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An Interdisciplinary Approach to Petroleum Extraction in the Ecuadorian Amazon: Implications and Remediation Strategies

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Abstract

As recently as five decades ago, Ecuador was among the lowest ranking countries in the Western Hemisphere on the GNI per capita index. However, the discovery of oil in the Amazon provided an opportunity for the nation's economic development. The Amazon region of Ecuador is an area of significant global value due to its biodiversity, cultural heritage, and largely intact rainforest providing species protection. Ecuador's national development has brought recent, massive expansion to their petroleum industry, overlapping oil blocks with zones of dense species richness, protected areas, and Indigenous land. This paper aims to analyze the lasting socio-environmental impacts of petroleum extraction in the Amazon region of Ecuador. In doing so, it is crucial to integrate two of the knowledge systems that create the areas under review: local Indigenous knowledge and ecological knowledge based on institutional science. Within the framework of ethnoecology, a historical analysis and literature review were conducted to understand the implications and remediation strategies of petroleum extraction. The findings suggest that Ecuadorian policy has led extraction to deforestation and the disruption of native communities. The use of native organisms and community methods were found to be promising approaches to address oil-contaminated areas. This study concludes that mutual support between local, traditional, and institutional knowledge is necessary to assess the impacts of petroleum extraction and potential remedial strategies.

1. Background

The ecological services and natural capital stocks that Earth produces create the inherent value that supports all life and systems involved. Ecosystem services (ES) are the direct and indirect contributions of ecosystems to human well-being.[1] Ecosystem valuation as a whole is the process by which environmental resources and their services are quantified to estimate their contribution to human welfare. It is often argued that ecosystem valuation is impossible due to life's intangibility and long-term ecological benefits. A significant contribution of ES is of a public goods nature, such as clean air, water, and soil formation, that support human welfare without directly passing through the monetary economy.[2] In a world that has come to be dominated by commercial markets, it becomes clear where policy finds value when industries that cause environmental hazards are placed in regions of infinite ecological benefit. To strategize potential remediations for the environmental risks of petroleum contamination, a contextualization of petroleum extraction in Ecuador must first be established.

The Amazon region of Ecuador, known to Ecuadorians as the *Oriente*, is an ecologically diverse forest habitat and tropical rainforest biome.[3] Forest biomes provide abundant, interdependent ecosystem services in the forms of regulating, supporting, provisioning, and cultural benefits. The Amazon forest provides necessary provisioning services and goods such as food, fuel, timber, and medicine to local and global communities. Support services supplied by the Amazon include nutrient cycling, the hydrological cycle, soil formation, and photosynthesis. The Amazon region of Ecuador creates global benefits through the ecosystem processes of climate regulation and air quality

management, and carbon sequestration.[4] In biological material above and below the ground, tropical forest ecosystems are capable of storing between 208 GtC and 288 GtC (GtC = gigatons of carbon; 1 Gt equals 1 billion metric tons).[5] The ability of forests to store carbon is essential for many reasons. Forests sequester carbon by transforming carbon dioxide (CO2) from the atmosphere into biological material through the process of photosynthesis.[6] The biological material in which carbon is stored in forest biomes can include all living biomass above and below the soil, such as understory, branches, stumps, seeds, foliage, and coarse, live roots. The two other main categories of forest carbon sequestration exist in forest floor litter of nonliving decomposing plant materials and all organic soil to a depth of 1 meter.[7] In an estimate of carbon stocks, forests in Latin America were found to hold about 49% of the total carbon biomass in tropical regions.[8] The Amazon forest has acted as a global sink for storing atmospheric carbon, as trees are still growing faster than they are dying. Tropical forest carbon sinks such as the Amazon rainforest are capable of absorbing around 20% of global fossil fuel emissions collectively.[9] However, the recent steady increase in deforestation will significantly impact the Amazon's ability to take up carbon dioxide. It is also estimated that tropical forest ecosystems are hotspot areas of species richness, together hosting 50-80% of all terrestrial species.[10] It, therefore, becomes essential to find strategies for preserving the Oriente to conserve biodiversity and protect the globe's atmosphere. Changes in forest biomes can result from a variety of anthropogenic or natural influences. Clearing forest land for human development projects such as natural resource extraction allows the carbon dioxide stored by the biological material to escape into the atmosphere as a greenhouse gas. When forests have been cleared, there is not only an impact on ecological systems but on local and global communities as well.

Previous studies have shown that nature and culture are inherently co-evolutionary, each affecting the other's processes and transformations.[11] Cultural services of the Amazon forest biome refer to the non-extractive use of the land in terms of recreation, tourism, scientific research, and the symbiotic relationship between ancestral lands and Indigenous communities. Much of the Oriente is lands traditionally used by numerous Indigenous nationalities.[12] With over one million Indigenous people living in Ecuador, over 24% of that population live in the Oriente. Ecuador has 14 recognized Indigenous nationalities that are involved in local, regional, and national organizations to unite for stronger identity and social organization.[13] Despite the inherent significance of Indigenous lives, trends can be seen across Indigenous and forest impact among the mass destruction carried out by government developmental policies, agricultural settlement, and oil extraction. To look at the petroleum industry alone as the sole driver of the increasing subversion of the Oriente would be a significant oversight. A holistic approach toward the historical processes of colonization that led to such impacts must be taken into account in order to find a comprehensive understanding.

The Ecuadorian government's intent on integrating the Amazon with the rest of the country can easily be seen in their legislation and policy before the arrival of major petroleum companies Texaco and Gulf in the region. The administration took great public action for settlement and economic expansion to occupy the rainforest region. In 1875, the government imposed the *Vacant Land Law*, in which "unused" lands were declared to be national patrimony and therefore property of the Ecuadorian State. This law meant that Amazonian territories were to be declared "vacant land" and therefore openly encouraged for colonization and development. This concept of declaring lands and intent on expansion can be traced back to the Papal Bull documents in 1493, issued by Pope Alexander VI.[14] The papers supported Spain's rights to the lands explored by Columbus in the previous year, effectively giving Spain a monopoly on lands in the "New World". The Papal Bulls stated that any land not inhabited by Christians was therefore available to be "discovered" and claimed, in order to spread Christendom and maintain an absolute right to "New World" lands. This "Doctrine of Discovery" became the basis for all European land claims in the Americas and can here be seen enacted by the Ecuadorian government in claiming the vast Oriente as vacant and unused to determine it national property.

Ecuador then used the *Oriente Law (1920)* to divide the Amazon region of Ecuador into government-sanctioned provinces and appointed them governors and civil administrators.[15] A highway built by Shell linking Ambato to Puyo across Ecuador was opened in 1947, opening access to a massive part of the central Amazon for oil exploration, settlement, and more roads.[16] On this road, modern agricultural expansion began into the Oriente, followed by other major roads in the Amazon. In 1963, government policymakers in Quito, Ecuador, identified areas in the Amazon region for agricultural settlement, imposing a law the following year that emphasized the "integration" of the Oriente with the rest of the country. The *Agrarian Reform and Colonization Law (1964)* established the Ecuadorian Institute for Agrarian Reform and Colonization (IERAC). The IERAC was granted authorization to allocate "parcels for family farming units" in maximum parcel sizes. These parcels were allocated in the settlement zones of the Oriente which were located within traditional Indigenous territories of the A'i Cofán, Siona-Secoya, and Waorani people. Both Indigenous and new immigrants looking to settle had to establish their land claims by obtaining a legal title to 50-hectare parcels, which were required to be 25-50% in production or cleared. The Ecuadorian Institute for Agrarian Reform and Colonization was also directed to create native territorial reserves and regulate forest use.[17] That same year, the *Vacant Land and Colonization Law (1964)* determined the legal definition of "vacant land", also normally

including all traditional Indigenous territory in the Ecuadorian Amazon. This began a massive transfer of ancestral Indigenous lands to migrant homesteaders recruited for settlement from outside the Amazon region in Ecuador's more-developed highlands. In determining by law that large portions of the land had no owner other than the state, the Ecuadorian government ignored the prior rights of possession and stewardship of Indigenous nations and began the uncontrolled land-grabbing by the petroleum industry, settlers, and developmental construction. By 1970, around 43,000 colonists had moved to the Oriente to live on the agricultural parcels through the roads built by the provincial government and partnering agencies such as Shell.[18] The emphasis placed on populating the Oriente through legislation and infrastructure development demonstrates the Ecuadorian government's focus on the colonization of the Amazon and the exploration of economic opportunities in the region.

The expansion of roads and settlements throughout the Ecuadorian Amazon also allowed for further exploration of oil extraction opportunities. Texaco and Gulf Oil companies began their search for hydrocarbons in the northern Oriente in 1964, making significant finds of large oil fields three years later.[19] In 1972, the government gave Texaco Oil Company operational responsibility of 442.9 thousand hectares of land, which they later handed over to the national oil company of Ecuador, Petroecuador.[20] Although oil production did not begin until 1972, the Ecuadorian government demanded that oil companies build transportation infrastructure, whether or not roads and bridges were needed for petroleum exploration and extraction.[21] Throughout the following years of oil exploration, fields were found and contracted out by petroleum industries and the Ecuadorian government. Many progressive Latin American regimes have continued to re-politicize natural resource extraction to forge an extractive imperative. This is a model of development calls to mind earlier Ecuadorian legislation in which the intensified use of natural resources takes on an 'essential' role.[22] President Rafael Correa came into Ecuador's office in 2007 with an agenda to transform the State, its development model, and its economy. He inspired the 2008 Constitution that adopted a development concept called Buen Vivir, which defined Ecuador as a plurinational state and granted inalienable rights to nature. This was thought to be a progressive attitude for the government to take on as it not only addressed the existence of multiple political and constitutional communities within Ecuador, but also the legally enforceable rights of nature to "exist, flourish, and evolve".[23] At the same time, however, it declared natural resource extraction to be a "strategic sector" of the Ecuadorian economy, over which the state has "exclusive decision-making and control".[24] The Correa government hoped to boost the oil exploitation system and large-scale mining in order to expand human, national, and even environmental improvement. By 2008, Ecuador had about 35 oil blocks in the Amazon region, each with a maximum surface area of 200,000 ha.[25] Oil blocks are the geographical areas that are contracted for the exploitation of oil. With the national development of Ecuador through the petroleum industry, oil blocks have expanded to cover about 68% (68,196 km^2) of the Ecuadorian region of the Amazon, overlapping with zones of dense species richness and Indigenous territory.[26] These oil blocks also often have very limited environmental controls.

Due to poor environmental controls of the technologies used to exploit petroleum blocks in the Amazon, oil continues to impact forests and communities as wastes and byproducts that get released into local soils, waterways, and ecosystems. In only the years between 1994 and 2001, over 29,000 crude oil barrels were spilled across the Ecuadorian Amazon, of which, over 7,000 were never recovered or cleared from the environment.[27] Billions of gallons of untreated toxic wastes are released into the environment as a result, causing health impacts for rainforest species and human populations.[28] Due to this negative impact, an investigation of current remediation strategies of oil-contaminated soils will also be conducted. Potential strategies include the traditional Kichwa agroforestry system called "chakra",[29] microorganismal bioremediation to degrade oil contaminants from the soil,[30] and holistic grassroots efforts.[31, 32]

2. Theoretical Framework

The theoretical framework that guides this research is most closely related to the field concepts of Ethnoecology. Ethnoecology can be generally described as the study of the anthropogenic use of nature. Its use has been defined by biologist Victor Manuel Toledo and associated with local ways of understanding the relationship between humans and nature, including the ecological aspects of soil, climate, and other environmental factors.[33, 34] This concept was further developed by anthropologist Arturo Escobar in the context of resource political ecology with the aim of balancing three categories of economic, ecological, and cultural rubrics in discourse on natural resource issues. Escobar maintains the importance of the "plurality of place-based knowledge" to claim that there are different relations and ways of knowing that are successful in different ways based on place, culture, and history.[35] This framework finds itself at the intersection of cultural systems and ecosystems. For the purpose of this paper, the framework will integrate multiple knowledge systems that create the areas under review: local Indigenous knowledge and science, and

ecological conservation knowledge based on institutional science. An important aspect of this framework is the incorporation of Local Ecological Knowledge (LEK, also known as Indigenous Ecological Knowledge, IEK, or Traditional Ecological Knowledge, TEK), that can be defined by the systems of understanding that a population of people has regarding the ecology, relations, and implications of their environment.[36] Another is Indigenous Science, which can be thought of as a culture-dependent collective rational perceiving of reality.[37] Ethnoecology intersects LEK based on perspective, historical aspects, and science. The theoretical goal of this paper is to strengthen mutual support between local, traditional, and institutional knowledge as the epistemology systems regarding petroleum extraction in the Ecuadorian Amazon region.

3. Methodology

The significance of integrating Indigenous knowledge and science with institutional ecological science is highlighted by their mutually dynamic support of biodiversity conservation based on lived experience and data. Indigenous knowledge of this field is crucial in order to accurately assess the impacts of petroleum extraction,

The complexity of an interdisciplinary assessment of ecological impact calls for place-specific analyses. It is, therefore, necessary to include place-based sources in this study. To properly analyze the impact of petroleum extraction in the Ecuadorian Amazon region, it was important to not only look at scholarly articles on scientific databases but also those voiced by regional Indigenous individuals.

The study is qualitative, however, the articles used to support this research were both quantitative and qualitative data. All information in this study is secondary, as it was collected from outside, existing primary and secondary sources. A historical analysis and literature review were conducted to understand the implications and remediation strategies of petroleum extraction.

Perspective from those living in this region was collected for this research from various Indigenous databases, institutes, websites, and news sources, all of which are either run, voiced or collaborated on by individuals from the respective communities. The Indigenous sources incorporated into this study include La Confederación de Nacionalidades Indígenas del Ecuador, La Fundación Sobrevivencia Cofán (FSC), El Instituto Científico de Culturas Indígenas, La Confederación de Nacionalidades Indígenas de la Amazonia Ecuatoriana (CONFENIAE), NativeWeb, and Abya Yala Net. Articles from these sources were collected based on their relevance to resource extraction, community history, land-based perspective, and ecological knowledge. Articles were disregarded if they had no affiliation, collaboration, or permission by individuals from their respective communities. They were also eliminated based on irrelevant information to this research.

The scholarly articles, collected from a variety of scholarly databases such as JSTOR, Google Scholar, ProQuest, and Science direct, were studied and applied as contextual analysis. Other articles relating to more recent events were collected through various global news sources found through Google News and Indigenous news organizations. Database searches included keywords such as Ecuador, Amazon, Petroleum, Development, Extraction, Buen Vivir, Ethnoecology, Traditional Ecological Knowledge, Biodiversity, Deforestation, Yasuni, A'i Cofán, Waorani, and Bioremediation, among others. Articles were collected based on their direct relevance to petroleum extraction and remediation in the Ecuadorian Amazon in relation to historical perspective, TEK, and ecological science. Articles were eliminated based on their alignment with other extraction industries, such as mining, that did not contribute to an understanding of oil extraction. Articles that were deemed biased based on their derogatory or overly positive or negative language toward certain policies, communities, industries, and strategies were also disregarded.

After finding articles that would support the synthesis of Indigenous knowledge and institution-based scientific knowledge, they were textually analyzed to find additional trends and information. The data was evaluated in order to directly explain and answer the question of how petroleum extraction has come to impact Indigenous communities and the Ecuadorian Amazon forest biome, as well as to discuss potential remediation strategies.

4. Findings

Despite being one of the most biodiverse areas of the world, contributing massively to global carbon sequestration, species richness, and cultural significance, the Amazon rainforest of Ecuador is exposed to numerous socio-environmental impacts of petroleum extraction. Since the boom in extraction after large oil fields were found under the Oriente in 1967, petroleum quickly shot up as Ecuador's main export, and has dominated exports ever since. In

2017, petroleum accounted for over half of the country's export earnings.[38] Other secondary exports include bananas, seafood (including fish and crustaceans), and flowers. With petroleum being a nonrenewable resource, the government of Ecuador has acknowledged that basing the economy heavily on petroleum is not environmentally, socially, or economically sustainable.[39] Therefore, income diversification must be a priority. Addressing the current influences of oil exploitation and potential remediation strategies requires the consideration of forest ecosystems and Indigenous communities.

4.1 Deforestation

As established through the historical analysis of Ecuadorian national development, the key reason for the decrease in the Oriente forest cover was the government's endorsement of the geographic expansion of large-scale, settler agriculture. Before this large-scale human expansion and settlement into the Oriente, over 90% of Ecuador's surface area was covered by forest.[40] The desire of the State to develop throughout the twentieth century brought massive roads and settlements to the Oriente with little regard to the large number of species and Indigenous communities and already inhabiting the land. Policymakers made large quantities of "unoccupied lands" available to agricultural colonists in the late 1800s. Migration was slow to the Amazon until the State enacted a plan in 1963 to fill the "empty" Oriente with settlers. The IERAC required that both Indigenous and new immigrants looking to settle had to establish their land claims by obtaining a legal title to 50-hectare parcels, which were required to be 25-50% in production, and therefore, cleared.[41] The vast majority of land cleared during this time was for livestock production. As Ecuador's GNP per capita increased, as did the demand for food, especially livestock. Official government agencies then provided encouragement through subsidies for large livestock production and gasoline in the Oriente settlement areas.

By 1987, only twenty years after the initial discovery of oil fields in the Oriente region, Ecuador's forest cover dropped dramatically down to 45% of the original surface area.[42] Data shown by satellite imagery displays that by the year 2000, agricultural settlement specifically within the Oriente had "destroyed 240,888 hectares of forest, or 54.4 percent of the total area".[43] The cause, as previously demonstrated, points toward the oil access roads and legislation attracting agricultural colonization and large-scale settlement. Oil companies were able to use the infrastructure that had been created primarily for transportation and migration to continue their exploration of petroleum hydrocarbons in order to continue their expansion. The first large fields were found around the Lago Agrio area. In addition to the expenses paid by early oil companies in Ecuador such as Texaco, the Ecuadorian government also invested 48.8% of its total public sector investment in road construction to aid expansion.[44] The 35 oil blocks that occupy the Ecuadorian Amazon overlap intensely with protected areas, ancestral, and titled lands of Indigenous groups.[45] These areas have become cleared and fragmented with road construction, agricultural expansion, and a growing population moving to new settlement. Therefore, the main drivers of deforestation in the Ecuadorian Amazon lie within the government's intent on settling the "unoccupied" rainforest, and the discovery of oil. Ecuador as a whole finds its most recent forest cover study between 34.5 to 44.8% of its original surface area.[46] The lack of change in this rate of conversion from 45% in 1987 to 34.5-44.8% most currently can be attributed to an increase in Protected Areas and local resistance. The Ecuadorian Government created the Ministry of Environment and Water, as well as the National System of Protected areas, which together conserve 18.4 million hectares of land in 59 protected areas.[47] The International Union for Conservation of Nature (IUCN) defines a protected area as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values".[48] These areas represent over 20% of Ecuador's land area, and 12% of marine area.[49] However, Indigenous communities such as the Waorani nation have proven that Ecuadorian legislation such as this does not automatically create immunity from interference by oil companies.

4.2 Impact on Indigenous communities

The Waorani people, who currently number somewhere around 2,000, once maintained one of the largest territories of all Indigenous Amazonians in Ecuador, occupying a large area of rainforest estimated at 2 million hectares between Ecuador and Peru. Traditionally, they live as nomadic hunter-gatherers, collecting and cultivating plants and subsistence gardens in small settlements in the Upper Oriente.[50] Since 1990, the community has held title to 680,000 hectares of land, part of which was eventually included by government decree in an "untouchable zone," therefore prohibiting extraction and development. However, this area also incorporates areas of the Yasuni National Park as well as three oil blocks. As a result of government-ordered roads for oil companies, the Waorani also face intense illegal settlement on their traditional Amazon territory.[51] In 1986 the Conoco petroleum company signed an exploration agreement with the Ecuadorian government for Oil Block 16, which included Protected Areas and

intangible zones of the rainforest, parts of the Yasuni National Park, and the homelands of the Waorani. As a result of a 2012 "consultation" with the Waorani, their rainforest was divided into oil blocks and put up for sale by the government in an international oil auction. The community says that the Ecuadorian government failed to get their legal consent before putting parts of their territory up for international auction.[52] According to both Ecuadorian national law and international law, governments are required to undergo a free, prior, and informed consent process with communities before beginning any extraction projects on their territory.[53] The Waorani sued three branches of the government - the Ministry of Energy and Non-Renewable Natural Resources, the Secretary of Hydrocarbons, and the Ministry of Environment and Water - for failing to obtain legal consent from the community prior to putting their lands up for international oil auctions. After many years in court, on July 11th, 2019, the Indigenous Waorani community in Ecuador won the landmark lawsuit against the three government bodies for conducting a faulty consultation with the community in 2012 before putting their territory up for sale in an international oil auction.[54] This win set an important precedent for other communities in Ecuador's Amazon rainforest trying to keep extraction out of their lands. Despite the inherent significance of Indigenous peoples and communities, trends can be seen across Indigenous and forest impact among the mass destruction carried out by government developmental policies, agricultural settlement, and oil extraction. To look at the petroleum industry alone as the sole driver of the increasing subversion of the Oriente would be a significant oversight. A holistic approach that includes Indigenous perspective toward such impacts and remediation strategies must be taken into account in order to find a comprehensive understanding.

Conservation ecologists, natural resource managers, and local communities are increasingly recognizing the value of interdisciplinary approaches to assessing environmental injustices. Incorporating local ecological knowledge, created by local users through local contextualization, observation, and experiments is crucial in the discussion of impact, management, and strategy.[55] As informed by the International Alliance of Indigenous-Tribal Peoples of the Tropical Forests and the International Work Group for Indigenous Affairs (1997):

"… Any discussion on Indigenous peoples and forests has to address the totality of our rights: our identity as peoples, our territoriality, our cultural heritage, our customary law and our political institutions which are framed by our fundamental right to self-determination…"[56]

Due to the systematic oppression and exclusion of local ways of knowledge and beliefs, Indigenous perspective is often left out of Eurocentric scientific discourse, and unrecognized by authorities. However, local knowledge is heavily supported by and grounded in lived experience. For example, Indigenous individuals living on ancestral land in the Amazon have a far richer understanding of the natural land than a non-Indigenous scientist studying the same region. Though much of this knowledge is traditional, that does not mean it is static, but rather in constant transformation as it relates to the frame of reference around them. As a result, the development of the mutual support both of institutionalized ecological science and free-willed local intellect can create a holistic assessment of impact and strategy.

The Napo River is one of the main river tributaries of the Amazon River. On April 7, 2020, an oil spill occurred affecting over 90 Indigenous communities living near the area, becoming one of the largest oil spills in Ecuador's history. The spill came as a result of the regressive erosion.[57] In the absence of a response from authorities regarding the spill, affected Indigenous nations who live on the banks of the Napo river have submitted multiple requests to the Francisco de Orellana Judiciary Council. The letter noted that the spill will directly impact the lives of 27,000 Indigenous people living along the banks of the Coca and Napo rivers. The letter, written by Indigenous Kichwa individuals from multiple communities notes that at least 15,800 barrels (664,000 gallons) of crude oil spilled into Amazon rivers and tributaries as a result of the spill.[58] Alleged warnings of the potential for increased soil erosion to cause a pipeline rupture were ignored. There was no alert system in place to warn downriver communities about contamination from the spill, nor were the communities consulted on the petroleum company's remediation plan. Additionally, amidst a global pandemic, these affected communities wrote that they were provided with wildly inadequate emergency food and water rations despite the contamination of their territory's waterway. At the time of its creation, the 2008 Ecuadorian Constitution became a beacon of hope as it recognized the Rights of Nature and Indigenous peoples. However, as plaintiff and Kichwa leader, Veronica Grefa spoke it, "Once again, we have felt the injustice on the part of the judiciary, since we clearly see that the Ecuadorian government cares more about its income than about the health of its citizens, at least us Kichwas."[59] After their court case was suspended, Kichwa communities filed dozens of lawsuits demanding the suspension of the two current Ecuadorian pipelines – the SOTE and OCP pipelines. Carlos Jipa, Kichwa leader and President of FCUNAE, the region's Indigenous Federation of United Communes, and Marlon Vargas, President of CONFENIAE (Confederation of Indigenous Nationalities of the Ecuadorian Amazon), both issued statements following the spill, respectively:

"We are already suffering from various illnesses caused by oil contamination, and now we are also facing this pandemic. We face discrimination as the government has failed to include us in its emergency plans yet again. This is why the families, represented by FCUNAE, decided to join this lawsuit: we don't want this to happen ever again."

"Oil spills are the death of biodiversity and life. The Ecuadorian government must remedy and suspend all extractive activities and shift towards post-extractive economic development. Oil exploitation and the extraction of other minerals pollute the environment, and they are no longer profitable, they're now being rejected across the globe. This pandemic has shown the world very clearly that oil doesn't sustain life. Instead, it is the forests and harvests of Indigenous peoples and rural communities that are keeping us alive today."[60]

This Indigenous campaign builds upon previous recent Indigenous-led victories against extraction, such as the Waorani's. Nemonte Nenquimo is a Waorani leader and co-founder of the Ceibo Alliance, an Indigenous-led organization working toward the defense of indigeneity, cultural survival, and solutions-based alternatives to rainforest destruction.[61] Nemonte led her people in a landmark lawsuit against three Ecuadorian governing bodies, for failing to conduct a legal consultation process in 2012 with the Waorani community before putting their territory up for sale in an international oil auction. As a result, the Amazon territories of Waorani and seven other Indigenous nationalities were divided into 16 oil blocks. In March 2019, the Huaroani sued the Ministry of Energy and Non-Renewable Natural Resources, the Secretary of Hydrocarbons, and the Ministry of Environment.[62] Experts and elders from the community explained that the 2012 consultation was largely inadequate and violated the community's rights to self-determination. Nemonte Nequimo led her community to protect half a million acres of primary rainforest in the Amazon. In her words, "we are taking a stand for the planet. Throughout the world, women, not just Indigenous women, must take leadership to build the future. For our children, so that they can live well, healthy, without disease, without pollution."[63]

4.3 Potential Remediation Strategies

With a foundation of the way that oil has come to impact the forests and people of the Ecuadorian Amazon, an appropriate, brief investigation of potential remediation strategies may be assessed. For the purposes of this study, the bottom-up, Indigenous and grassroots approaches will be looked into. The importance of incorporating Indigenous knowledge has been established, however this knowledge and science is often be held in rights by community members themselves. Therefore, much of the specific ecological knowledge of plants and systems that may help in remediation *for* these communities lies within the communities themselves.

The Kichwa nation has a traditional form of an agroforestry system, called "chakra", which cultivates plots of land that grow native, edible, medicinal, and commercial plants among native trees. The selection of native species for remediation is important for biodiversity protection is noted within "chakra" as well. In a 2016 study of among 20 tree saplings to select adequate tree species for the recovery of areas degraded by the oil industry in this region, it was found that the best performing were native species of the Amazon basin itself - *Apeiba membranaceae, Cedrelinga cateniformis, Inga densiflora, Myroxylon balsamum, and Pouroma cecropiifolia*.[64] The chakra landscape creates a multifunctional use and non-use area creating food security, economic productivity, and biodiversity and carbon protection. The chakra system is a valid example of how agriculture and economic prosperity can work *with* its environment rather than directly against it.[65]

The Amazon Mycorenewal Project identifies fungi and bacteria that are capable of bioremediation by digesting petroleum hydrocarbons in oil-contaminated soils. A study of the fungi genus *Geomyces* in soil samples from the Lago Agrio oil field in Ecuador show promising results as the plant growth rate went from just 20% before treatment, to 100% growth rate after the bioremediation of the soil.[66]

Local to Lago Agrio, La Clinica Ambiental was founded in 2008 in response to the area's high levels of oil and chemical activity as a holistic repair proposal, including the soil, plants, animals, social systems, and socio-ecosystems. Through participatory action research in areas affected, La Clinica Ambiental works with communities to regain soil and social health.[67]

5. Conclusion

To the extent that the economies of our world continue to grow, the demand for ecosystem services such as minerals, building materials, hydrocarbons, and oil will also grow. This will only further drive the geographical expansion of

the extractive industry. A scenario such as this raises various important concerns and questions for policy, research, and theory. World policies and strategies that attempt to conserve living resources must be prioritized. Earth politics must be implemented to address, establish, and implement important principles like ecology and sustainability. The threat of another geographical expansion of the extractive industry will put more pressure on the environment at a time when it simply cannot stand higher demand. The consequences of this could cause even harsher relationships between movement, people, the biosphere, and the political economy, and new forms of social conflict and social movements will erupt. It is the varying nature and presence of Indigenous social movements and organizations that hold significant influence on intimate communities, government actions, and large-scale industries alike. It is also these groups who maintain model economies and lifestyles that allow them to thrive for generations in harmony with their land.

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