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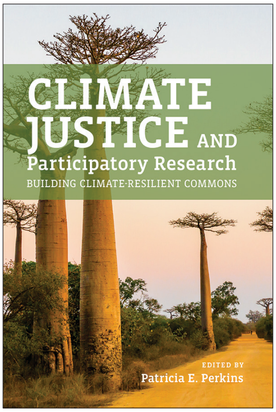

CLIMATE JUSTICE AND PARTICIPATORY RESEARCH: BUILDING CLIMATE-RESILIENT COMMONS

Edited by Patricia E. Perkins

ISBN 978-1-77385-408-3

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Mining and Water Insecurity in Brazil: Geo-Participatory Dam Mapping (MapGD) and Community Empowerment

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Introduction: Environmental and Climate (In)Justice, Mining, and Water (In)Security

Brazil (see Map 2, page 30) can be considered a water power, given that it possesses 12 per cent of the total available fresh water on the planet, 90 per cent of its rivers are perennial, and 90 per cent of its territory receives regular rainfall. Brazil houses several aquifers, including the Guarani aquifer,[2] as well as large extensions of important planetary wetlands, including the extensive ecosystems of the Pantanal and Amazon. Brazil also houses a major portion of the biggest watershed in the world—the watershed of the Amazon River (Rebouças et al., 2002). Yet despite this apparent abundance, water is not evenly distributed in all states and cities. Moreover, as a country of huge size, Brazil encompasses regions with great water wealth while other regions experience water scarcity. In addition, due to poor management and usage of water, supply problems are increasing in urban centres. In Brazil's major cities, with high demand for water and patterns of land occupation and use that disregard impacts on the watersheds and waterways, there is increasing scarcity of fresh, potable water. Another situation of concern in Brazil with regard to water is the major mining disasters provoked by ruptures of mine tailings dams that have occurred in recent years, killing hundreds of people and contaminating entire watersheds.

In this chapter, we show how water-related environmental injustices in Brazil are worsening, due in part to climate change. These climate injustices are predictable, resulting as they do from a combination of overt government policy, the inefficiency of the Brazilian government in its implementation of management and inspection systems, corporate impunity, and private-sector interventions to sway public opinion. We focus on situations in Brazil in which mining activity impacts water quantity (destroying areas of water storage and replenishment) and water quality (through mine tailings dam disasters). Mining impacts the water security of thousands of people. Many of these people do not have the slightest notion of the risks and violations associated with mining in terms of their right to water access. Many regions affected by mining are far removed from the actual site of extraction, meaning that mining is invisible as a component of people's daily economic reality. The mining companies themselves are promoters of environmental injustices, especially in times of climate change-related rainfall events which worsen disasters like breaches of mine tailings dams.

Fighting such planned climate injustice requires naming and exposing it, combatting corporate obfuscation and government failures through public education, organizing politically, and building international solidarity. We describe some movements and methods that are part of this struggle, based in our own experience as participatory researchers and educators in Minas Gerais, Brazil.

The following section of this chapter overviews recent mine-related water disasters in Brazil and their roots in regulatory and enforcement failures. Section three shows how this mismanagement is organized and planned, using disinformation as a concerted strategy. In section four we describe ways of countering disinformation and strengthening local awareness of climate injustices and risks, such as geo-participatory mapping. The chapter's conclusion situates popular education, organizing, and global solidarity as the political context for mining and water-related climate justice.

Mine Disasters: Climate Injustice Produced by Regulatory and Enforcement Failures

In November 2015, the Samarco mining company's Fundão tailings dam ruptured. Samarco is located in Mariana in the state of Minas Gerais and is jointly owned by multinationals Vale S.A. and BHP Billiton. The Fundão dam contained a volume of about 60 million m^3 of toxic mud tailings. The impact of the spill, however, went far beyond the mine site, with a flow path extending for more than 600 km along the Doce River system until it reached the Atlantic Ocean. On arrival at the coastline, it travelled several kilometers out into the ocean and affected areas along 80 km of the Brazilian coast. Throughout this journey, the spill of toxic waste affected thirty-nine municipalities in the states of Minas Gerais and Espírito Santo (ES).

Just over three years later, in January 2019, the dam at the Córrego do Feijão mine collapsed in the city of Brumadinho, also in Minas Gerais state. This mine was owned solely by Vale S.A., with a tailings dam holding a volume of 12 million m^3 of mine waste. This spill extended along 300 km of the Paraopeba River, a tributary of the Sao Francisco River, one of the longest rivers in Brazil (Zonta & Trocante, 2016; Pinheiro et al., 2019).

In addition to being among the largest in the world in terms of tailings volume, the Fundão dam in Mariana was also the most extensive in the world. The Brumadinho disaster had the second largest number of fatalities, and the highest number of workplace fatalities of the twenty-first century (Zonta & Trocante, 2016; Wanderley et al., 2016), in addition to being the largest "workplace accident" in Brazilian history (Espindola & Guimarães, 2019). These were not the first tailings dam collapses to occur in Brazil and, it seems, will likely not be the last (Zonta & Trocante, 2016; Pinheiro et al., 2019; Campolina, 2021; Campolina, Gianasi, et al., 2021).

A total of 291 people lost their lives in these two recent disasters (19 in the Samarco-Vale-BHP disaster and 272 in the Vale S.A. disaster). Two important river basins were destroyed, resulting in a variety of impacts on ecosystems, public health, and economic activities throughout the various municipalities and in the region as a whole. Shortly after the collapse of the dams, one of the problems immediately identified was the quantity and quality of water supply to several urban areas. This was due to contamination, especially in the Paraopeba River. Even three years later, at the beginning of 2022, environmental agencies were still recommending that the water not be used for drinking, animal watering, fishing, leisure activities, or gardening. Most of the affected population depended on the river and its resources for survival, meaning that their food supply and economic security was severely impacted. This population, already vulnerable in socio-economic terms, has experienced various situations that violate their basic rights since the dam collapsed, especially their right of access to water.

Many of these communities were unaware that there were mine tailings dams located upstream from their cities. They had no idea of their risks in the event of a possible rupture. Even more alarming is the fact that, upstream from these same populations, there are dozens more tailings dams, some of them also operating at critical safety levels, categorized as "high risk" by government monitoring authorities.

We can therefore see that millions of people in Brazil are experiencing situations of environmental injustice. Many others risk being victims of future tailings dam ruptures, especially taking into consideration climate change scenarios with predictions of increasing extreme weather events in regions where the dams are concentrated. According to Milanez and Fonseca (2011, pp. 93–94), the concept of "climate justice" emerges as an integral part of the paradigm of "environmental justice." Given that existing social inequalities define a social group's degree of exposure to environmental risks, it becomes clear that the impacts of climate change affect particular social groups with differing forms and degrees of intensity.

Acselrad, Mello, and Bezerra (2009, p.9) conceptualize environmental injustice as the "phenomenon of disproportionate imposition of environmental risks on populations less endowed with financial, political and informational resources." The authors, when observing the mechanisms that lead to the production of environmental injustice, start from the assumption that environmental inequality manifests itself in two ways: unequal access to environmental resources and unequal environmental protection.

Unequal access to environmental resources can occur in the spheres of both *production* and *consumption*. While the sphere of *consumption* refers to access to natural resources that are already transformed into manufactured goods, the sphere of *production* relates to different ways of appropriating nature for creation of the basis for sustaining life itself (Acselrad et al., 2009, p. 73). In relation to *production*, then, what we see is the continuous destruction of non-capitalist ways of appropriating nature, such as artisanal fishing, family farming, or a "commons" of shared resources. Diverse territories are affected by the environmental impacts arising from large enterprises implanted in frontier areas where capitalism is expanding. Monocultures, dams and mining enclaves create major destabilizing effects on activities carried out on traditionally occupied lands, destroying the resource base that sustains such forms of life (Acselrad et al., 2009).

This is also reflected in the unequal environmental protection that emerges as environmental policies are implemented—or the omission of such policies as a result of neglect and/or action by market forces. All of this generates disproportionate environmental risks, intentional or unintentional, for the most vulnerable. The vulnerable are characterized as lacking financial and political resources: they are among the poorest of the poor, least covered by public policies, residents of devalued areas and of marginalized ethnicities. This unequal exposure to environmental risks and impacts does not result "from any natural condition, geographic determination or historical causality, but from social and political processes that unequally distribute environmental protection" (Acselrad et al., 2009, p. 73).

With respect to environmental protection, it is worth highlighting the relatively recent achievements in Brazilian legislation, both in relation to water management and dam safety. These may be threatened, however, by a proposal for a New Brazilian Mining Code, discussion of which began in December 2021.

Brazil's National Environmental Policy (PNMA, Law L6938 9) was adopted in 1981 and established legal instruments to monitor environmental impacts. Enterprises that generate substantial environmental impacts must prepare and submit Environmental Impact Studies and Environmental Impact Reports (EIA/RIMA), as a requirement in the licensing process. The EIA/RIMA encompasses both environmental and socio-economic impacts. Its main objective is to orient inspection bodies and affected communities with regard to the type of project to be carried out and feed into their decision-making on the feasibility of issuing an environmental license.

With regard to water management, the country has recently moved from a model of centralizing legislation—which gave priority for water use to the energy and industrial sector—to a proposal to build democratic management of water. In 1997, a National Water Resources Policy (PNRH, or Política Nacional de Recursos Hídricos) was instituted in Brazil, known as the "Water Law." According to the Water Law, "the management of water resources must be decentralized and involve the participation of public authorities, users and communities."[3] It must be carried out by collegial bodies, designated as Hydrographic Basin Committees (CBH), or watershed committees. These are spaces for discussion and decision-making on the uses of water, in addition to planning actions to maintain the quality and quantity of this resource. According to the PNRH, water is a public good which has economic value, and its management must include multiple uses, but, in case of scarcity, priority must be given to human supply and animal watering. The committees' management territory is determined by the hydrographic basins which, according to the law, must be "basic units for planning the use, conservation and recuperation of natural resources" (Brasil, 1997).

Despite introduction of the Water Law in 1997, the water resources management system has not yet been fully implemented in Brazil. Many of the management instruments such as Water Resources Plans, which are meant to contain a large compendium of information about each watershed such as water demand and predicted flow capacity, as well as plans for water usage, do not mention mine tailings dams. There is no mention of the probable impact of these dams over large areas of the watersheds. Moreover, there is almost no coordination of the policies involving water security (Campolina, 2021).

With respect to dam safety, a National Policy on Dam Security (Política Nacional de Segurança de Barragens—PNSB, Law L 12334) was established in 2010, although it did not begin to be implemented effectively until 2020. One of its requirements was for mining companies to develop Mining Dam Safety Plans (Plano de Segurança de Barragem—PSBM) that contained, among other pieces of information, flood maps based on all available information, including estimates of worst-case scenarios from a dam rupture. The requirements of the PSBM included technical information regarding the construction of the dam, probable causes of breaches, means of monitoring and controlling possible failures, and steps to be followed in the event of emergencies and/or rupture of the dam. This body of information was to guide the elaboration of a Contingency Plan (PLANCON) by municipal bodies responsible for civil defense of the affected cities as defined by the flood maps study. Moreover, actions were also to be defined based on the geographical delineation of possible areas affected in the event of a breach. This was to include impact on water security throughout the river basin during a spill event (Campolina, 2021; Campolina, Iwama, & Gianasi, in press).

The legal requirement for flood studies and flood maps is also found in the 2017 legislation of the former National Department of Mineral Production, DNPM, which in 2018 became the National Mining Agency. Article 2 defined a flood study as a study to adequately characterize the potential impacts from flooding originating in the rupture or functional failure of a mine tailings dam. The flood study had to be carried out by a qualified professional using best available methodology as defined by the mining corporation and the professional. The flood map produced by the flood study had to establish the geographic limits of the areas potentially affected in the event of a rupture and delineate possible scenarios, including worst case scenarios. The objective of these studies and maps was to facilitate efficient notification and evacuation of people in the affected areas.[4]

In Brazil, thus, national—and state—policies exist, with their respective management instruments. These policies are designed to calculate and provide warnings about potential risks affecting water security among the different populations along a hydrographic basin. Looking back at the last two major mine tailings disasters, however, what is remarkable is the ineffectiveness of these instruments. No estimate or document prepared in advance came anywhere close to capturing the dimensions of the actual impacts provoked by the breaches at Mariana and Brumadinho. Nor was there any anticipation of how these impacts would be further intensified by the crisis they created in terms of water supply. A study of the documentation on which Hydrographic Basin Committees make local decisions regarding water management reveals a more serious issue. The existence of mine tailings dams in the territories they manage is not even mentioned, much less the safety risks presented by these dams and the possibility of impacts affecting extensive regions.

As for the impacts of mining on water security, in addition to mining disasters, it is necessary to highlight the cases of regions in Brazil where mining destroys ecosystems that are essential for climate maintenance. The Amazon Forest in the north of the country is one such case. Another is the Iron Quadrangle in the central region of Minas Gerais state, an area rich in iron deposits extending over 7000 km^2. Here mining is destroying the aquifers that store water in the midst of the iron deposits (Matschullat et al., 2000; Varejão et al., 2011; Teixeira et al., 2017), which are vital both for human use and for entire ecological systems.

The New Mining Code that is currently under discussion in Brazil contains proposals contrary to the principles of environmental justice. It sets up automatic approval processes for technical and environmental impacts of mining and proposes to establish mining as "an activity of public utility, of national interest and essential to human life." If the New Mining Code is approved as it stands, it will call into question existing conservation areas and demarcation of Indigenous lands. In addition, the New Mining Code provides for flexibility in environmental rules. In practice, this change may allow for exemptions from environmental licensing and automatic approval of processes that have been stopped for more than a year at the National Mining Agency (ANM) (Bispo, 2021). If this proposed law advances, more than 90 thousand mining concession processes could be authorized without due investigation. Data from the Amazônia Minada project reveals that 2,478 current requests to mine in Brazil are on Indigenous lands, and at least 254 of these requests are for artisanal mines (Potter, 2021). It should be noted that many of the regions with mineral deposits are heavily forested areas, essential for climate maintenance, and their destruction would tend to intensify extreme weather events, making the water security situation in the country even more delicate. More mining projects are problematic, both in regions prone to drought where new mines would increase the water demand, and in regions with excessive and intense rainfall which could increase the possibility of tailings dam disasters. In other words, what is at stake is not just a proposed law and approval of its text, but the impacts that will be felt across the country should this New Mining Code be approved. It seems the country is heading towards a battle in which popular pressure could be a means to force the debate to include the effects of environmental and climate injustices.

In a study carried out on earlier tailings dam failures between 1910 and 2010, Azam and Li (2010) identified two main causes of failures. The first was adverse weather conditions (which increased from being contributing factors in 25 per cent of the dam failures in the period before 2000, to 40 per cent after 2000); the second was mismanagement of dams (which grew from 10 per cent before 2000 to 30 per cent after 2000). "Adverse weather conditions" were described mainly as unusual rainfall, attributed to recent climate changes (Azam & Li, 2010). As for the "poor management of dams," the authors took into consideration inadequate choice of procedures in dam construction, inadequate maintenance of drainage structures, and ineffective or non-existent inspections. Bulletin 121 of the International Commission on Large Dams (ICOLD, 2001) also indicates, among the main causes of tailings dam failure, factors related to inadequate management of structures.

The likelihood of disastrous tailing dam collapses becomes increasingly imminent, not only in view of the complications regarding climate change that will tend to worsen in the coming years, but also when we consider the increasing number of tailings dams being constructed throughout the world (Davies et al., 2002; Zonta & Trocate, 2016). The collapses that have occurred and the possibility of new disasters show the importance of diverse measures, carried out by different bodies (companies, government, civil society), with the aim of avoiding dam failures, and of warning systems so that new tailings disasters can be averted.

However, such proactive measures are actively fought by mining companies which benefit from lax and poorly-enforced environmental rules. One of their strategies is to spread disinformation to influence public opinion.

Organized Disinformation and Climate Risk

Many researchers have presented studies and evidence that support the argument that dam failure disasters are not isolated events, but processes, cycles of actions and omissions that are foretold long before the moment of the dam collapse and endure for many years after, as illustrated in Figure 8.1 (Zhouri, 2017; 2018; Zonta & Trocate, 2016; Carmo et al., 2017; Marshall, 2019; Campolina, Rodrigues, & Silva, 2021; Campolina, 2021).

Sometimes companies refuse to provide information essential for water management in territories where the presence of mining complexes means the definitive destruction of aquifers and/or possibilities of tailings dam failures. Furthermore, they may carry out processes of "organized disinformation" (Campolina, 2021). Following mine-related disasters, mining companies sometimes develop marketing campaigns involving schools in order to promote "organized disinformation" about mining (Campolina et al., 2020).

Acselrad, Mello, and Bezerra (2009, p. 81) define "organized disinformation" as taking place when "those responsible for the production of risks avoid making public the dangers they create." This makes it difficult to "perceive the causal relationships between corporate actions and environmental impacts and risks for affected populations."

In this context, schools have been the focus of organized disinformation processes that range from mining companies designing teacher training courses and curriculum activities on mining, to activities with students including art and writing contests and field trips / mine visits. The mining companies may further enhance their image by financing school equipment and infrastructure (Campolina, Gianasi, et al., 2021; Campolina, 2021;

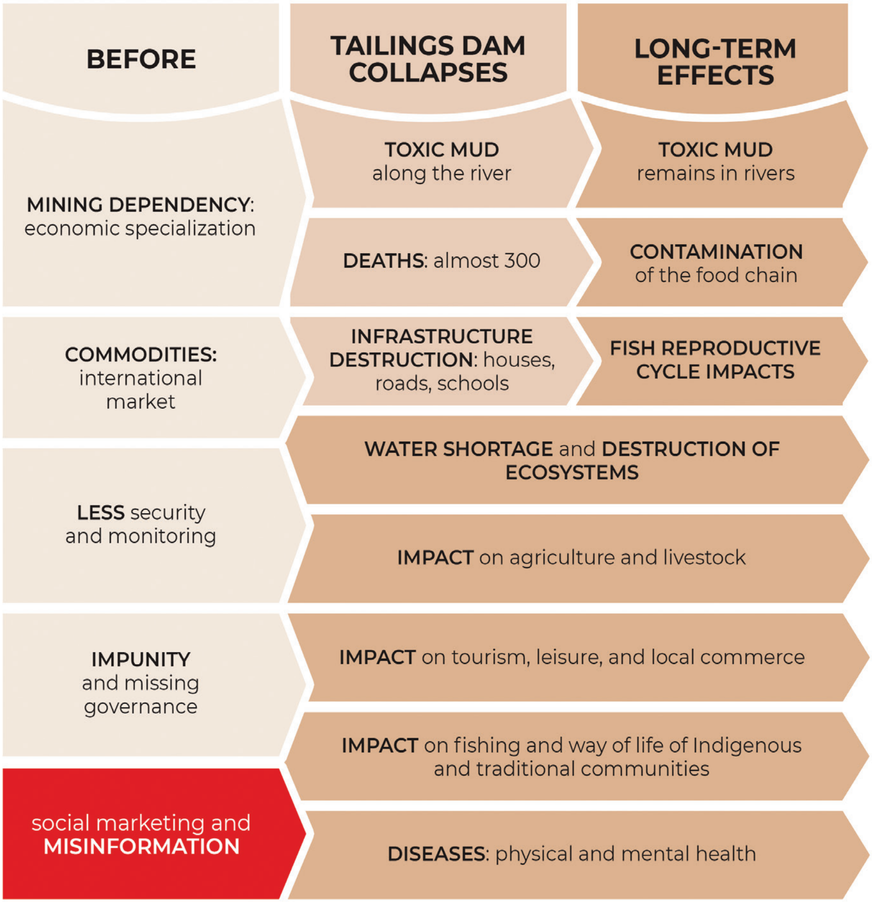

Fig. 8.1 Tailings dam collapses as a process: actions and omissions before, during and after the collapse.

Campolina, Rodrigues & Silva, 2021; Campolina, Gianasi, et al., 2021). Many of the actions undertaken by mining companies with schools are carried out through partnerships between mining companies and local educational management bodies—the Municipal Education Departments. These activities in schools are featured in the annual Sustainability Reports published by the mining companies, complete with numbers and indicators. Mining initiatives focussed on the school system are presented positively to company shareholders and the international market (Campolina, Gianasi, et al., 2021; Campolina, Rodrigues & Silva,, 2021).

The mining company narrative propagated in the schools has a pronounced bias towards linking mining projects to local development and job creation. Although mining is surrounded by controversies and negative impacts, the mining company rhetoric is uniformly positive and serves to legitimize mining activity (Campolina, 2021; Campolina, Gianasi, et al., 2021, Campolina, Rodrigues, & Silva, 2021). The mining companies tout the existence of "magic" technological solutions to solve any problematic consequences caused by mining.

Coelho (2012; 2014), for example, in his dissertation on mining dependency in the region of the Iron Quadrangle Aquifer in Minas Gerais, has developed a concept that he calls Discourse on Development through Mining (DDM). He shows how DDM has been propagated in territories where there is likelihood of a mining project. The discourse presents a highly positive vision of community and territorial development based on the employment and economic gains to be generated through implementation of the mining project. This vision of mining's contribution to socio-economic development serves as a powerful argument for community consent.

According to Coelho (2012; 2014), among the arguments that support DDM are supposedly high rates of job creation and local development, increased tax collection by cities, belief that science and technology can mitigate or even eliminate all negative impacts of mining activity, dissemination of an image of social responsibility on the part of the mining company, and belief in the hypothetical sustainability of mining as a lasting activity in the region. He counters DDM with several arguments, among them the questionable number of jobs compared to other economic activities, such as tourism, and the various negative socio-environmental and even economic impacts that the mining project will generate in the region. This is in addition to the overload of public infrastructure and services; the inability of science and technology to mitigate damage that is irreversible, such as the definitive destruction of aquifers; and the limited duration of the activity, as the resources by definition are not renewable.

Coelho developed the DDM concept based on his research on mining activities in Brazil, but this same discourse is to be found in other countries where mining companies are active. Promotion of this discourse is often carried out in activities involving schools (Campolina, Gianasi, et al., 2021;

Campolina, Rodrigues, & Silva, 2021). One example from Canada is a national organization called *Mining Matters*, a registered charity that claims as its mission “educating young people to develop knowledge and awareness of Earth sciences, the minerals industry and their roles in society” (Mining Matters, n.d.). Mining Matters’ main financial backers are mining companies themselves, but financial support also comes from Canadian government departments responsible for matters pertaining to Indigenous communities. Rich mineral deposits are located on Indigenous lands and there are serious conflicts over extractive sector projects. After Vale made major investments in nickel mines in Canada in 2006, it very quickly took its place in the top donor circle for Mining Matters.

PDAC (the Prospectors & Development Association of Canada) is an important mouthpiece for the global mining industry and a long-standing partner of Mining Matters. PDAC holds an annual international convention in Toronto, considered one of the biggest mining industry gatherings in the world. Mining company executives from Vale and BHP (both responsible for major tailings spills in Brazil) are among the attendees (Campolina, Gianasi, et al., 2021; Campolina, 2021). PDAC and Mining Matters jointly organize special events for teachers and students during these conventions. In 2010, just four years after Vale’s purchase of important nickel mines in Canada, Vale was being lauded for its support in a Mining Matters newsletter. “Vale dreams big. The company, headquartered in Brazil and currently the second largest mining company in the world, aims to be the largest. … At PDAC Mining Matters, we’re excited that Vale is helping us to dream big, too. We are extremely grateful for the company’s generous commitment of $75,000 over the next three years” (Mining Matters, 2010).

These actions promoted by mining companies in the field of education are a *programmed business modus operandi*, using access to young people through the schools as a way to gain community support for mining (Campolina & Gianasi, 2020). Figure 8.2 maps a sequence of actions that have taken place in cities downstream from tailings dams in Brazil. The mining company discourse, DDM, has been disseminated in these cities with actions undertaken by mining companies through “partnerships” with municipal education departments. This results in a “culture of silence”[5] around mining. On the one hand, actions by mining companies, including in schools, propagate a uniformly positive narrative about the benefits of mining. On the other hand, communities, teachers, students, and even universities demonstrate

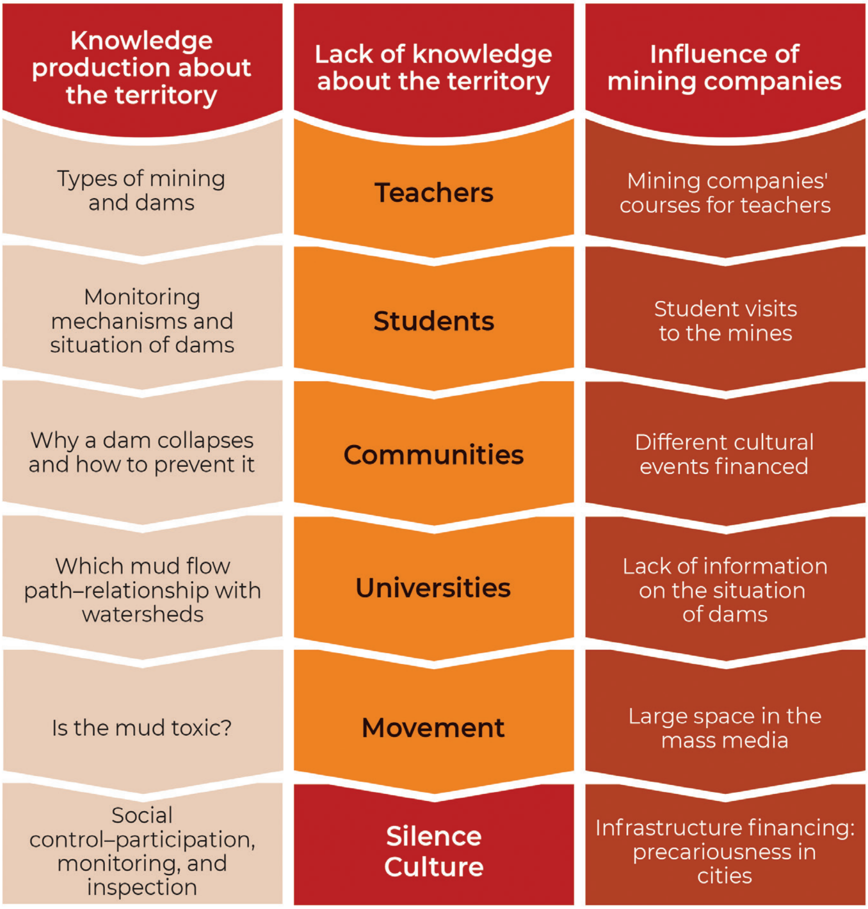

Fig. 8.2 Sequence of actions that generate the "culture of silence." **Source**: Campolina, Gianasi, and Perkins, 2020.

a lack of knowledge about the controversies surrounding mining. Critical perspectives on mining are rarely addressed as topics in initial or continuing teacher-training courses for science and environmental studies teachers. These kinds of disinformation about mining are one of the factors in the processes that lead to tailings dam collapses.

Fighting Disinformation with Geo-Participatory Mapping—(Re)Learning the Territoriality of the Disasters to Gain Critical Perspective

Education processes that provide credible information, training (for community members, young students, and teachers), and actions that enhance social participation and citizenship are imperative to help learners build on their lived experiences about mining's impacts. These processes can provide ways for the population in general, as well as in schools, to become aware of the risks to which mining subjects them and to prepare themselves to face possible future disasters related to tailings dam failures—also equipping them to take actions that reduce the risks and harms.

The starting point is to address people's limited knowledge on the location of dams, their watershed impacts, and the local-territorial impact of possible dam ruptures. We have adapted the widely-used methodology of geo-participatory mapping of hydrographic basins and applied it to geo-participatory mapping of tailings dams in a methodology we call MapGD: Geo-participatory Mapping of Dams (Mapeamento Geoparticipativo de Barragens or MapGB in Portuguese) (Campolina et al., 2013; Gianasi & Campolina, 2016; Campolina & Gianasi, 2019; Campolina, 2019). This adaptation serves as a diagnostic strategy for territories in which there are dams along watersheds. MapGD has among its objectives increased understanding of environmental injustices and construction of popular knowledge in order to contribute towards empowerment of teachers, communities, and activist movements facing water insecurity and tailings dam disasters.

As noted above, policies and instruments exist that *should have been* able to estimate damages caused by dam breaches or even the impact of mining on water quantity and quality. The collapses, however, revealed not only the ineffectiveness of these instruments, but also the vulnerability of diverse communities located below the dams.

Starting from the principle of dam failures as processes, and considering schools as an important focal point for mining companies in the propagation of the Discourse on Development through Mining and "organized disinformation," we see schools as spaces for training and construction of important information for empowerment. In this context, MapGD goes beyond just identifying dams located upstream from communities and schools. It is necessary to understand the territoriality of disasters, as well as the risk of disasters. This territoriality is related to the fact that the rupture of a dam—or even the possibility—can change the entire dynamics of a territory, causing effects from the health of the residents (including mental health) to the community's mode of production, each within its particular economic and cultural dynamics (Campolina, 2021; Campolina, Iwama, & Gianasi, in press).

The concept of *territoriality of mining disasters* emphasizes the importance of recognizing the path of the spill and how it coincides with the water path along hydrographic basins (Campolina, 2021). As a basic education teacher in a public school located below multiple mines and the flow path of about thirty tailings dams, the first author has experienced—and continues to experience—how organized disinformation campaigns hinder the processes of mobilization, information, and training in territories with a strong mining influence.

Identifying the location of the dam and the flow path in the event of a dam failure is part of the MapGD methodology. We developed and applied this method during continuing education courses for teachers at the Federal University of Minas Gerais in 2018 and 2020, within the scope of the first author's doctoral research. The thesis was entitled *Mining and Socio-Scientific Controversies with Strong Local Impact in Continuing Education Programs for Teachers*. It proposed a conceptual approach to socio-scientific controversies in the field of science education, considering territoriality, with mining as a central theme. During the research, two courses were developed in teacher-training programs dealing with the theme of socio-scientific controversies in mining. Methodologically, part of each course was constituted as data collection for the broader research. MapGD was not centrally involved with the research objectives and general questions, but it was configured as one of the steps in the courses taught (Campolina, 2021).

MapGD is an adaptation of the methodology we used and developed in "Geo-participatory Watershed Mapping: 3P—Problems, Potentialities and Possibilities"—a series of extension projects at the Federal University of Minas Gerais (UFMG) between 2011 and 2017[6] (Campolina et al., 2013; Gianasi & Campolina, 2016). 3P Geo-participatory Mapping consists of a geo-environmental analysis of the surroundings of a school or a community, using the territory of hydrographic micro-basins as a methodological/theoretical reference point. The spatial technique is consistent with popular mapping, drawing on community knowledge and local lore in addition to geographic objects and areas that can be observed in satellite images through free software such as Google Earth. Free satellite images of the region are used, highlighting the hydrographic network. Field work and walking trips allow students, teachers, and communities to also include in the map what they consider the *problems* and the socio-environmental *potential* of the territory under study.

Based on analysis and discussion of the problems and potentialities identified, the group lists *possibilities* for intervention or action in the region, taking into consideration the proposals of the Hydrographic Basin Master Plan (linked to the National Water Resources Policy—PNRH), but within the scope of micro-basins. The logic underlying 3P Geo-participatory Mapping is that students, schools, and/or communities will not only increase their knowledge and capacity to discuss problems and potentials of the region through mapping, they can also produce localized information that can assist with participatory water management. Submission of maps to the Hydrographic Basin Committees and to local, municipal, and state water managers is one of the goals of the methodology.

Both MapGD methodology and 3P Geo-participatory Mapping use the territorial contour of the watershed to locate the path of a spill, because geographically that is where the water mixed with mine tailings and other components will travel. The tailings dams in Brazil are usually located on hilltops, close to the mines. They are built to take advantage of the valleys as part of the design of the tailings reservoirs. Tailings reservoirs are usually located above water sources and small rivers, with a foundation and supposed waterproofing. The valley reservoirs are then blocked by dams, which function like dikes. In the event of a rupture, the flow follows the natural path of the rivers.

The main difference between 3P and MapGD is that MapGD is aimed at geo-participatory mapping of the tailings dams themselves. At the end of the mapping activity, those who produced the map are confronted with a geographic reality and the question of whether or not they feel threatened by the presence of tailings dams in their territory. As the mapmakers (community members, students, and teachers) construct the map, tracking the actual dams and their location in that territory, observing the level of safety and risk of the dams being mapped, delineating the possible flow paths in the event of a dam collapse, following it along the lines in the map that make up the streams and rivers, they are also deepening their knowledge on the subject and increasing their ability to discuss it with their peers.

In addition, MapGD analyzes the safety situation of dams by consulting information about them in the Integrated System of Mining Dams—the

Public SIGBM, using its Portuguese acronym—which is part of the National Information System on Dams that was made available as of January 2020.[7] But this data, although it marks an improvement in the availability of information on dams in Brazil, has data by city and not by hydrographic basin, therefore making it difficult for the population to identify whether or not there are dams above the towns and cities where they live. The Public SIGBM does not include hydrographic networks, making it impossible to verify the flow path of a spill through the system and the communities affected by this flow path. The fact that dam location information data is not available also makes it difficult to understand that when there are dam complexes, where several dams are located close to each other, the location of one dam with a rupture in process can also compromise the safety of dams that are located downstream. When the tailings flow from the dams located above reach the downstream dams, the structure of the downstream dams could well be compromised, leading, therefore, to the rupture of multiple dams in the process.

There is other important data regarding water security that is also not available in the SIGBM, namely the location of water collection points for water supply systems that would be affected in the event of ruptures. This topic is also addressed in MapGD where a methodology is included for mapping water catchment points that supply community drinking water and determining whether they would be affected in the event of a dam rupture.

Conclusion: Building Information-Training-Action Networks to Confront Disasters, Organized Disinformation, and Environmental and Climate Injustice

Mining disasters and environmental and climate injustices are topics that are still fairly unfamiliar to the general public, despite the fact that many communities have already suffered the impacts arising from these phenomena. Even being affected, many communities find it difficult to recognize the impact or defend their right to compensation for the damages suffered. Among the various effects, the violation of access to water is what permeates and creates the potential for damages in interconnected fields: environment, health, food security, economy, culture, and ways of life.

In opposition to the cycle of actions and omissions perpetrated by mining companies and governments in Brazil, which has contributed to the processes of tailings dam disasters and threatened the population's water security, it has become imperative to develop participatory methodologies that help communities fight for their rights. In such a context, we believe that schools have a latent potential for information production. Teachers can be agents of collective knowledge production and facilitate the transfer and exchange of critical knowledge about the territory in which they work, in the face of the territoriality of disasters.

Faced with the negligence of mining companies and governments, schools, together with communities, activist movements, universities, and non-governmental organizations, must unite in the construction of grounded information and action networks. This becomes even more urgent in the face of climate change and increasingly critical situations of water insecurity.

Given the importance of creating information-training-action networks, we see the development of the MapGD methodology as an instrument that can contribute to community empowerment. We understand that MapGD is just the starting point for producing quality materials and up-to-date geospatial data, both for education and for community struggles. We see in this methodology the possibility, through the production of collective and popular knowledge, to contribute to the construction of more participatory water management. New knowledge is created in the midst of the process of delineating the territory, as the mapmakers construct the map, identify the dams and their position in that territory, observe the level of safety and risk of the mapped dams, and trace the possible flow path of a spill along the lines that make up the streams and rivers. This new knowledge opens new discussions and new perspectives for collective action. We believe that the lack of information about the territoriality of disasters, the location of dams and the flow path, in the event of ruptures, intensifies the vulnerability of the affected population. Critical knowledge and popular pressure are possible ways to minimize or perhaps eliminate environmental injustice, climate injustice, and mining disasters.

In order to create a database that can be accessible to other teachers, researchers, and the general population, we have organized a research group called Education, Mining and Territory—EduMiTe—and two observatories: Mining Dams Observatory (OBM) and Education and Mining Observatory (OEM). With these proposals and actions, we aim to structure a network of collaborators who can contribute to the construction of materials, methodologies, and practices in the classroom that empower people and enable the teacher to work with these themes in depth, with actual data and high quality materials.

This work opens up possibilities for interaction and dialogue about what has been happening in Minas Gerais, ranging from mining dam disasters to dialogues around water security and water management. We see in these initiatives a vitally important space to discuss the connections between mining and water security, affecting the quantity and quality of water for countless populations in different parts of Brazil and the world.

We extend an open invitation to others to strengthen this movement through the creation of international networks for the co-creation of materials, exchange of successful experiences, and knowledge of phenomena such as those we describe here in Minas Gerais.

NOTES

1 This chapter was translated from the Portuguese by Judith Marshall, to whom we express our great thanks.

2 The Guarani aquifer is one of the largest in the world, covering 1.2 million km^2, with an estimated volume of 370,000 km^2; 70 per cent of the Guarani aquifer is located in Brazil (Ribeiro, 2009).

3 Water users include all those who directly use the surface or groundwater of a watershed. The user can be a natural or legal person, private or public, who without needing a license for water use, captures water directly from cisterns, dams, streams, rivers, lakes, or releases effluents (sewer, industrial, agricultural or domestic) directly into water bodies.

4 See: Portaria DNPM n 70389 de 17 de maio de 2017—SEGURANÇA DE BARRAGENS —Português (Brasil) (www.gov.br).

5 Paulo Freire (2017) defines the culture of silence as arising from an education that prioritizes the oppressor, the dominant groups that have been perpetuated in Brazil from colonization to military dictatorships. Freire says that the history of Brazil has brief snippets of democracy, which makes a culture of participation and mobilization difficult, as there is a tendency towards a culture of silencing in the face of injustices and violations of rights.

6 These projects included: “Monitoring of Watersheds”; “Fapemig—Training of Teachers, Production, and Dissemination of Knowledge on Urban Micro-Basins of the Velhas River Basin as an Instrument for Participatory Environmental Management”; “Geo-Participatory Mapping and Instruments for Participatory Environmental Management”; “PROEXT/MEC Program: Environment, Education, Health, and Citizenship for the Urban Watersheds and Basins of the Rio das Velhas”; “Proext Mec 2014—Geo-Participatory Mapping and Monitoring of Hydrographic Microbasins”; “Extension and Research: Geotechnologies in Water Management Education: 3Ps Geoparticipatory Mapping”; and “Mapping and Visualization of Didactic Practices and

Challenges for Teachers in the Rio Doce Basin Affected by the Collapse of Samarco's Fundão Dam."

7 Although the National Information System on Dams has been in the making since the establishment of the National Policy on Dam Security (PNSB) in 2010, only years later were norms established and only in 2020 did this system begin to make dam information available publicly, such as the locations of dams by municipality.

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