

Law, Geography and Insurance: Establishment of Socio-Environmental Protection as a Standard for Government and Industry

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Abstract— *The authors have proposed a fusion of Brazilian environmental law to US jurisprudence, and, financial risk management practices. The immediate goal was to bring together concepts and processes to suggest remedies for the dam tailings crisis in Brazil. The method used was called GeoLaw. This method has been employed in insurance strategies, combined with an in-depth discussion of geodetic data. However, the broader aim was to provide useful models to address issues of climate change resilience. Consequently, specific policies and technological systems were examined. This facilitated implementation of cohesive socio-environmental justice for vulnerable populations and ecosystems, on a global scale. Means were suggested to better predict disaster risks. These strategies, consequently, had significant implications regarding insurance. The concepts of Geographic Law (GeoLaw) were introduced as a means towards greater effectiveness in decision making.*

Keywords— *EcoLaw, Geodetics, Geographic Information Systems, Insurance, Environment.*

I. INTRODUCTION

It is estimated that 80% of data currently produced is accompanied by a geospatial component of geolocation (Robinson 2016). Geospatial information and intelligence have been referred to as "paladins of a New Age" (Santos 2017). This technology continues to stimulate creation of new professions with new skills focused on Geographic Information Systems (GIS). In addition, the US Department of Labor Statistics projects that jobs related to GIS will grow by 29% between 2014 and 2024, at a much faster pace than the expected average for all other professions. This highlights the fundamental importance of georeferencing and regulation of spatial data infrastructure systems for strategic governance decisions. This includes analysis related to territorial planning, at all scales, and to policies with socio-environmental impacts. Cartography is an ancient practice. For millennia human societies have sought to identify references which depicted their own relationship to the environment and to other groups of people. As those tools improved, increasingly complex societal patterns emerged. With passage of each century, mapping was applied to virtually every issue.

Therefore, geographic processes can be applied in contemporary society to major infrastructure projects. This utilization can take various forms, such as detailed examination of generating energy by means of a dam, or more specifically, determination of management strategies to deal with accumulation of rejected minerals in mining production. Mapping is fundamental to aid public managers in the most diverse spheres of administration. Three researchers take an expansive view of cartological relevance, "Maps for ecosystem services (ES) are made for a broad set of purposes including advocacy (awareness raising, justification, decision support), ecosystem assessment, priority setting, instrument design, ecosystem accounting, economic liability and scientific spatial analysis (Jacobs et al. 2017)."

Geospatial technology is crucial for design of environmental policy and prevention of risks associated with a given enterprise. It follows that data collected for maps, and its quality, is critical. (Jacobs et al. 2017). When using GIS, typography is combined with other types of data and contextual information. The map itself is not the whole of the process, but the central tool of quantification (Jacobs et al. 2017). Most countries have laws that plan land use and occupation, but often do

not take into consideration geography concepts and techniques to establish legal categories that can be clear, sufficient and enforceable for legal categories to comply with, such as judges, public prosecutors, builders, insurance companies and ordinary citizens. In the case of Brazil, laws dealing with land use and occupation planning in cities and metropolitan regions exist, as well as an environmental licensing procedure that requires in-depth study to predict environmental impacts, to propose mitigation solutions and to reduce risks to communities and nature, such as dams and large-scale mining. This is critical, especially in the current context of a climate change process where climate dynamics are changing and we increasingly need to develop resilient structures and resilience-based legislation, which is of direct concern to insurance companies that can afford the costs of possible disasters.

When planning involves economic development, it should be preceded by exact surveying. This would be combined with knowledge of applicable legal rules of the jurisdiction. This is necessary both for government, in the implementation of its public actions, and for private investors. A joinder of GIS with law and financial risk management constitutes creation of a new field of knowledge. This innovation connects geodetic data directly to political, bureaucratic and insurance functions. On a more activist front, the new field can advocate environmental, ecological, and territorial justice. This perspective, that distributive justice emerges from pressure upon legislative decision making, is not new. Furthermore, questions whether (and how) that concept can be related to environmental and urban planning has been extensively researched. This fact is borne out by abundant empirical evidence and bibliographical production, especially on the origins of the environmental justice movement, (Bullard 2000; Taylor 2000; Walker and Bickerstaff 2000; Cole and Foster 2001; Martinez-Alier 2003; Mitchell and Dorling 2003; Bryant and Hockman 2005; Walker and Bulkeley 2006; Ascelrad 2010).

The argument states that poorly conceived and inconsistently implemented ecological initiatives can generate unequal distribution of burdens and benefits, geographically and among population groups (Lazarus 1993; Ascelrad 2010). Land occupation may constitute a relevant mechanism to remedy, or to reinforce, socio-spatial inequalities (Been 1992; Arnold 1999; Fernandes 2007). It must also be noted that risk inherent within such injustice has gone generally unrecognized by the insurance investment sector. For example, a low-end estimate of unaccounted financial services liability due to climate change impact (closely associated in this research with

lack of societal resilience) is a staggering \$2.4 trillion (Goldstein et al. 2019). In Brazil, there is a legislation known as the City Statute Law, which mandates obligation to use geographic data to identify areas at risk. This same law directs municipalities to adopt comprehensive development. Risk mapping is also mandatory. The major problem faced by Brazil in the various regions is the low rate of compliance to these rules.

Well-designed legislation is not sufficient for disaster prevention. However, a combination of law and geography efforts could produce what we call GeoLaw, legal instruments and data that can assist in legal and administrative decision making. Understanding geodetics will allow more effective modeling. This approach will highlight ecosystem dynamics and their association with equitable conceptualization of loss prevention (Kretsch 2016). In this paper, analysis of these practices will be accomplished by evaluation of Brazilian case studies. But the true impact is contained in potential utilization of these principals across the globe, in response to distributive issues linked to climate change. Furthermore, a geodetic summary of socio-political impact, using the framework described above, would provide an objective instrument for comparing losses and defining indemnification. For example, water contamination can cause serious damage to vulnerable populations because of that community's dependence on the free benefits of nature. Concepts of ecosystem services and proper compensation are related to progressive "greening" of the law in correcting such situations.

It is necessary to understand such scenarios involve complex socio-ecological systems, which require a broad interdisciplinary analysis. Therefore, an adaptive model is needed. Development of flexible and effective governance strategies are a crucial component in managing insidious environmental problems. This calls for systematic integrated resource categorization, cross-functional bureaucratic units, producing analytics-based outcomes (Groninger et al. 2016).

II. METHODOLOGY

We use a comparative methodology between Brazilian and North American cases, applying principles of geography and legal parameters to make intervention in nature safer, in order to cause less damage and expand the scope of benefits for the parties. Thinking about the following parameters:

- the main environmental risks;
- the main environmental conflicts;

- the main environmental susceptibilities and social vulnerabilities;
- the measures taken by the public authorities of the States to mitigate risks;
- principles and recommendations for fairer public policies and whose interventions in nature are less harmful.

Thus, as a basis for our investigation we think of the laws of the largest countries in the American continent, the United States of America and Brazil, making a comparison in legislative terms, although at first we can identify substantial differences in the institutionality of both countries, as well as similarities.

Then, we reflect on the responsibility model of both countries and the impact that these interventions can cause and we seek to formulate a proposal for an instrument that could make problems and solutions more predictable through what we call here GeoLaw, principles of geography through geolocation and law working together to present decision makers and public policy makers with better conditions for those decisions.

Land Demarcation, geography and Law: paths for a Geo-Law

GIS and financial risk management tools can prevent or resolve conflicts. Among these conflicts we can mention the lack of regularization in certain portions of land, the inertia of the public power in not allowing the construction in places that present risks, the authorization of mining enterprises without a geographical and legal study that can mitigate as much as possible. the risk of vulnerable communities and cities and the lack of regularization of empty spaces in urban regions. There many more, like these: Boundary conflicts, Inheritance conflicts, ownership conflicts due to legal pluralism, ownership conflicts due to lack of land registration, ownership conflicts between state and private/common/collective owners, Multiple sales/allocations of land, Limited access to land due to discrimination by law, custom or practise, peaceful, informal land acquisitions without evictions, violent land acquisitions, included clashes and wars over land, evictions by landowners, illegal evictions by state officials acting without mandate, market evictions and distortion of local land market/values, disputes over the payment for using/buying land, disputes over the value of land, Conflicts between human/cultural and natural use (flora and fauna), destruction of property (Wehrmann, 2008).

The object of study where we can cross legal, geographic and insurance knowledge is certainly the land and its demarcation, in which we adopted Platt's (2014) notions about land. A very pragmatic view of geography and law is Platt's (2014, 42), in which he states the following: Geography focuses on the substance of what we do with the bits and pieces of the earth that happen to fall under the ownership or concern of "stakeholders" (e.g., individuals, companies, nonprofit organizations, or governments). Law is concerned with the process by which those stakeholders are permitted to engage in various uses while minimizing adverse effects on each other or the wider public. This is a way to think about structuring a Geo-Law that can give more certainty than uncertainty or bring decisions closer to a safe space. Law ends up being a complex mosaic of rules, both in Brazil and in the United States, including a series of spheres and roles of actors that have an interest in certain processes. Among these we can mention, especially in relation to the United States, but which can be applied to Brazil, although the federative model is in both, they are of different scopes:

1. Constitutions (federal and state);
2. Legislative acts (also known as statutes or legislation);
3. Judicial decisions in court cases (also known as case law);
4. Administrative regulations issued by regulatory agencies.

An important detail in relation to the United States is the high level of autonomy of states vis-à-vis the central government, notably in relation to legislative production, and regulations and laws may change from state to state. Brazil has a federation with more centralizing characteristics, with national laws that regulate the use and occupation of land, as well as distinct responsibilities in relation to the implementation of an urban policy. advance due to the lack of structure, especially of specialized personnel to implement and monitor the results.

Addressing geography first, it is particularly suited to adjudicate ownership and registration of real property, and, assessment of parcel boundaries. It follows that the quality and accuracy of said geographic information must be as reliable as possible. If visuals are of poor resolution or material is not updated, higher costs and procedural delays will occur. Those legal consequences bring the discussion to financial risk management. The field of insurance is extremely facile in securing

rights. The field may be separated into three parts, underwriting and claims; asset management and cash reserve allocation; investment. Underwriting is important because it standardizes contractual obligation of parties and rationalizes judicial standards. Asset management is necessary for its functionality of indemnifying losses and solidifying a market structure to secure real property. Investment is very effective at bringing pressure upon ecologically insensitive companies and limiting underhanded tactics. Investors tend to demand ethical compliance.

All this supports a super-discipline that employs law, geography and insurance. Its strength is bringing accountability to public management questions. It is essential to create an infrastructure reliant on this agglomeration of statute, GIS, and financial remuneration to redress socio-environmental vulnerabilities. Risks increase for these investors regarding the installation, for example, of large works such as dams or even large mining involving various groups of people who are indirectly and directly affected by possible damage resulting from disasters such as Mariana, Brumadinho and Belo Monte Hydroelectric with its impacts on the environment. In addition, cities and communities need to be prepared for possible problems.

Another important relationship between geography and law is in the field of geography's perception of environmental laws, in that field Thompson, Shelley and Wije (1997) already set a parameter for this stating that "Geographic information systems and other technological advances in the process of geographical such impacts need to be predicted and measured to provide, for example, security for investors and companies, taking into account the safety of the business and the possible human and nature hazards. Clay and Berkovitz (2012) also helps us to realize that geography brings us understanding of other demarcations, which may be social or legal, what kind of drafting is performed, where it is done, income, state budget Americans, for example, among other important variables for understanding various dynamics.

It is important to highlight that the mapping that demarcates lands, areas, territories is involved in three relevant factors: scale, projection and symbolism (Santos, 2015). The scale will determine how much detail is desired on the map which means that the larger scale more detailed it will be the closer it is to the represented reality; the projection concerns the level of detail inserted in the representation; and symbolism is the meaning of this cartography for the development of public policies and even investments.

Geography helps in determining responsibilities. Biger (1988) already pointed to the necessity of approximation of geography and the legal field to analyze the case of rivers as a border demarcation between countries, since for the jurist could be well defined the question, but for the geographer the river dynamics could change which causes legal repercussions in the definition of land demarcation.

In the case of Brazil, there is a very advanced legislation known as the City Statute, Law n. 10.257/2001, which provides in its text the obligation to use geographic data, obtained through maps that can effectively demonstrate the areas of risk. This same law establishes that cities need to have master plans and according to the Brazilian constitution these plans are mandatory for cities with a population larger than 20 thousand inhabitants. Risk mapping is also mandatory, which means that occupying territories must be classified according to the level of risks so that we know what can be occupied and how it should be occupied. The major problem faced by Brazil in the various regions is the low rate of compliance with what is foreseen in these master plans, as well as the non-obligation of these plans for smaller regions, such as the cities of minas gerais state that are exposed to tailings dams. which expose people and nature to great risks. Failure to comply with these plans is a cause of the proliferation of irregular occupations in areas exposed to landslides, contamination and flooding. However, we ended up with another law known as the metropolis statute (n. 13.089/2015), which regulates the operation of regions formed by two or more cities, because the point that required the geo referencing of the spaces occupied between cities was not approved.

In the American case, there is the American City Plan (Farvacq and McAuslan 1992), and as the Brazilian plans they are not mandatory in their fulfillment, but they are parameters for judicial and administrative demands. It is important to mention that since the nineties of the last century there has been a search for reform of the law, striving for clearer laws in the United States. Nevertheless, the discussion about georeferencing as a right of every citizen and a duty of public entities that has this responsibility is not yet institutionalized. However, Arnold (2007) states that geographic delimitation is fundamental and lists the uses of this process for soil management in the United States:

- mitigation of droughts and floods
- purification of air and water
- generation and preservation of soils and renewal of their fertility

- detoxification and decomposition of wastes
- pollination of crops and natural vegetation
- dispersal of seeds
- cycling and movement of nutrients
- control of the vast majority of potential agricultural pests
- maintenance of biodiversity
- protection of coastal shores from erosion by waves
- protection from the sun's harmful ultraviolet rays
- partial stabilization of climate
- moderation of weather extremes and their impact.

The legal culture of each country will define how this obligation can be implemented. We think that the observed experiences, especially in Brazil, and the presence of the obligatory of these devices do not guarantee the effectiveness of these planning instruments. Kayden (2000, 446–447) highlights how she understands the perspective of regulating land use and occupation, “land-use planning is a process conducted by public officials to analyze and recommend in a comprehensive manner, from social, economic, environmental infrastructure capacity, aesthetic, and other relevant aspects, the best present and future uses of geographically specified land areas”. However, this understanding does not explain the finalistic content of geography in this process, which is to act directly on the best use of soil, whether in an environmental dimension, in an urban dimension, or in the prevention of risks through the intervention, for example, of enterprises. The geography and the data produced are seen as important in the planning process and the law is the one that calls the public authorities' responsibility in establishing this regulation of land use and occupation and its effective compliance as necessary in the prevention of disasters that may be empowered by climate change. The fact is that land use directly affects the ecological services provided by ecosystems (Arnold 2007), there is a causal link that becomes clearer when thinking about a resilient city model.

Similar legislation in the United States requires comprehensive municipal planning. But in the American case, there is much less clarity. Nevertheless, discussion about geo-referencing by public entities has been ongoing. The legal culture of each country will define implementation of GIS. But the realities in both cases are the same. Land use directly affects social and ecological services (Arnold 2007). In summary, disaster prevention is a process which combines law, geography and insurance reform. Understanding geodetics will allow

more effective modeling. This approach will highlight ecosystem dynamics and their association with equitable conceptualization of loss prevention (Kretsch 2016).

III. DISCUSSION

Realistic Perceptions of Security

Stability is the most marked feature of capitalism and enriches insurance companies because peace of mind carries a high premium. But is this attitude justified by experience? The discussion up to this point has dealt with societal willingness to take certain risks, while underestimating others. The reason for this paradox rests in the misapprehension of the true peril of climate change. Comfortable traditional assurances carry the day. But the age is tumultuous (Bauman 1999), and certainty inaccessible due to baffling scientific and technological progress.

This scenario gives little credence to the notion that science will be able to offer humanity anything like a carefree existence. Inaccurate perceptions may offer a degree of security, but with unintended consequences. It is as if humanity were being offered a "black box" package of solutions. These philosophical palliatives resemble chemotherapy, where the cure would be nearly as debilitating as the disease. When this reasoning is viewed through the prism of industrialization, a cultural ambivalence can be detected. This situation is often referred to as technological optimism. That term can be defined as an opaqueness in, or absence of, cognition that development has a downside. Take Brazilian mining, which offers undoubtable benefit but also devastation of ecosystems and vulnerable populations. Overtly negative elements of progress must be neutralized, or at least minimized. This requires an intellectual balance be struck between technological optimism and acceptable risk. Regarding infrastructure activities, ventures will have inherent danger. But public officials, businesspeople and citizens could act as a control to excess, if knowledge acquisition is the rule.

Experience of past events is used by actuaries in the insurance field as key indicators. Furthermore, strict liability laws in the US have become more stringent by recognizing that environment and industry coexist. So, progressive altering of the relationship between traditional ideas of industrial progress and ecological protection is possible. Institutionalization of these concepts has taken the form of several entities creating standards regarding erection of dams and buildings, paving of streets, and development of sanitation systems. These criteria may be used for general construction projects. But the focus

of this paper concerns use in those enterprises associated with mineral tailings dams.

The Current Situation

The diurnal cycle of Brazilian public administration, specifically in the municipalities, has produced a federation model with legislative and administrative autonomy which lacks planning. This situation has generated pressure on the judiciary to standardize administrative rules surrounding such issues as licensing. The novelty of climate change, and its sequelae, has confronted the Brazilian administrative hierarchy with major disasters, whose complexity assumes ever-greater proportions. A train of circumstances follow which are very detrimental to vulnerable people and the environment. Large multinational corporations aggravate this situation with ill-conceived ventures. This is exacerbated, in the Brazilian case, with those corporations intimate association within the lattice of public power. The result is a very strong lobby in support of dubious industrial construction projects.

The Mariana Disaster

Minas Gerais is one of the biggest Brazilian states that became known around the world after the rupture of reject dams, caused by mining. The first accident was Mariana. The dam was owned by Samarco, a joint venture of the Vale and Anglo-Australian BHP Billiton corporations. The waste barrier failed in November 2015. In its wake, it left a legacy of 19 deaths and massive contamination. The ecological impact is difficult to quantify. An estimated release 50 million cubic meters occurred (Oliveira et al. 2018).

It is certain this was the most destructive disaster attributable to Brazilian mining. The mud spread through the Rio Doce basin on its path to the sea, eventually reaching the Abrolhos archipelago. The supply of water to regional cities and ecosystems along and the basin, and those further afield, were fouled by the sludge. This was a tragedy for local communities that relied on fishing and agriculture. Figure 1 shows the course of the mud. It traveled about 700 kilometers (437.5 miles) to the sea. Nearby villages were simply obliterated by the rolling force. This disaster accelerated various civil conflicts which existed due to Vale corporation mining activities. Figure 2 illustrates a survey of the more serious social conflicts.



Fig.1: Path of the Mud

Source:

https://brasil.elpais.com/brasil/2015/11/10/politica/1447117167_264357.html



Fig.2: Conflicts Generated by Vale Activities

Source: <https://diplomatie.org.br/mapa-conflitos-mineracao-extrativista-vale-brasil/>



Fig.3: Barrage of the Fundão dam has covered more than 600 km - Gesteira (above), rural district of Barra Longa.

Source: Felipe Werneck/ASCOM-IBAMA

Brazilian law prosecutes this sort of offense through administrative, criminal and civil statutes. Therefore, the company was fined by relevant environmental agencies, with action pending for environmental crimes covered by the 1988 legislation (discussed above). The Brazilian judiciary is hyper-bureaucratized, so decades may pass before resolution of cumulative damages. Moreover, company directors were absolved of intentional homicide in the 19 deaths because the company issued prior warning. That ruling may be appealed. If viewed from an insurance standpoint, more preventive measures may have been obtained. There are a growing number of insurers who underwrite Mariana-type losses. These policies include provisions which would have required directors foresee the accident itself. In this case, the reinsurer could have found the officers acted in bad faith. Coverage for errors and omissions would have been removed, exposing personal assets of the directors to forfeiture.

Aside from this scenario regarding indemnification, residents throughout the Rio Doce basin are still at risk from high-level metal contamination (Oliveira et al. 2018). In approaching this case, Brazilian law uses the theory of integral risk and objective liability (Rezende et al. 2018). These dicta concern damages caused by activities exercised through self-interest, without reference to corporate conduct (Rezende et al. 2018). They are similar to strict liability precedent, especially as interpreted in the United Kingdom (Rylands v. Fletcher). The causal relationship between harm suffered by the victim and the tort created by the agent suffices. Using this principle, it would be incumbent upon the company to take responsibility for all necessary actions in order to protect ecosystems and communities. However, arriving at correct quantification of damages is problematic. Assessment of health issues causes great difficulty because effects are often cumulative. Figures 3, 4, 5 and 6 graphically illustrate potential long-term concerns due to the magnitude of this exposure.



Fig.4: Bento Rodrigues School, district of Mariana.

Source: Rogerio Alves/ TV Senado



Fig.5: Samarco Mining Tailings Mud Trail. (above)

Source: Felipe Werneck/ASCOM-IBAMA



Figure 6. Mina Bean stream before the accident. (above)

Source:https://www.huffpostbrasil.com/entry/brumadinho-antes-depois_br_5c4ca8cde4b06ba6d3bd9509

Dam Insurance as a Measure of US Strict Liability Doctrine

The goal of this chapter will be to bring both Brazilian and US cases together to suggest remedy, employing applicable insurance language and models. It would be helpful to give a short description of the topic, before application of its tenets to the Brazilian situation. Effective insurance regulation is a preserve particular to a given state and local jurisdiction in the US. Anything can be insured for a correlative risk premium. For example, insurers will cover high hazard dams within commercial liability policies, generally, because the presumption of strict liability is so weak in the US. A “rule of thumb” definition of the subtle principle of strict liability can be summarized as entrepreneurial protection from excessive tort judgements due to practices inherent within a given enterprise. Interpretation of US cases involving dams is somewhat inconsistent because it brings up issues involving, not only strict liability, but recognition of ecological damage and its relationship to the precautionary principle.

Therefore, adjudication of environmental tort is limited by several factors in the US. When dams are considered, general precedent has been to discourage strict liability complaints on the basis that economic benefit outweighs recompense for land exploitation, and any risk encompassed therein. This attitude has tended to influence most decisions caused by dam construction and failure, though most states have strict liability statutes on their books. Consequently, the argument has been increasingly made, in conjunction with adoption of the precautionary principle as a dictum. Still, a more straight forward legal doctrine for arguing such cases has been that of negligence.

Strict liability doctrine is also more of a British concept in common law (*Rylands v. Fletcher*) than in the US. This is because benefit of doubt has traditionally been given in US law to land development. A liability insurer won a very influential Kansas Supreme Court appeal, attributable to this “manifest destiny” outlook *Lee v. Mobil Oil Corporation* (Supreme Court of Kansas 1969). The decision stated that strict liability was not pertinent to “acts of God” (flood) which cause damage to people and property. The logic was expressed that disasters were not inclusive in strict liability principal because the nature of refinery operations was not at fault (Binder 1990). This stance is supported by government due to eminent domain doctrine, a major hinderance to “GeoLaw” aims.

This doctrine of strict liability in the United States of America generally limits the potential for compensation and accident insurance that results in considerable environmental damage as in the Brazilian and American cases mentioned above. It is important to think about the extent of the damage, the possibility of recovering the affected environmental resources and human lives that have been injured or lost, as well as what would be the measure that would bring a balanced cost benefit to the parties, whoever they are (Oxford University Press 1992). A big problem is precisely to calculate the damage itself, which also occurs in Brazil that adopts this doctrine, and there is no need to value life and ecosystems lost in some disaster.

Another issue to be faced, which we want to avoid with the GeoLaw model, is the difficulty of holding companies and limited liability to account, as well as the difficulty of reaching individuals and shareholders, although the environmental damage, depending on its extent, could until justifying the breaking of this inaccessibility to the components of the limited corporation (Dent 1991). Dent defends in his important article “the social importance and immense costs of pollution make environmental law an ideal arena for reconsidering theories of limited liability for tort” (Dent 1991, 151).

Lawson believes that this doctrine of strict responsibility needs to survive as long as the following points are found in the case to be analyzed or judged: “the defendant must have been said to bring the ‘thing’ which has caused damage to the claimant on the defendant’s land, the thing must be something that is likely to do mischief if it escapes, the thing must be a non-natural use of land, and finally, the thing must escape. It is implied that the absence of proof of any of the aforementioned elements will amount to a shortcoming in establishing liability under strict liability principle.” (Lawson 2017,79) These fundamentals would apply to the cases exposed here, with emphasis on the rupture of ore tailings dams in Brazil.

In the tort law, we can also consider that is also an instrument of environmental policy, serving as a prevention of new environmental damage, as well as a compensatory mechanism for the victims (Abelkop 2009). Courts are important in the current context with innovative measures to solve future environmental problems that extend beyond what they are used to facing (Abelkop 2009).

However, the growth of the field of environmental law has replaced or even acted in partnership with other doctrines, but according to Lathan “the complexities of many modern

environmental harms and the current or perceived inadequacies of the common law, however, have led policy makers such as Congress to enact wide-ranging laws that provide legal remedies.” (Lathan et al 2011, 737). So, it is necessary to analyze on a case-by-case basis, but establish a preventive mechanism that could be GeoLaw as an alternative for monitoring large potentially polluting projects.

Wagner points out that “however, the collectivization of liability to the benefit of both victims and tortfeasors might continue to play a role in cases of major catastrophes, if only on an ad-hoc basis.” (Wagner 2006, 290). Interesting that he cites the case of 11 of September in which a fund was set up to repair the damage caused. The fund combines the low thresholds for liability typical of no-fault plans with the full compensation principle typical of tort remedies. He believes that future catastrophes, such as those related to the environment, may follow the same path of forming a fund to repair victims, which does not guarantee a complete indemnity of the damages (Wagner 2006; Witt et al 1983). As for the implementation of the Principle of Absolute Responsibility as a legal aspect in the Environmental Law System, Ulfah (2018) understands that two aspects need to be taken into account:

1. contains the interest to utilize various mixed tools of compliance to realize the channeling for environmental risk risks (liability) as well as fund management for the prevention of environmental risks encountered (Trust funds for environmental risks management).
2. has meaning giving obligation to each party to manage environmental risk (risk assessment), while application of Mechanism of Insurance Service as instrument of law compliance and environmental management have role to realize the application of Absolute Responsibility Principle through process of transfer Guarantee of coverage and management of funding to anticipate various environmental risks.

Post consent monitoring and periodic inspections also become fundamental mechanisms for reducing costs and preventing major damage, where the GeoLaw tool can act in our understanding. This is an issue to be checked when holding accountability, the elaboration of protocols and compliance with government regulations must also be attested. The American government has established procedures in this regard (EPA; Martin 2009). Omg (2011, 717) already understood that

inserting rules of environmental regulation in corporate governance would be an interesting way with cost benefit since it would act preventively. So, the question he asked was: what are the main benefits and costs that can derive from the inclusion of environmental interests within corporate governance law?

1. There will be greater scope for shareholder action to ensure directors’ haccount- ability. However, if shareholders do not take the responsibility to act, then it may prove difficult to hold company directors accountable for their actions or omissions, even when these are clearly not within the company’s or even shareholders’ interests.
2. The need to prepare environmental and social audit reports on the company’s impact on the environment and society will increase company directors’ reporting burdens. On the other hand, the company thereby obtains a better picture of its overall social and environmental impacts and is thus able to take steps to reduce these impacts, often to its own economic and public relations benefit.
3. The scope and extent of company directors’ xfiduciary duties will be increased but uncertain due to the inclusion of environmental considerations within the corporate governance matrix.

Power of the Purse

Insurance investment decisions in the US, as elsewhere, can greatly influence corporate environmental awareness. When discussing “insurance”, it is important to note that there are three sectors of the industry, underwriting and claims (retail); asset management and reserve allocation (solvency/profit analysis); investment (hedge funds, stock/bond portfolios, etc.). A scenario may therefore pose the question whether, and how, increased disclosure from companies engaged in operations prone to strict liability will further ESG (Environmental Social Governance) targets. Fortunately, a current news article illustrates just that sort of influence regarding Brazilian dams. Although the investment players are nominally European, the multinational character of asset management makes it very pertinent to events that could take place in the US. The story concerns two huge investors, The Church of England and Sweden National Pension Funds. After the Mariana and Brumadinho accidents, these two bodies requested specific business operations information from those constructing dam tailings worldwide (Lewis 2019).

This data would then be collated to determine mining companies' ecological sensitivity. After receiving these disclosures from the miners, the evaluation process would entail rating disaster exposure criteria against ESG standards. A firm called Ceres has formulated methodology to do this. It employs componential subcategories. For example, "Governance" would be listed as a heading, under which "Board Oversight", "Management Accountability", and "Public Policy [adherence]" would be grouped then scored on a hierarchal scale (Ceres 2019). Disclosure respondents would then be "graded" by their sensitivity to sustainability, resilience, worker and community safety, and, other factors. According to The Church of England, 200 of the 665 miners contacted have disclosed operational details. In addition to probable application of a scoring methodology, as discussed above, "global review is now being led by the Swiss former Environment Minister, Professor Bruno Oberle, that is co-convened by the International Council of Mining & Metals (ICMM), The Principles for Responsible Investment (PRI) and the United Nations. (Church of England 2019)."

Innovative Indemnification of Climate Change Losses

To quote a current news article, "It's important for companies to consider alternative futures including ones that are not good for their business businesses will have to confront accelerating climate change (Drugmand 2018, 2)." There are forecasts, relevant to our subject of dam tailings, that are based on already occurring effects. For example, "companies in the Colorado River Basin use that analysis [alternative futures] to drive their strategy", and more than 70 serious water risks to the Basin were reported in 2017 alone (Carbon Disclosure Project 2018). Furthermore "[b]y the end of this century, potential damage costs in some industries could tally in the hundreds of billions of dollars annually (Carbon Disclosure Project 2018)." Estimates of worldwide exposure to these risks lie in a range from billions to trillions of US dollars. Lack of response by insurers to deal with the threat can be attributed to the fact that ecosystem alterations are not immediately obvious, but part of massive shifts in global weather patterns. Plans for anticipatory funding of cash reserves to account for such types of unprecedented risk are not widespread. The insurance culture militates against the perception of drastic moves. Therefore, connection of disaster incidence with trends requiring fundamental adjustment of capital asset organization is viewed as speculation by this conservative industry.

The new paradigm doesn't fit into traditional loss analysis practices. A recent paper on the topic argues these "blind spots" defy logic (Goldstein et al. 2019). Still the fact remains

that "short-term extreme weather events like hurricanes and longer-term impacts such as prolonged heat, droughts causing water shortages, and other climate-driven operational challenges are realities that companies must manage (Drugmand 2018, 1)."

If those who specialize in US financial risk management are hesitant to accept climate change, how much more so would be constructors of Amazonian dam tailings. Insurance coverage for those endeavors is ignored due to attitudes prevalent throughout the Brazilian business community, which are akin to those of US insurance professionals. Each ethos discounts environmental risk as insubstantial. However, there are ways to introduce the concept for wider acceptance. A new underwriting and claims model may bridge this gap, while providing US insurers with limitation of overhead costs. In other parts of the world this is already practiced through predictive, or "indexed", analytics.

This process is the main feature of "microinsurance". It is an innovative strategy to extend adequate coverage for climate risk, and other perils, to vulnerable populations. This empowering financial underwriting product is closely allied with already extant indigenous self-help relationships. The innovation involves formalizing those self-help arrangement through adaptive business models. The tool for achieving this is price indexing of likely events. Predictive analytics software is used to value various probable events. A fund is established through insurers, NGOs, and governments which pays out directly in the case of a disaster event. In this way the costly bureaucracy of individual claims administration is bypassed.

Jurisprudence: The Role of Law

When any dam rupture occurs, it is assumed that the cause is inherent to the activity itself. Research points in this direction (Machado 2007). There are two primary possibilities regarding these disasters, either ceasing mineral exploitation within vulnerable regions or mitigation of such occurrences by indexing risk. The first option would totally prohibit industrial contact with ecosystems that are rich in biodiversity and whose inhabitants lack resiliency. The latter choice would allow development while minimizing incidence factors. This would involve creation of schedules listing compensation levels for communities effected by government sanctioned mining projects. This mechanism would also be triggered in situations where a containment dam had already been deactivated with no further exploration. Lingering toxins could still be present at the site because of cumulative damage. Minas Gerais is experiencing this problem. With lawsuits

pending, it is essential that judges, prosecutors, and officials address: containment of tailings from the mining activity; ecosystems impact; surface and underground reservoirs; planning for protection of human lives and ecosystems; inclusive resident participation; evacuation plans.

In Brazil, the National Mining Agency (NMA) is tasked to oversee mineral extraction. The organization has little bureaucratic support. The National Policy on Dam Safety (NPDS) was written to insure prevention of accidents through periodic monitoring (Statute 12.334 of 2010). The NPDS established an institutional design imposing obligations upon private initiative, to guarantee respect of public interest. For the purposes of this paper, Article 3 of the final document is most instructive.

The objective of article 3 was to mandate observance of standards to reduce accidents and their consequences. Mining companies were required to describe infill, business operations, deactivation procedures, and, future use. This process was envisioned as an integral part of all planning phases. Furthermore, promotion of follow-up actions were to be categorized. Collection of data was to aid public supervision and correction of security actions. Common language was to be used in specifications, allowing standardization of adequacy parameters. This was all designed to promote a culture supporting dam safety and risk management. Reticence in NPDS adoption has necessitated creation of pressure groups, outside of government. It is very difficult for law professionals, alone, to fully understand complexities of mining operations and environmental sequelae of accidents. Formation of an interdisciplinary group of geodetics, juridical, and financial risk professionals could effect the decision-making process, involving a so-called "GeoLaw" approach.

Application of GeoLaw concepts possesses many variables. In these cases GIS mapping tools could be widely employed toward planning, disaster risk prevention and management (Haklay et al. 2014). The novelty lies precisely in aligning mapping with the application of law and financial risk management. Collection of social data could also chart repercussions of disaster in relation to vulnerable populations and ecosystems. This would support technical analysis in the effort to avoid future recurrence. Indexing techniques for indemnification could be developed (Solden and Lord 2018).

Participation of vulnerable populations is key. Charettes and other interactive measures must precede the construction and monitoring loop. A recent study proposed GIS assistance,

through the Public Participation Geographic information System (PPGIS), in the schematic stage of projects (Giné et al. 2019).

Georeferenced data collection from non-expert users would engage public temporal-spatial participation by those in protected areas (Giné et al. 2019). Survey of opinions and ideas of inhabitants would also be possible, along with analysis of scenarios to balance conservation and land use (Giné et al. 2019). Capabilities of PPGIS can generate indexes from nested data, illustrating a variety of permutations collected from crowdsourcing and crowdsensing (Giné et al. 2019). This could serve as a model for population participation with the ability to provide policy makers with accurate, real-time results. However, these innovations are not embraced by those in power. Tragic consequences for this deficiency of compassion were visible when the Brumadinho tailings dam failed, making it impossible to evacuate as a wave of mud quickly covered people and vehicles desperate to escape. It has been written that, even though we live in a moment of technological wonders, the challenge is to insert them into the daily life of the decision makers (Marchezini et al. 2017).

The question must be posed whether such an effort could prevent future disasters. It is commonly agreed that legal proceedings are painful in their duration. If the types of individual and collective agreements discussed above were made before tragedy occurred, the Mariana and Brumadinho imbroglios could easily have been avoided. Cooperation between public-interest attorneys, government prosecutors and bureaucrats, and associations defending residents of those regions looks more attractive with hindsight. Monitoring of dams in Brazil can still be ineffectual (Carneiro 2019), using outdated equipment and methods. This is added to manifold problems of National Policy on Dam Safety (NPDS) implementation. It is inescapable to conclude that the probability of further tragedies, given lack of preparedness by state and industry, remains high.

IV. RESULTS

A Model for GeoLaw Application

Extreme events must be mitigated so that, if they occur, there is as little damage as possible. It seems that the challenge is how to quantify such damage. This is because mineral extraction can cause imperceptible harm initially, but is prodigious in its sequelae. Thus, it is difficult to predict all the variables that can generate contamination, or other deleterious effects,

to the environment and human society. Naturally, multiple uncertainties and conflicts exist at the junction between complex social and biophysical systems. It is therefore crucial that a formal governance model integrate public oversight, local initiative, and (because mining ventures possess cumulative harm characteristics) transparent implementation of remedies. Current Brazilian bureaucratic mechanisms lack these adaptive, integrated, and participatory qualities. The scenarios presented above indicate the population was not consulted before or during the project. Regarding Brumadinho, absence of contingency plans and exposure of corporate employees to excessive risk, illustrate this planning deficiency.

In both dam rupture circumstances, it has been argued that employment of spatial analysis would provide verification of the environmental injustice that harmed fishermen, riverside communities and the city dwellers through waterborne contamination by heavy metals. This would confirm the thesis of scholars concerning spatial disposition of these enterprises, (Martinez-Alier 2007); (Ascelrad 2009). Urban populations were better able to mitigate the disaster but were not completely unharmed, especially in terms of water resources. Requisite to building a model that involves geography and law is equitable access to information, in order to understand the extent of potential risks. In this way vulnerable populations and ecosystems would be in the future. It has thus been argued that neither government nor state supported corporations were properly prepared for disaster, because they suffered the same lack of tools to ascertain risk. This situation led to proposals to unify territorial and environmental justice through application of geoprocessing techniques, enabling easy access to data for everyone. To facilitate this, the “JustSide Cyted” project is

building a platform to concentrate geographic information to assist in decision making, when planning environmental intervention actions such as mining. But this does not apply just to planning but also to court decisions, by assisting judges and prosecutors to fairly adjudicate indemnification of torts. State and corporate responsibility would be the result, thus insuring the Mariana and Brumadinho tragedies will not be repeated.

The Model Flowchart

A diagram (Figure 7) illustrates combination of mapping principles with those of law and engineering. This model may also encompass public administration, relative to planning and monitoring environmental projects. Professionals from various fields would be utilized. It will be important that legislation establish the use of mapping to inform and support decision-makers. Nested information will provide details of many variables, such as location, soil type, topography, and applicable legislation. Geolocation would thus proceed to mapping consistent with cartological attributes, accomplished using software such as *gvSIG*. This type of mapping must be mandatory and, if not done properly, would be archived or interrupted. Access would be given to public or private users. Those entities could request more information, amend the map, and make relevant decisions by reviewing output. If the analytics were positive, the project would be authorized. And, if results were negative, work would be terminated. The “GeoLaw” movement aims to develop growth of interrelationship between geographic mapping, and statute. Such a protocol would include, for example, analysis of the merit of a lawsuit. All this technology would have but one goal, to tackle territorial and environmental injustice.

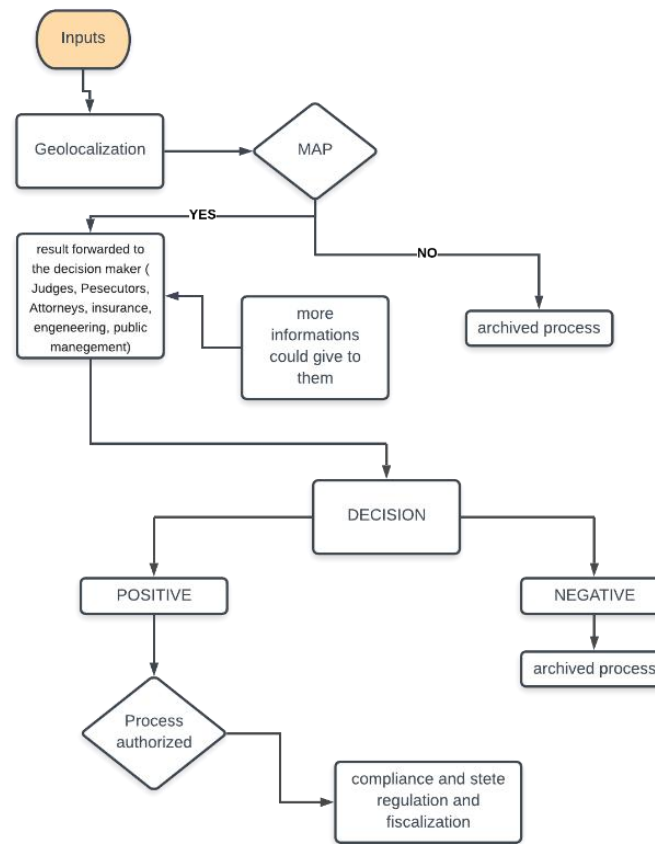


Fig.7: Model Diagram Found.

Source: Author

V. CONCLUSIONS

The disasters in Brazil are emblematic of wider socio-environmental concerns. Employment of GeoLaw modalities can mitigate conflict in better management of tailings dams, but also in general practice. The new field can apply safety parameters to any industrial venture which involves ecosystems and vulnerable populations. This paper has proposed fundamental changes in current behavior, subordinating project conception and operation to legal, geographical, and indemnification strategies. With these three components in place, those in power will be held accountable for their actions, due to availability and transparency of information. This concept defines the goal of “GeoLaw”. Information and variables inherent within that system will continue to evolve, presenting as yet unknown possibilities. The most crucial potential of this interdisciplinary effort may well be more comprehensive tracking of climate change effects. The true destiny of

“GeoLaw” lay in this broad issue, magnifying remedies far beyond those proposed for Mariana and Brumadinho.

This essay has proposed a new methodology to improve the construction process of dams for ore mining tailings. Furthermore, this approach could also be applied to other enterprises. The conclusion may be drawn that certain economic means and technologies are particularly suited for advocating equality of resource distribution. Use of GIS can help to open information access resulting in public transparency and identification of problems within a given geodetic region. Exacerbation of societal imbalances through land use, mining operations, and valuation of environmental services can be better understood through that process. Planning of equitable public services, such as availability of sanitation and water, can also be enhanced. Nigerian government policy is illustrative of GIS impact. The technology was used to identify subtle exploitation of nomadic culture (Gagnol and Afane 2010). Acquiring such

information requires proper design of GIS apparatus. For example, legal precedents flowing from a land use decision will be interpreted and codified. If land distribution addresses the reality of a situation, and its spatial dynamics, it would follow precedent and encourage fair legal, regulatory, and financial strategies. On the other hand, lack of such machinery would perpetuate dysfunction, accelerating inequality and injustice (Pereira et al. 2017).

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