customers or coordinating their activities via WhatsApp rather than spending the day at the market in the city. They have also started to engage in their form of e-commerce, selling various goods regionally via messenger services, organizing logistics networks across the region including friends, family, and mobile phones. Others have engaged in online activism on Facebook and WhatsApp to mobilize resistance against environmental destruction by energy companies [31].

Their use of mobile phones and internet to achieve the desired level of indepence and their own vision of development is ironic, tragic, and circular. It is a wicked cycle: cellphones and internet infrastructures help them resist changes and negative impacts brought by development, such as power lines and mining. Yet these advocacy tools to counter environmental destruction, potential health impacts, and resulting loss of income depend on the very raw materials produced through the mining which is constitutive of the development in the nearby community.

4 DISCUSSION: DISENTANGLING WICKED CYCLES

Through this article we do not aim to legitimize the idea of going back to the Stone Age (even if the stones and its derivatives are what we need most nowadays for the production of technology). Instead, we argue to pay more, and careful, attention to our dependency on minerals and metals. The speed of development, as defined by modernity and coloniality, and the ways in which it occurs in communities in the Amazon is frightening. Local natural and ecological

[1] https://coletivo-co-nectar.webflow.io/

resources are the main source of local communities' sustenance. However, in areas where valuable minerals and metals are found, the development arrives through trees being cut down, lakes and rivers being polluted, increasing inequality, and slow removal of local communities from their food and land sovereignty, traditions, and social relations, making them more and more dependent on external markets. Despite the connection to mining and the associated destruction, the wish for and use of digital, mineral-based technologies is by no means the product of flawed reasoning, but a sensible and effective strategy. In the community of Boa Vista we have witnessed the impact mobile phones have had, not least on their economic independence. We also know that Boa Vista is not the only community who is simultaneously struggling with the impacts of mining and using technologies to their advantage. Elsewhere mobile phones are used extensively to document and fight incursion into protected and indigenous lands [104]. Mobile phones can clearly be powerful tools in fighting for one's own vision of development and against economic destruction.

The writing process of this paper offered us a space to hold these tensions and understand further the violence we are contributing to as HCI researchers within global technological supply chains and its deep impacts. This is an issue that has been partially reflected upon by previous researchers and that we considered as part of a wicked cycle. For Araoz, *modern colonial mining* and *technological advances* "are, in fact, the perfecting of the art of war" [9, p. 13] which has led us to environmental crisis. This crisis forces us, now, to understand and accept the existence of interconnected worlds; to acknowledge an understanding of the world which is radically different from those of western contemporaries [30, 33, 67]. Following their ideas, we must re-envision design and technologies as design for different ontologies [39, 57], and for understanding the pluriverse as an alternative to the unique universal ontology of one world: a "world in which many worlds fit" [34, p. 10]. As a result, we do not provide the customary guidelines or implications for design researchers at the end of the paper. Instead, we raise unanswerable questions to help us think through this, and other similar, dilemmas. We do not give clear solutions to these, but rather provide alternative views of what could be if we lived in a true pluriverse where we meaningfully apply these kinds of critical thoughts to our HCI research. Through these questions and theories, we aim to provide room for others to reflect, to acknowledge our complicity, and to create common spaces for meaningful and respectful action.

The dilemma we introduced through Boa Vista do Acará illustrates several of the actors, relations, and dynamics which hint at global colonial structures of power [99], and how they specifically play out in the region. We have the *Global North*, in this case, represented by a European company conducting an economic extractivist activity, mining, in a *Global South* territory. The Amazon territory is the place having been exploited for its resources (human and nature) for a long time. Some of its environmental destruction has been documented, including mining which has diverse scales of impact not only in Boa Vista but also in other places of the Amazon region. Developmentalist discourses have promoted these activities as strategies of growth and modernization where the production and use of technology is core to the narrative. These ideas have been prioritized by the government and other actors over more nature-protective forms of dialogue as well as use of nature and its resources as part of the practices of various local communities (ribeirinhos, quilombos, and Indigenous communities). At the same time, the communities are also aiming to have access to telecommunications, internet infrastructures, and other technologies. It is at this point that we should, as technology researchers, stop and question our practices and roles.

As authors, what we learn from this dilemma and decolonial ways of thinking is that our usual, Western, approach to research and design is not the right way of understanding and dealing with wicked cycles. Changing or adapting our practices will not be enough to tackle these global problems. The scale of change is different to our more traditional research projects in HCI, particularly those that relate to local communities and their empowerment. While the immediate needs of the ribeirinho community with which the first author has worked for many years are important, the level of thinking in this paper does not relate to the local level. Nor does it really relate to the systems level of understanding the use of technologies and their impacts on the community and its surroundings in Brazil. Rather, we are thinking at the scale of global economic change, and the impacts of colonization, coloniality, extractive policies, and the impact of growth culture in the technology sector (and elsewhere).

It is still unclear to us, as authors, what we can practically do to engage in this kind of global change in our economies - perhaps that is why this years' Communities and Technologies conference theme "Wicked Problems in the Age of Tech" felt like the right venue for our thinking. We feel that decolonial ways of thinking have helped us reflect further on some of these issues and want to offer up a similar feeling of (dis)comfort to readers of this paper that we had as a team of co-authors while discussing and working on this paper. Below, we present three different frameworks of thinking that we have discovered in our search for holding tensions, crises, and feelings of discomfort at the intersection of ecological destruction, local community needs in response to the climate crisis, and their need for technologies that created many of these crises in the first place: Ecofeminist Perspectives, Design as Conviviality, and reflections on the Speed of Development. We present these frameworks as potential alternative starting points for others as part of a pluriversal worldview [34], and hope they will be helpful for thinking through some of the wicked cycles in your own research.

4.1 Ecofeminist Perspectives

Industrial agriculture and mining embody a relation to soil that is purely extractivist and profit-oriented, rather than reciprocal. Mining operations not only modify the landscape and erode the soil but also lead rapidly to its desertification and sterilization. It takes minerals without giving or caring for the reproductive capacity of what is physically above the minerals [75]. Vandana Shiva [114] provides us insight into alternative ways of understanding, working with, and being with the soil. Learning from this ecofeminist lens, we can start to think not only about alternative farming and mining practices, but we can start to change our frame of reference for the extraction of materials from the soil.

Shiva focusses her analysis of colonialism and coloniality on Europe's wealth in the colonial era as largely based on the transfer of resources from the colonies to centers of imperialist power and

the replacement of the colonies' biodiversity with monocultures and large mining operations for the production of raw materials for European industry [115]. She argues that this domination, violation, and exploitation of the colonies' nature and people lead to their reduction of nature and people into objects of knowledge rather than recognizing them as beings with agency and rights. Such vision over them was imposed when they were conquered by Western patriarchal structures and systems as part of colonial rule. In [114], Carolyn Merchant [81] relates this reduction to a change in the ways in which we understand nature: from a nurturing *mother figure* to the manipulable matter, which is then, of course, also well-suited to the exploitation of capitalist growth.

Drawing on this theory, what would happen if our relationship to soil would be reciprocal, and not based on such Western scientific ideas around binaries and fragmentations[2]? What if we respected or even worshipped the reproductive potentials of the land, how would it affect mining? Would mining be possible at all? Or, how would we need to adapt existing mining practices? And ultimately, how would answering these questions reconfigure our practices as researchers in a field in which the very tools we use and design are dependent on mining for their production?

4.2 Design as Conviviality

For many decades, philosophers and technicians have pointed towards technology's disastrous potential to disrupt humans' social relations (see e.g., [58, 78, 80, 87]). These perspectives range from "enhancing each person's range of freedom" to build and create, all the way to an exploration of how technologies have transformed people into "mere consumers" [58, p. 12]. Especially Ivan Illich highlights that our economy's need for endless expansion leads to the constant invention of new needs to which industry can respond with new products - creating cycles of needs (re)invention and technology development. As HCI researchers, we are also implicated in this constant need for (re)invention and expansion. Arguably, from a capitalist mindset, this is the ultimate goal for technologies, but Illich's thoughts come from a different perspective. He argues that what follows on from this way of being is an ever-growing dependency on metals and minerals and the destructive consequences of mining - we hope our paper has pointed to many of the ecological, social, and rights-based crises this can create.

To overcome this negative role of technology in society, Illich proposes the concept of *Tools for Conviviality*. He believes that science and technology could be enlisted in the service of more efficacious convivial tools and designs, so that technology serves humans rather than humans being at the service of machines and their societal instrumentations. Some scholars already explored the implications of conviviality for HCI and design (see e.g., [23, 39, 63, 88]), pointing out the importance of tools that guarantee freedom and autonomy, eliminating the need for slaves or masters, but limiting the freedom tools are afforded when the freedom of some comes at the expense of the freedom of others or for the capacities of the environment. Computing technologies certainly expand the freedom (of some), but because of the violence and destruction associated with the mining for technology's building blocks, this freedom comes at the expense of nature and of the freedom of communities impacted in different ways by mining.

To slow down world-wide extraction of metals we believe Illich's ideas hold some crucial lessons not just for the design of new individual tools but for the reform of the global digital economy as a whole. How could we, not as individual designers and researchers but as the HCI community, detach ourselves from the need for constant innovation and contribute to conviviality instead? Can we create digital technologies that offer a *better* life for all, without limiting freedom of others or the regeneration of the environment?

4.3 Understanding the Speed of Development by detaching Science from Technology

We have seen traditional communities in the Amazon region using and making tools that have been passed through generations and used for economic maintenance and social strengthening[3]. Nardi and O'Day [88] say that in traditional communities, where tools and technologies do not change quickly, "tool use is learned in interaction with others, not through manipulations staged by unseen designers." The slow speed of technology transformation helps local environmental preservation in contrast to several environmental deteriorations derived from modern lifestyles, such as one that is known by some Brazilian natives as the "people of merchandise" [65, p. 37], who have an unhealthy relationship with the Earth and represent a threat to them. For some scholars, the speed of technological evolution and its understanding can lead us to reorient our civilization and understand society, culture, and ourselves [25, 57, 87].

Varsavsky [124] proposes that if we want to get out of the problem presented by capitalist technological practices (such as cultural domination, economic dependence, environmental pollution, among others), each type of society must develop its own *technological style*. Vieira Pinto adds that cultural diversity has the intellectual and creative conditions to incorporate modern science and create their own advanced technology without technology transfer processes, no matter how crude the technological stage seems. With this, he critiques globalization and argues that each community has the technological resources to meet their own needs [125, p. 297]. To understand this kind of development of communities and technologies, we look towards Krenak [68], a Brazilian Indigenous thinker and leader, whose land was impacted by 50 million cubic meters of mining tailings [93]. He argues that with the arrival of modernity and technologies, science and knowledge were placed in *secret places*, places of exclusivity. People, mostly scientists, "took the voice of science," treating knowledge almost as their exclusive asset, aiming to do the "job of bringing us to this place that we call modernity." He argues that technology can end up being confused with science, not because they are the same, but because they develop alongside one another [68]. Nowadays, what is possible to find in communities like the Amazon region is technological dependence and overexploitation of the natural

[2]Together with the Western industrial revolution, the Western scientific revolution "transformed nature from terra mater into a machine and a source of raw material" [114, p. xiv]. Such transformation was based on Bacon's contribution to modern science (1561-1626) (see more for discussion [14]), which enforced the separation between superstition and rationality, creating binaries such as: "male and female, mind and matter, objective and subjective, rational and emotional, and a conjunction of masculine and scientific dominating over nature, women and the non-west" [114, p. 15].

[3]Tools like *tipiti*, used to squeeze out the juice from the cassava, are made with local resources and passed through generations.

resources and workforce [22]. Krenak says that: "With the advent of industrialization, technology skyrocketed in front of science and started to govern the world we inhabit" [68].

This distinction between science and technologies is important, because science has a voice that is sensitive to the complexity of the ecology of the planet. Technology instead can be understood as being *in a hurry* to anticipate ideas of progress and the future. As Krenak says: "Technology is the tool of time." From the moment that companies approached universities to encourage research, universities started to commit to the production of responses, devices, and technologies to meet an external demand. Arguably, this is a demand of "the 'people of merchandise' not that of the 'people of knowledge'" [68]. To counter this history in HCI and beyond, we need a new orientation of science and technology towards "the organic, the gentle, the non-violent, the elegant and beautiful" [113, p. 35]. We must look for ways to find solutions which reverse the destructive direction that now threaten not only Indigenous people and communities like Acará, but us all.

Building on these thoughts: What if we thought about resources as localized, where only local communities and peoples are able to fairly and justly use them? What if technological development went at a speed that was relational to the speed of environmental regeneration and local practices? And finally, what impacts would this alternative world have on our practice as HCI researchers?

5 CONCLUSIONS

Decolonial thinking can help us better understand and complicate notions of development and mining, particularly in the Latin American context. It helps to evaluate the impacts of mining, both large-scale and ASM, as the results of a historical extractivist practice which perpetuates colonial structures and dynamics in what we usually understand as post-colonial contexts. Of course, these issues also have wide environmental justice repercussions on the communities who are part of and impacted by it. However, decolonial thinking also allows us as HCI researchers to critically acknowledge the "colonial matrix of power" [100] in which the research we carry out with communities in Global South countries are embedded. It allows us to unpick aspects and issues of our role and address our perpetuation of colonial practices. It gives us tools to reflect on how our research steps, from the funding source, the topic selection, the community we engage with, to the shape in which the research is implemented, as well as its outcomes, is deeply embedded in coloniality and contributes to destructive processes at the foundation of our discipline, but outside our daily view. This is true not only for those of us who engage with mining or communities affected by mining, but all of us. This presents a fundamental problem to our discipline, and our usual tools of researching and designing interaction with technology are not appropriate to address them. We explicitly refrain from presenting easy ways out of this deeply uncomfortable situation. The questions we raise at the end of each of the sections in the discussion are only a start to think together about how we can address our complicity, and relate to alternative worldviews of environmental justice relevant when thinking about the future of the planet. And we would like to see future papers drawing out long reflections from differing perspectives from them. They could be reflected upon as a suggested premise that human subsistence cannot be prioritized without also considering the priorities of nature [50, p. 60]. At the end, one of the central cores of ecofeminism (and also decolonial thinking) is the interdependence that exists among all beings [Ibid.].

In recent decades work in HCI on issues of sustainability has also explored the complicity of our discipline in contributing to *un*-sustainability, and its complicated role in matters of the anthropocene, as mentioned above. We contribute to this body of work through engagement with the issue of mining, hoping to deepen our understanding of this complicity and enable the development of an appropriate response. To this end, we bring together decolonial thinking in computing, bringing a specific dilemma to think through some of the complexities associated with HCI4D and critical sustainability. In the discussion we have also presented alternative frameworks that we can use to think about research when working with wicked problems and as part of wicked cycles. We realise this paper puts forward a radical perspective, one that strives to address a global system without a solution. But that is why this paper is important. In HCI, we do not only need to engage with wicked problems, but also with the complexities that arise out of wicked cycles. Our paper presents a dilemma that encapsulates what we call wicked cycles. Through the analysis at the global systems scale it allows us to tie further knots to think through our role as HCI researchers rather than untying knots as would be traditional and pragmatic in HCI research. We must do this to hold tensions, to understand our role in the climate crisis and its multifaceted socio-political and socio-technical consequences, and to explore our deeper engagement with the impacts of our research at the community level. Aráoz [9] calls for a revolution that allows us to reverse the perverse *mining-dehumanization* process and find ways to recognise us as the humus of Mother Earth. Afterall, we don't have to just *stay with* the trouble as HCI researchers, we have to understand that *we are* the trouble.

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We leave this space for Ivo Cípio Aureliano, Indigenous Macuxi: "The shamans say that the mountains, the rivers and the forests are not holding what the white man is doing with nature. And that weakens the work of the shamans, who are therefore unable to heal their people. Gold mining is destroying more and more, not only the sacred sites but also the entire culture of a people" [103].

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