

An Environmental Education Model Based on Bio-dynamic Agriculture: a case study in the 2025 May's election in Suriname

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Abstract: On May 25 of this year will have presidential elections in Suriname and this is difficult to find a candidate, among the six who compete for the most important position of the country, seriously committed to environmental education and preservation.

There is no any governmental interventions, required to prevent green gentrification: 451,000 hectares of Amazonian primary forest were granted to agricultural installments. This has resulted in a shocking amount of primary forest loss for a country that has suffered an average annual deforestation of 6,560 hectares in the last 21 years (137,746 hectares in total since 2002).

It is a country with various climatic challenges due to the lack of education, available only in The Netherlands. This is related to the vast Chinese and Indian population density, which dominate the private sector and has a large influence on the public sector with the endorsement of The Netherlands.

Due to the lack of access to knowledge, the pollution of Suriname, in particular the amount of garbage in the streets of Paramaribo, is a chaotic situation that can no longer continue since it is gravally affected the health of the population. A growing body of research highlights that enhancing green spaces can play a significant role in preventing or reducing the severity of various chronic conditions.

Environmental education cannot be developed in isolation; it must be integrated within a broader social and cultural context to be truly effective. This study explores the importance of incorporating environmental education into early childhood learning and fostering greater engagement with students. By embedding environmental education into diverse learning environments, this approach promotes both ecological awareness and a deeper respect for the environment.

An ecologically conscious citizen who respects nature and diverse cultures is more receptive to effective environmental education practices and better equipped for active participation in government initiatives. In response to this need for transformation, this research proposes an environmental education new paradigm based on transversality.

In parallel, the insertion of environmental education as a cross in mathematics, chemistry, literature, biology and physical education, it is necessary that Suriname farmers begin to use biodynamic agriculture practices as a rock dust.

The main result is a model of biodynamic agriculture based on the transversality of the teaching of Environmental Education and rock dust as an excellent remineralizer for the Suriname's soil.

Keywords: bio-dynamic agriculture. Ecological citizen. Communities of Practice. Environmental education of children. Rock dust.

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1. Introduction

According to Balaguer e Cantavella (2018) it is widely acknowledged (e.g., Dasgupta et al., 2002 Lange and Ziegler, 2017), more education can improve environmental quality. In fact, it can imply further level of understanding to incorporate cleaner technologies and social awareness among people enforcing, this way, higher environmental standards. Moreover, it is suggested that the true total effect of education at each level is not even identified if a linear relationship between the percentage of school enrollment and the percentage of emissions is assumed.

Rodrigues (2023) asserts that Latin America has significant potential to play a major role in advancing a positive Climate Change agenda, particularly following the re-election of Luiz Inácio Lula da Silva. Lula aims to restore Brazil's leadership position and promote regional cooperation in Latin America. At the Major Economies Forum on Energy and Climate (MEF), he reaffirmed Brazil's commitment to achieving zero deforestation by 2030 and announced a summit involving all eight Amazon countries in August 2023 to develop a unified regional agenda. This initiative could enhance cooperation between Europe and Latin America, especially amid global geopolitical tensions.

However, Castiglioni (2024) notes that Lula proposed a Mercosur trade deal with China following discussions on an agreement with the European Union on January 25, 2023. Meanwhile, Hoffmann, Sandrin, and Doukas (2024) highlight that the EU-Mercosur agreement remains unresolved. European Commission President Ursula von der Leyen sought to revive the agreement and address opposition from certain member states and civil society organizations by introducing the "EU-Mercosur sustainability instrument." This instrument was intended to enhance Latin American nations' environmental accountability. However, a leaked provisional text from March 2023 faced criticism from anti-Mercosur activists, who deemed its proposed measures insufficient. Several EU member states and civil society organizations shared concerns about the new instrument, with Austria being the first country to publish a critical annex pointing out deficiencies, particularly in food safety and agricultural imports, before the Council of the European Union for agriculture.

In recent years, scholars have debated the concept of "climate imperialism" or "climate colonialism," arguing that the wealthiest countries shift the hidden costs of energy transition onto the Global South (Hoffmann, Sandrin, & Doukas, 2024). Given previous challenges in ratifying agreements with Latin America—such as those involving Central America and the Andean Community—the primary challenge for the EU-Mercosur deal will be finding a compromise that preserves the core provisions of the provisional text. Meanwhile, Mercosur is actively exploring alternatives, with some members considering offering China a deal similar to the one under negotiation with the EU (Castiglioni, 2024).

While the United States and Brazil diverged on climate policy during their climate denialist administrations, China and Europe have engaged in a competition for leadership in green and renewable technologies, recognizing their growing importance for future competitiveness (Climate Advisers, 2023).

At a meeting in Santiago, Chile, representatives from Bolivia (Vice-Chancellor Carmen Almendra), Uruguay (Vice-Chancellor Ariel Bergamino), and Suriname (Ambassador Edgar Armaketo in Cuba) were present but did not sign the declaration. Suriname

joined PROSUR in 2022, the same year Chile withdrew from the organization.

The declaration established PROSUR's primary objective as:

Strengthening and prioritizing dialogue among participating countries to create a platform for coordination and cooperation, fostering greater regional integration and joint action in South America.

The Constitutive Treaty of the Union of South American Nations (UNASUR) was signed by 12 states (Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, and Venezuela) in Brasilia on May 23, 2008, and came into effect on March 11, 2011. UNASUR's formal institutional structure includes the Council of Heads of State and Government, the Council of Chancellors (Ministers of Foreign Affairs), the Council of Delegates, 12 Ministerial Councils, a Pro-Tempore Presidency, and a Secretary General. However, climate change and environmental issues were not prioritized within this structure, as there was no dedicated Sectorial Ministerial Council for these topics despite some transversal references. Piñeros et al. (2020) argue that the Initiative for the Integration of South American Regional Infrastructure (IIRSA) was absorbed into the South American Council for Infrastructure and Planning (COSIPLAN) in 2011. This initiative aimed to develop connectivity infrastructure throughout the Amazon region, utilizing its resources and water sources without adequate environmental considerations.

French oil major TotalEnergies (TTEF.PA) recently signed a final investment decision (FID) for a more than \$10 billion offshore oil and gas development in Suriname, the South American country's first. Located in Block 58 about 140 km offshore, the Gran Morgu field has estimated recoverable resources amounting to 700 million barrels of oil equivalent, adjacent to Exxon Mobil's (XOM.N), opens new tab massive 11 billion-barrel find in neighbouring oil hotspot Guyana.

This article is structured as follows:

1. Key Facts About Suriname
2. The Development of Ecological Awareness
3. Soil Remineralization through Rock Dust
4. A Model for Popular Participation and Cultural Change in Environmental Education

1- The most important facts about Suriname and Australia

Suriname, perched between the Atlantic Ocean and the Amazon rain forest, is a diverse, multi-ethnic nation where agriculture and fisheries are the primary sources of livelihood. Totness, the capital of the Coronie District, is home to around 1,717 people and is notably more developed than other local communities. Suriname, along with its vibrant capital, Paramaribo, is located in the lush northern region of South America. The national flag reflects the country's core values: red stands for progress, white symbolizes freedom and justice, and green represents the fertile land.

Carolina, situated about 50 km south of Paramaribo, is known for its scenic wooden bridge spanning the river. In Domburg, an artificial white sand beach along the Suriname River adds to the nation's natural allure. In the historic center of Paramaribo, the

Surinaams Museum at Fort Zeelandia offers a fascinating look into the country's rich history. Suriname's biodiversity and natural beauty, especially in areas like Saramacca, Coronie, and Nickerie, make it a truly remarkable place.

However, Paramaribo faces significant cleanliness challenges, earning the title of the dirtiest city in the country. If residents embraced the importance of maintaining a clean environment, the city could attract more tourists and investors. Recycling could also help reduce waste, benefiting both the community and the environment. To address this, an environmental awareness campaign led by the Paramaribo City Council or an NGO could make a real difference. By incorporating environmental topics into subjects like math, biology, chemistry, literature, civic education, and cultural studies, we can foster a generation that is more attuned to nature. This interdisciplinary approach would help cultivate a nature-conscious mindset among future generations.

The candidates are Chandrikapersad Santokhi (atual presidente), Geen, Gregory Rusland, Ronnie Brunswijk (atual vice-presidente), Paul Somohardjo e Ronny Asabina.

Chandrikapersad "Chan" Santokhi, the current president of Suriname, originally from Bihar, India, has devised a strategy that transfers the most intense corruption to Vice President Ronnie via an international drug cartel. This has resulted in a heavy crackdown on crime and private drug trafficking, while the government manipulates the public perception of an opposition between Chan and Ronnie, fostering the illusion of political rivalry. Simultaneously, the development of Suriname's oil and gas sector, coupled with energy collaborations with French Guiana, has led to an alarming increase in the deforestation of the Amazon.

A total of 451,000 hectares of primary Amazon forest were allocated for agricultural use—441,362 hectares for the Ministry of Agriculture and 9,958 hectares for foundations supported by private developers. This move is particularly troubling for Suriname, which has already faced an average annual deforestation rate of 6,560 hectares over the past two decades, amounting to 137,746 hectares since 2002.

Additionally, the arrival of Mennonite groups in Suriname has raised red flags, given their role in deforestation in Peru (7,032 hectares) and Bolivia (210,980 hectares). The Mennonites, originally from Russia, were invited to the Russian Empire by Empress Catherine the Great, and now their relocation to Suriname is contributing to environmental concerns.

Ramsodh (2018) discusses the political discontent in post-independence Suriname, noting five indicators that reflect citizens' dissatisfaction. However, these perspectives remain underexplored in the broader analysis, possibly because of the pervasive patron-client relationships in Suriname, which, as Ramsodh suggests, lead to a lack of intraparty democracy and intense loyalty to political leaders.

Hoefte (2014) found that, in comparison to other Caribbean nations, the 1930s in Suriname were relatively stable, owing to a strong reverence for the Dutch monarchy and fear of Marxist ideologies. This period also witnessed a boom in bauxite mining and political mobilization driven by growing union activity. The country's ethnic divisions led to the formation of a consociational alliance between ethnic political parties.

Asian Surinamese account for about 43% of Suriname's population, with 27% identifying as Indo-Surinamese, descendants of 19th-century indentured laborers from British India, and 14% as Javanese Surinamese, descendants of workers from the Dutch East Indies (now Indonesia). There was also a surge in immigration in the 1990s and early 21st century, with over 40,000 Chinese nationals recorded in Suriname by 2011.

Amid persistent clientelism, corruption, and mismanagement, Suriname's political system has drawn comparisons to the path followed by Hugo Chávez's Venezuela, where the executive bypasses parliament, weakens civic institutions, demands unconditional loyalty, and forms unconventional international alliances, particularly with China, Russia, and India (Hoefte, 2014).

2- The formation of ecological awareness.

Azimi, Rahman, and Nghiem (2023) explored the relationships between environmental degradation—such as CO₂ emissions and the consumption of non-renewable resources—and external factors like good governance. Good governance is a complex, multi-dimensional process that involves evaluating how well public institutions manage resources, carry out institutional functions, and protect human rights in a transparent, fair, and law-abiding manner, free from fraud and corruption (Gazley & Nicholson-Crotty, 2018). Their findings suggest that high-income countries benefit more significantly from good governance in mitigating environmental degradation. In contrast, the positive effects of good governance diminish in upper-middle-income countries and are even weaker in lower-middle-income and low-income countries.

On a global scale, Cost, Kaufmann, and Almeida (2025) found that the total production of electricity from renewable sources is more meaningful when considering all sources combined. Isolated data on individual renewable energy sources, such as solar and wind, show relatively small contributions, with only hydroelectric power being notably significant on a country-specific basis. The Global Energy Review (IEA 2021a, b) highlights China as the leading producer of renewable electricity, generating nearly 300 TWh, followed by the United States (96 TWh), the European Union (67 TWh), and India (32 TWh).

Some African countries, with high oil-based electricity production, low GDP, and limited access to education, also have relatively low outdoor air pollution and domestic material consumption. Yawson et al. (2024) examined the contextual and compositional factors that influence people's perceptions of environmental issues. Recent research has increasingly focused on how these factors affect perceptions of environmental changes, particularly in relation to climate change (Altea 2020; Kim & Ahn 2019; Clayton & Manning 2018).

Mohan (2025) investigated community-based adaptation strategies in 13 Caribbean countries, emphasizing the empowerment of local communities to address climate change impacts. These communities have undertaken livelihood response actions to adapt to the effects of climate change on activities such as coastal fisheries, agriculture, and tourism. Efforts to educate and raise awareness about climate change among decision-makers and the public have also been highlighted.

Studies have shown that men and older individuals tend to be more skeptical about climate change than women and younger people, respectively, in the UK (Whitmarsh 2011). In the United States,

young adults are generally more pro-environmental than older adults (Zaval et al., 2013). Other factors, such as values, political beliefs, and ideologies, have also been found to influence attitudes toward climate change (Bauman et al., 2018; Kahan 2015; Clayton & Manning 2018). Additionally, there has been an increase in the perceived importance of livelihood activities in response to environmental changes.

Among the communities and countries studied (Belize, Dominican Republic, and Suriname) those in Suriname were the most rural and Suriname is, perhaps, the least developed. Participants in these communities almost unanimously viewed livelihood activities that are natural-resource dependent, such as agriculture and fisheries, as extremely important (but less so for tourism) for community and household sustenance.

It's important to note that people tend to mimic the behavior of others, often neglecting to make the effort to properly dispose of waste like plastic, paper, and cardboard. Researcher Andrea Ceschi has highlighted that over population, deforestation, fishing, mining, and waste production play major roles in environmental changes, contributing to climate change and biodiversity loss.

High-income individuals would likely be more concerned about the environment than their low-income compatriots (Franzen and

Meyer 2010; Franzen and Vogl 2013a; Gelissen 2007). The results in the current study might contrast with the mainstream narrative in the literature on the influence of education and income on environmental perceptions. Perhaps, the difference arises from the fact that our study connected environmental change with livelihood activities

As a result, integrated waste management services are urgently needed in Suriname, particularly in Paramaribo, to address the consequences of increasing waste production. Experts like Adekunle Oke, Chantay Jennifer Pinas, and Oluyomi A. Osobajo from Robert Gordon University in the UK emphasize that the lack of government commitment, ineffective policies and regulations, insufficient investment in infrastructure, and the socioeconomic status of citizens contribute to the unsustainable waste management practices seen in Suriname today.

While there is agreement about the influence of socioeconomic factors on waste management behavior, the role of formal education in shaping waste management practices remains less clear. However, it is evident that formal education can help shape people's views on environmental issues. Raising awareness and providing education on waste management are key to changing behaviours.



An increasing body of evidence reveals that improving green spaces plays a crucial role in preventing or mitigating the severity of various chronic conditions, including arthritis (Metsios & Kitas, 2018), asthma (Hartley et al., 2020), cancer (Wu et al., 2024), dementia (Astell-Burt et al., 2020), diabetes (Liu et al., 2023), cardiovascular diseases (Wang et al., 2019), kidney disorders (Park et al., 2024), respiratory conditions (Zhang et al., 2022), mental health issues (Liu et al., 2024), and stroke (Paul et al., 2020). The collaboration between government, businesses, and NGOs—whether independently or together—can play a key role in raising environmental awareness, helping the public foster a deeper respect for their surroundings and their communities.

Sanna et al. (2024) report that in 2022, malaria cases worldwide were estimated at 249 million, with around 608,000 deaths (World Malaria Report 2023). While the global efforts to combat malaria reduced case numbers between 2000 and 2015, indicators of morbidity and mortality remained mostly unchanged from 2015 to 2020, even worsening after the Covid-19 pandemic.

Gunansyah, Ariadi, and TuBudirahayu (2024) found that environmental education programs in schools often fail to address the structural causes of environmental issues (Parker & Prabawa-Sear, 2019) and ignore justice-related concerns (Howard-Jones et al., 2021), reducing learning to technical solutions (Kohan, 2018). However, the AS program has shown positive results in enhancing students' environmental awareness and skills, including knowledge about air pollution, biodiversity, waste recycling, and energy conservation (Adela et al., 2018; Roswita, 2020; Kamil et al., 2020; Nurwidodo et al., 2020). Despite this, some studies suggest that AS programs place too much emphasis on uniform assessments (Purwaningsih, 2020), technical solutions (Warju et al., 2017), and are hindered by funding limitations (Roswita, 2020).

Environmental activities in schools are categorized into indoor and outdoor initiatives. For indoor activities, schools focus on “Perilaku Ramah Lingkungan Hidup” (PRLH), which aims to develop habitual behaviors that promote environmental preservation. These activities include waste management, tree planting, water and energy conservation, and maintaining

cleanliness. Integrated into the curriculum, extracurricular programs, and the “PBLHS movement,” these actions encourage students to participate in voluntary, collective environmental efforts. Schools aim to instill sustainability through environmentally conscious behavior.

Bio pores, which are cylindrical holes drilled into the ground to improve water absorption and reduce waterlogging during floods, have been especially helpful in flood-prone areas. However, it's critical that the process begins with a critical, dialogical presentation of information. Communication should foster mutual understanding, encouraging an open school climate that supports deliberation and is free from manipulation. Interactions between various stakeholders can facilitate the development of democratic, fair, and responsive planning practices. This critical review emphasizes the importance of revising the environmental education curriculum to promote educational and socio-ecological transformation.

Mendes et al. (2024) assessed environmental knowledge with a true/false questionnaire, awarding 3 points for correct answers and 0 for incorrect ones. Navarro and Gallardo (2003) highlight that universities are increasingly faced with the need to adapt to social and environmental demands. Higher Education Institutions (HEIs) must broaden their scope beyond technological innovation to include social and environmental innovations (Guerrero & Siegel, 2024; Menter, 2024). Klofsten et al. (2019) confirm that HEIs have a significant influence on social change and contribute to broader public benefits.

3. Soil Remineralization through Rock Dust

Rock dust, as a scientific concept, is closely tied to the field of agrogeology, as defined by Van Straaten (2007): "The branch of geology that deals with the materials and geological processes used to enhance the physical, chemical, and biological productivity of soils." The practice of rock dusting involves the application of rocks, typically silicate-based, and minerals to the soil, either as an alternative to or a complement for soluble fertilizers (Bergmann and Holland, 2014).

Beyond conventional fertilizers, soil nutritional deficiencies can also be addressed through the application of finely ground rocks such as phosphate rocks, plaster, and mafic or ultramafic rocks (Silva et al., 2012; Rafael et al., 2017). Recently, silicate rocks, especially those in the form of fine waste from the grinding process in quarries, have garnered increasing attention. However, the effectiveness of rock dust application on tropical soils largely depends on the specific chemical and mineralogical composition of the rocks, the soil's deficiencies, and the particular needs of the crops (Van Straaten, 2017).

One of the key advantages of rock dust is its slower nutrient release compared to chemical fertilizers, resulting in longer nutrient retention and providing a more sustainable solution for soil fertility (Theodoro & Leonardos, 2006). This slow release not only enhances agricultural production but also reduces the environmental impacts associated with chemical fertilizers, such as soil pollution and contamination of water resources (Silva et al., 2020).

An analysis of 48 crop trials by Swoboda, Döring, and Hamera (2022) demonstrated the potential of rock dust as an alternative source of potassium (K) for tropical soils, though its benefits for temperate soils remain inconclusive. Beneficial results were

particularly noted with mafic and ultramafic rocks, including basalts and rocks containing minerals like nepheline or glauconite.

One effective approach, as described by Viana, Caetano, and Pontes (2021), involves combining intermediate doses of basalt dust with higher amounts of cattle manure. While various techniques have been tested, the most successful approach was the use of rock dust in combination with other fertilizers.

Theodoro & Leonardos (2006) reported that farmers who conducted experiments with rock fertilizers acknowledged their distinct advantages over conventional chemical fertilizers. In line with these findings, Conceição et al. (2022) emphasized the multiple benefits of basalt powder, which provides both macro and micronutrients essential for plant growth while also helping to balance soil pH. Corn and bean plants grown in soils enriched with basalt dust produced up to five times more than those grown without it (Conceição et al., 2022).

In line with this, several studies have demonstrated that the application of basal rock powder (BRP) significantly enhances the chemical properties of the soil, particularly increasing the concentrations of calcium, magnesium, phosphorus, and potassium (Curtis et al., 2022; Lucese et al., 2021).

Among various silicate rock powders, basalt dust stands out. Basalts are igneous rocks with a mafic composition, making them rich in magnesium (Mg) and iron (Fe) and characterized by a basic pH. These rocks also serve as valuable sources of phosphorus (P), potassium (K), calcium (Ca), and several micronutrients, all essential for plant nutrition (Swoboda, Döring, and Hamera, 2022).

Swoboda, Döring, and Hamera (2020) found that increased erosion of PRS could also capture significant amounts of atmospheric CO₂, while the addition of silicon (Si) could enhance plants' resistance to both biotic and abiotic stress. However, it's crucial to consider a range of factors when applying rock dust, as outlined in Figure 1.

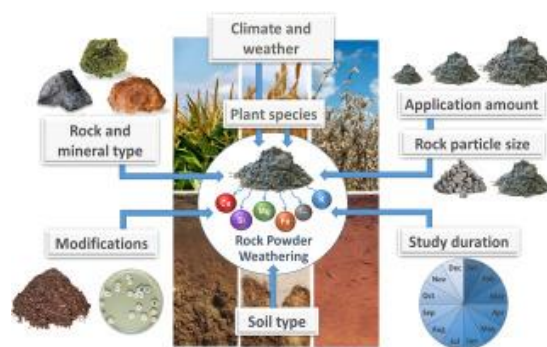


Figure 1- Important factors in the use of rock dust (Swoboda et al., 2023)

Bergmann and Holland (2014) explain that when considering the use of a rock as a soil remineralizer, these processes should necessarily be investigated through petrography, a method that allows the recognition of minerals, their texture, crystallization order, grain size and sanity status. And the materials added to the soil must comply with restrictive parameters, including the content of elements harmful or potentially harmful, such as some toxic heavy metals, and components that can promote the salinization of the soil, or add inert minerals that may compromise the soil structure. For example, sodium and quartz compounds.

Dos Santos et al. (2016) explain that while rock dust has an advantage (slower nutrient release), it is also a disadvantage, since it extends the process and requires a greater amount of material placed on the ground, which can damage certain sensitive crops. There are certain crops that require a high concentration of short-term nutrients, such as lettuce, so basalt is not advisable. Hanish et al. (2024) found that the application of up to 100 g of basalt dust, on both tested soils, did not promote an increase in lettuce and the yields observed without soluble fertilizer were almost four times less than those of the soluble fertilizer.

The best way to overcome the acidity of the soil is to trace it with calcium and/or magnesium carbonates (calcite and dolomite), where minerals react with hydrogen released by soil water, as well as with carbon dioxide and aluminum in the form of. Hydroxide, mitigating the toxicity of plants (Goulding 2016).

Guimarães et al. (2020) found that fertilized banana orchards exclusively with mineral sources had greater fruit productivity, compared to fertilization with organic-mining sources. However, the use of organic-minine sources provided lower acidification and greater availability of P and K on the ground. There was also evidence that an excessive increase in the concentration of K in the soil could induce a nutritional imbalance in plants and reduce productive potential. Therefore, more studies are needed on banana fertilization management strategies, focused on improving nutritional balance.

Therefore, it is important to carefully consider the overvaluation of rock dust as fertilizer in Brazil, as suggested by the investigation of Viana, Caetano and Pontes (2021). They emphasize that the use of rock dust in Brazilian agriculture has great potential, but it is not yet explored and requires the development of more studies and research, mainly evaluating the agronomic effectiveness of rock dust associated with animal waste (Viana et al., 2021).

Organicospro (2018) explains that a well-known type of underground rock is limestone, which is rich in calcium carbonate (calcite limestone) or a combination of calcium and magnesium carbonate (dolomitic limestone). On the other hand, basalt dust is rich in silicate minerals, providing silicon to the soil—an essential nutrient for plant health and productivity.

PUISEE et al. (2021) found that both basaltic rock dust (PRB) and limestone are associated with an increase in soil pH. However, PRB reacts much more slowly than limestone, which could be an advantage in the long term, offering gradual pH correction.

Batista (2016) applied basaltic rock dust to soil in varying amounts, both with and without added limestone. In samples that included limestone, there was a noticeable increase in potassium content compared to those without limestone. Additionally, the pH values were higher, although the pH correction was less pronounced in experiments that did not include lime.

Bamberg et al. (2023) discussed regional agrominerals—such as calcareous materials and monzogranite schists—used in combination with natural phosphate and organic nitrogen sources as an alternative to conventional fertilizers. Limestone lutite was found to be effective in releasing calcium (Ca) and magnesium (Mg) while correcting soil acidity, much like dolomitic marble. This led to marked improvements in corn and wheat productivity. The greatest benefit was observed when limestone was combined with 50% P from natural phosphate and 50% P from triple superphosphate. However, caution is necessary when applying

limestone slate with natural phosphates, as this combination can limit crop productivity due to the immobilization of phosphorus (P) (Bamberg et al., 2023).

Rock powders are increasingly being used in acidic soils to restore their pH. However, their acid-neutralizing capacity and reaction speed are highly variable, and proper evaluation protocols are lacking (Bauwhede et al., 2024).

It is important to note that soil reaction is a very slow process. Reapplying limestone to the surface is usually enough to correct soil acidity. Hammerschmitt et al. (2021) concluded that soybeans showed a modest but positive productivity response to lime reapplication, regardless of the method (increasing average productivity by 252 kg ha⁻¹ year⁻¹). In contrast, corn productivity was less affected by lime reapplication.

Further research is needed to better understand the combined use of silica rock dust with limestone, chemical fertilizers, or animal manure, especially in relation to the type of rock and its compatibility with specific soil types and crops.

4. A Model of Popular Participation and Cultural Change for the Construction of a New Paradigm in Environmental Education and Biodynamic Agriculture

According to Marconi and Lakatos (2003), the focus of field research is to study individuals, groups, communities, institutions, and other areas of society with the aim of understanding various aspects of society. Tripodi et al. (1975) classified field research into three main categories: quantitative-descriptive, exploratory, and experimental, each with its subdivisions.

This work is an exploratory study, an empirical investigation aimed at formulating a problem with three objectives: developing a hypothesis, enhancing the researcher's understanding of the environment, and identifying the phenomenon for more accurate future research, or to modify and clarify concepts (Marconi & Lakatos, 2003).

To construct the model, the action research methodology was applied. This approach integrates theory and practice, focusing on addressing significant organizational, community, and social issues in collaboration with those directly affected by them (Bradbury, 2015; Brydon-Miller & Coghlan, 2014). It emphasizes creating collaborative learning spaces and implementing and evaluating liberating actions, combining action and reflection in continuous knowledge-sharing cycles (Shani & Coghlan, 2019).

Cultural change through learning, collaboration, and comparison enhances environmental education by encouraging collective efforts focused on the common good. Figure 1 illustrates the model of popular participation and cultural change for developing a new environmental education paradigm—MPCEA.

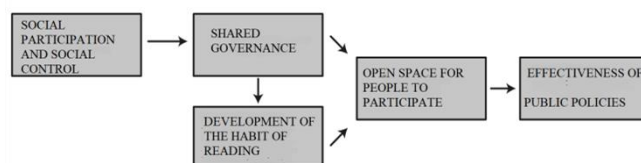


Figure 2: MPCEA model Source: Own elaboration, 2020.

It is evident that there is a clear relationship between the integration of environmental themes in children's learning and the

development of ecological awareness. This knowledge fosters the capacity for meaningful popular participation. Ecological citizens, such as indigenous individuals, are open and eager to learn from their community's experiences. This openness contributes to shared, quality governance that can create a new paradigm for environmental education in Brazil. The MPCEA model illustrates how a more holistic view of governance—built on both internal and external collaboration—can lead to a new awareness that prioritizes the public interest. This model serves as a catalyst for changes in corporate social responsibility, the exchange of knowledge, and the cultivation of wisdom.

Final Considerations

Environmental education should aim to create an educational process that fosters attitudes conducive to action, particularly in areas of disaster prevention and environmental preservation. It should foster greater integration with nature's stewards, including indigenous communities. For this to happen, it is essential to nurture individuals who are conscious, critical, reflective, ethical, competent, and proactive, aware of their role in transforming the world. Environmental education can promote the practice of citizenship by encouraging values that oppose selfishness and individualism, and instead support social transformation, ethics, social justice, and democracy—prioritizing the enhancement of life quality while maintaining environmental balance.

The active participation of the population is key to improving the effectiveness of environmental policies. The MPCEA model demonstrates that incorporating environmental education across a range of educational levels—from daycare to high school—has the potential to develop mature ecological citizens. These individuals, inspired by the example of indigenous community members who protect nature, can open themselves to enriching external experiences, allowing them to effectively contribute to government programs and projects. In this context, people become both beneficiaries and active agents of the development process, which should be inclusive and based on the free, active participation of everyone involved.

References

1. Ramsoedh, H. (2018). *Surinaams onbehegen: een sociale en politieke geschiedenis van Suriname, 1865-2015*. Uitgeverij Verloren.
2. Andrade, S. F., de Moura Pires, M., Ferraz, M. I. F., & Pinheiro, M. M. S. (2016). Índice de desenvolvimento como liberdade: uma proposta teórico-metodológica de análise. *Desenvolvimento em questão*, 14(34), 5-59.
3. Bradbury, H. (Ed.). (2015). *The Sage handbook of action research*. Sage.
4. Brydon-Miller, M., & Coghlan, D. (2014). The Sage encyclopedia of action research.
5. LIMA, M., MATOS, L., SILVA, Z., KNAACK, D., GIBIM, E.. (2018). Políticas públicas de educação ambiental para sociedades sustentáveis—uma análise no município de cacoal—RO. *Revista Educação Ambiental em ação*. Disponível em <http://www.revistaea.org/artigo.php?idartigo=2604>.
6. De Angelis, C. T. (2016). The impact of national culture and knowledge management on governmental intelligence. *Journal of Modelling in Management*, 11(1), 240-268. Disponível em <https://www.emeraldinsight.com/doi/abs/10.1108/JM2-08-2014-0069>.
7. De Angelis, C. T. (2013). A knowledge management and organizational intelligence model for public administration. *International Journal of Public Administration*, 36(11), 807-819. Disponível em <https://www.tandfonline.com/doi/abs/10.1080/01900692.2013.791315?journalCode=lpad20#.U5e1GPldVE>
8. Araujo, M. I. O., & Domingos, P. (2018). Perspectiva teórico-metodológica da educação ambiental na escola. *Pesquisa em Educação Ambiental*, 13(1), 182-195. Disponível em <http://www.periodicos.rc.biblioteca.unesp.br/index.php/pesquisa/article/view/13491>
9. Cabral, A. C., Junior, A. M., Cabral, C., Barbado, N., Frigo, E. P., Zanon, E., & de Azevedo, K. D. (2012). Estudo do conhecimento ambiental na escola municipal João da Costa Viana, Foz do Iguaçu-PR. *Revista Cultivando o Saber*, 5(4), 164-172.
10. de Carvalho, L. M., Festozo, M. B., de Andrade, D. F., & Thiemann, F. T. (2018). TRENDS IN RESEARCHERS' EDUCATION FOR ENVIRONMENTAL EDUCATION AND EDUCATION FOR SUSTAINABLE DEVELOPMENT. *Pesquisa em Educação Ambiental*, 13, 61-74.
11. De Carvalho, J. M. (2021). *Cidadania no Brasil: o longo caminho*. Civilização brasileira.
12. Chong, N. G., & González, D. G. (2017). La cultura política en el pueblo mapuche: el caso Wallmapuwen. *Revista mexicana de ciencias políticas y sociales*, 62(231), 137-165.
13. Cifuentes, S. (2023). Co-producing autonomy? Forest monitoring programs, territorial ontologies, and Indigenous politics in Amazonia. *Digital Geography and Society*, 5, 100068.
14. BARROS, G. (2017). S de. Educação Ambiental no Ensino Formal. *Educação Ambiental na Educação Básica: Entre a disciplinarização e a transversalidade da temática socioambiental [livro eletrônico]*. São Paulo (SP): PerSe, 69-74.
15. Dunlap, R. E., & Van Liere, K. D. (1978). The “new environmental paradigm”. *The journal of environmental education*, 9(4), 10-19.
16. Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of social issues*, 56(3), 425-442. Available at <https://spssi.onlinelibrary.wiley.com/doi/abs/10.1111/0022-4537.00176>
17. EUSEBIO, L. M. (2007). A. Educación ambiental: una necesidad en la formación del maestro Museo de Historia Natural. Área Educativa. Universidad Ricardo Palma. *The Biologist (Lima)*, 5(1).
18. Foladori, G. (2018). Educación ambiental en el capitalismo. *Pesquisa em Educação Ambiental*, 13(1), 48-57.

- Disponível em <http://www.periodicos.rc.biblioteca.unesp.br/index.php/pesquisa/article/view/13482>
19. FERRARI, S. WIGGERS, C. C., AFFONSO, A. K., A. (2019). Um estudo de caso em educação ambiental: traçando um paralelo entre a legislação e as práticas pedagógicas num colégio estadual do paran . *Revista Educa  o Ambiental em A  o*. V. 68. Dispon vel em <http://www.revistaea.org/artigo.php?idartigo=3680>
 20. Fraser, N. (2009). *Scales of justice: Reimagining political space in a globalizing world* (Vol. 31). Columbia university press.
 21. Gadotti, M. (2008). Educar para a sustentabilidade: uma contribui  o   d cada da educa  o para o desenvolvimento sustent vel.
 22. GALLARDO, L. M. G., BULEJE, J. C. M. (2011). Los Proyectos de Educaci  n Ambiental y su contribuci  n en la realidad peruana. *Investigaci  n Educativa* Vol. 15, N  28, 151–162.
 23. GARCIA, A. (2005). La educaci  n ambiental hacia el desarrollo sostenible. Recuperado de <http://www.monografias.com/trabajos25/educacion-ambiental/educacion-ambiental.shtml>
 24. Guerra, F. S. (2019). Ecopedagogia: contribui  es para pr ticas pedag gicas em educa  o ambiental. *Ambiente & Educa  o: Revista de Educa  o Ambiental*, 24(1), 235-256. Dispon vel em <https://periodicos.furg.br/ambeduc/article/view/802>
 25. Guimar es, M. (2020). *A forma  o de educadores ambientais*. Papirus Editora.
 26. Guti rrez P rez, J. (1995). La educaci  n ambiental: fundamentos te ricos, propuestas de transversalidad y orientaciones extracurriculares.
 27. Hanna, P., Langdon, E. J., & Vanclay, F. (2016). Indigenous rights, performativity and protest. *Land Use Policy*, 50, 490-506.
 28. Hoeft, R. (2013). *Suriname in the long twentieth century: domination, contestation, globalization*. Springer.
 29. Kroeber, A. L., & Kluckhohn, C. (1952). Culture: A critical review of concepts and definitions. *Papers. Peabody Museum of Archaeology & Ethnology, Harvard University*.
 30. Lamim-Guedes, V., & Monteiro, R. D. A. A. (2019). *Educa  o Ambiental na Educa  o B sica: entre a disciplinariza  o e a transversalidade da tem tica socioambiental*. Editora Na Raiz.
 31. Julio Vezub (2017). Controversy and Mapuche identity. Available at: <https://ipchsh.conicet.gov.ar/controversia-e-identidad-mapuche/>
 32. KINDEL, E. A. I., & LISBOA, C. P. (2012). Educa  o Ambiental: da teoria   pr tica. *Porto Alegre: Media  o*.
 33. Loureiro, C. F. B. (2004). Trajet ria e fundamentos da educa  o ambiental. In *Trajet ria e fundamentos da educa  o ambiental* (pp. 150-150).
 34. Martins, J. P. D. A., & Schnetzler, R. P. (2018). Forma  o de professores em educa  o ambiental cr tica centrada na investiga  o-a  o e na parceria colaborativa. *Ci ncia & Educa  o (Bauru)*, 24, 581-598. Dispon vel em <http://www.scielo.br/pdf/ciedu/v24n3/1516-7313-ciedu-24-03-0581.pdf>. 2018
 35. McCORMICK, J. (1992). Rumo ao para so: a hist ria do movimento ambientalista. *Rio de Janeiro: Relume-Dum r *, 213.
 36. MELLO, C. M., & Trivelato, S. L. F. (1999). Concep  es em educa  o ambiental. *II encontro nacional de pesquisa em educa  o em ci ncias*. Valinhos, SP: Instituto de F sica da Ufrgs.
 37. da Silva, M. A. M., & Ara jo, U. F. (2019). Aprendizagem-servi o e f runs comunit rios: articula  es para a constru  o da cidadania na educa  o ambiental. *Ambiente & Educa  o: Revista de Educa  o Ambiental*, 24(1), 257-273. Dispon vel em <https://periodicos.furg.br/ambeduc/article/view/8157>
 38. Neto, D. V. (2019). Um Debate n o Circular: por uma educa  o ambiental escolar interdisciplinar. *Educa  o Ambiental na Educa  o B sica*, 73.
 39. Lamim-Guedes, V., & Monteiro, R. D. A. A. (2019). *Educa  o Ambiental na Educa  o B sica: entre a disciplinariza  o e a transversalidade da tem tica socioambiental*. Editora Na Raiz.
 40. Nussbaum, M. C. (2009). Capabilities and constitutional law: 'Perception' against lofty formalism. *Journal of Human Development and Capabilities*, 10(3), 341-357.
 41. Nussbaum, M. C. (2011). *Creating capabilities: The human development approach*. Harvard University Press.
 42. Pipitone, M. A. P., & Nossllala, S. K. (2010). O Desenvolvimento da Educa  o Ambiental no Ensino fundamental: a participa  o dos programas oficiais. *REMEA-Revista Eletr nica do Mestrado em Educa  o Ambiental*, 25. Dispon vel em <https://periodicos.furg.br/remea/article/view/3375>.
 43. Rosa, C. D., & Profice, C. C. (2018). Que tipo de Educa  o Ambiental e para quem? Fatores associados a atitudes e comportamentos ambientais. *Revista Brasileira de Educa  o Ambiental (RevBEA)*, 13(1), 111-125.
 44. Roos, A., & Becker, E. L. S. (2012). Educa  o ambiental e sustentabilidade. *Revista Eletr nica em Gest o, Educa  o e Tecnologia Ambiental*, 857-866. Dispon vel em <https://periodicos.ufsm.br/reget/article/viewFile/4259/3035>
 45. Ruscheinsky, A. (2002). As rimas da ecopedagogia: uma perspectiva ambientalista. *Educa  o Ambiental: abordagens m ltiplas*. Porto Alegre: Artmed, 61-71.
 46. SANTOS, M. SOUZA LEITE, D. (2019). Intraempreendedorismo: a gest o inovadora como estrat gia para as organiza  es. (2019). *Revista de Educa  o Ambiental em A  o*. n.68. Dispon vel em <http://www.revistaea.org/artigo.php?idartigo=3744>
 47. Savino, L. (2016). Landscapes of contrast: The neo-extractivist state and indigenous peoples in "post-neoliberal"

- Argentina. *The Extractive Industries and Society*, 3(2), 404-415.
48. Segovia-Tzompa, S. M., Casimero, I., & Apagüño, M. G. (2024). When the past meets the future: Latin American Indigenous futures, transitional justice and global energy governance. *Futures*, 163, 103438.
49. Shani, A. B., & Coghlan, D. (2021). Action research in business and management: A reflective review. *Action research*, 19(3), 518-541.
50. Sorrentino, M. (2002). Desenvolvimento sustentável e participação: algumas reflexões em voz alta. *Educação ambiental: repensando o espaço da cidadania*. São Paulo: Cortez, 1, 15-21.
51. Oliveira, W. F. D. (2022). Índice de Desenvolvimento Humano e Pegada Ecológica: uma proposta de integração. *Revibec: revista de la Red Iberoamericana de Economía Ecológica*, 35(2), 0055-75.
52. TERRA, J. C. C.; GORDON, C. . Portais Corporativos: A Revolução na Gestão do Conhecimento. São Paulo: Editora Campus. 2002.
53. ANS, T. (1987). Introdução à pesquisa em ciências sociais: a pesquisa qualitativa em educação. *São Paulo: Atlas*.