Sustainable Climate Action Plan for Haiti, focusing on renewable energy

Julia Zhuo *

The Hewitt School, New York, The United States

* Corresponding author: jzhuo@hewittschool.org

Abstract. Haiti is one of the poorest and most vulnerable countries in the world that faces a multitude of challenges; its environmental conditions being one of its major concerns. There are many aspects regarding its climate problems, but the purpose of this report focuses on the adoption of pyrolysis, alternative materials for cookstoves in Haiti, as well as Haiti's potential in renewable energy. The methods suggested above are mainly to address the areas of waste management, deforestation, carbon emission, and energy generation. In addition to these methods, this research also briefly examines some of Costa Rica's sustainable climate policies and Haiti's opportunity to adopt such policies. The ultimate purpose of this report is to also raise awareness for developing countries, such as Haiti, hoping to gain public effort to help improve the environmental quality of these countries.

Keywords: pyrolysis, Haiti, sustainability.

1. Introduction

Haiti is a small nation located in the western part of Hispaniola in the Caribbean. Falling from the richest colony in the world to one of the poorest countries on the planet, Haiti currently faces many challenges, especially its vulnerability to the impact of climate change. Its vulnerability is particularly relevant when it comes to natural disasters: it suffered through various events such as storms, hurricanes, and earthquakes, killing thousands if not millions of lives of people and leaving them in urgent need of disaster relief [1].

Moreover, extensive deforestation, land erosion, significant emission in the atmosphere, rising temperature between 0.78° and 2.16° C in average annual temperature by 2050, and inconsistent rainfall patterns are some significant environmental problems that would also possibly damage the health conditions of Haitians and the economy of the island (since agriculture is one of the main sectors of its economic opportunity) [1].

Fortunately, there has been research dedicated to coming up with solutions to mitigate the severity and growth of climate problems. Methods such as using pyrolysis (which has been implemented in many countries, but has not been done widely in Haiti), replacing cookstove materials with environment-friendly materials, and investing in wind and solar energies, although not widely implemented in Haiti, have the potential to alleviate its climate situation. This research will examine various aspects of the method mentioned above in detail.

2. Pyrolysis

2.1. Haiti's Connections to the Use of Pyrolysis—Improper Waste Management

Waste management is a severe problem in Haiti, resulting from reasons such as improper waste disposal systems and a lack of government oversight. Unfortunately, the majority of waste ends up in illegal dumping sites, including rivers and drainage canals, without any prior treatment or establishment of proper disposal sites; in some cases, solid waste obstructs urban watercourses and contributes to the increase of waterborne illnesses in Haiti [2]. The harms of improper waste management are not limited to water pollution, and it affects the overall health of the people and the environment.

2.2. Essential Process of Pyrolysis

Pyrolysis is a technology that converts biomass into three principal outcomes: solid biochar, liquid bio-oil, and a gaseous blend known as syngas [3]. To be specific, biomass, which the majority of the Haitians rely on as their main energy production, is organic matter such as charcoal, wood, crop residues, etc. These materials are the fibrous structural parts of plants and are largely made of cellulose, hemicellulose, and lignin [3]. The essential idea of pyrolysis is that it involves the controlled heating of biomass in an environment devoid of oxygen. It is often conducted at temperatures equal to or exceeding 500°C, ensuring sufficient heat to break down the bio-polymers present [3].

Nonetheless, there are different types of pyrolysis as it produces three different kinds of outcomes (biochar, bio-oil, and syngas). Essentially, slowing down the heating rate, lowering the pyrolysis temperature, and extending the residence time will optimize the production of solid char (biochar); Increasing the heating rate, elevating the pyrolysis temperature, and shortening the residence time will maximize the generation of gas (syngas); Increasing the faster heating rate, maintaining the intermediate (pyrolysis) temperature, and shortening the residence time will boost liquid yield (bio-oil).

2.3. The Usage of Biochar, Bio-oil, and Syngas

The benefits of pyrolysis are not limited to waste management. The three substances from the pyrolysis process can benefit Haiti's environment, specifically around agriculture practices and renewable energy. Take biochar for instance: it fosters soil productivity. It consists mostly of carbon and resembles charcoal. "Biochar amendments not only elevate pH but also mitigate some of the heavy metal toxicity in soil, increasing plant growth in places that couldn't necessarily support it before [4]. In a place like Haiti, where its agriculture is a vital part of the island's economic opportunity, biochar can not only help improve crop yields but also the overall state of the island. Furthermore, biochar has shown usage in the quality of construction materials: "It helps regulating humidity, absorbs toxins, [and] fosters beneficial microbial life", improving the overall quality of the products [5].

Unlike biochar, the applications of bio-oil are more useful in terms of Haitians' cooking fuels. Data suggests that "[t]he annual consumption of wood products was estimated at 4 million metric tons (MT), of which about one-third is transformed into charcoal to meet the cooking fuel needs of urban consumers [6]. Haitians' reliance on fossil fuels worsens deforestation as well as pollution released in the air, impacting the overall health of Haitians. However, bio-oil can perhaps substitute for the use of fossil fuels as a cooking fuel, and "it can potentially generate a lower amount of greenhouse gas when compared to fossil fuels", reducing deforestation and serving as a relatively easy-access energy source, as shown in fig.1 [7].

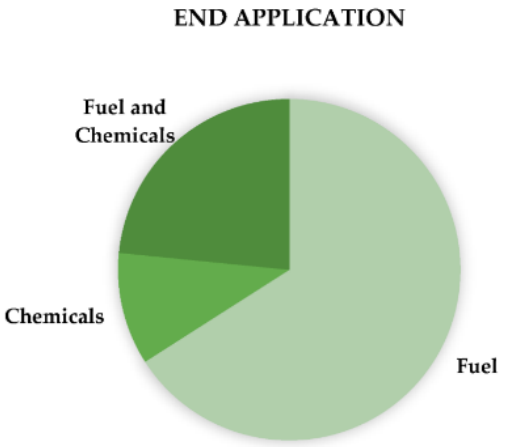

Figure 1. End application from bio-oil production research in the last 5 years [7]

Last but not least, the use of syngas can help with electricity generation. In Haiti, approximately "80 percent of electricity is produced from imported fossil fuels", once again showing Haitians' reliance on fossil fuels. Syngas contains hydrogen (H_2) and carbon monoxide (CO) and it is combusted in a gas turbine: the high-temperature, high-pressure gases drive a generator to produce electricity. It can serve as a renewable energy source just like the other two products while mitigating the environmental impacts associated with conventional energy sources (as mentioned above).

2.4. Areas of Improvements and Gaps of Biochar, Bio-oil, and Syngas

Although these three substances have much potential to help Haiti's environmental conditions, there are aspects of them that would require further research on a long-term scale. For biochar, "[t]he longevity of biochar in field conditions and the long-term impacts of biochar are two unknowns": Although it could potentially help with soil productivity, further investigation is required to delve into the mechanisms through which biochar influences the soil environment. This includes exploring alterations in soil physical and chemical characteristics and assessing biochar's effects on soil microbial communities (populations of microorganisms that live in the soil environment), particularly concerning possible changes in biogeochemical cycles. Similarly, there are also potential issues with syngas. Due to its flammable and toxic properties, if not monitored or conducted correctly, the uncontrolled release of syngas into the atmosphere could potentially pose a threat to both human safety and the environment. While these fuels show great promise as environmentally beneficial technologies, it is clear that further research and development are imperative to fully realize their potential and address any existing gaps or challenges.

3. Alternatives for Cookstove Material

3.1. Background of Cookstove Material Situation in Haiti

Energy poverty is another prominent problem in the everyday life of Haitians where they do not have access to modern (healthy) tools for cooking. In Haiti, the use of traditional cookstove materials, predominantly solid fuels like wood and charcoal, has deep-rooted implications for both public health and environmental well-being. Unfortunately, over 8,000 lives are lost annually in Haiti due to Household Air Pollution (HAP), which accounts for nearly 10% of all deaths, with mothers and children being the most vulnerable. HAP in Haiti is an acute concern as it exposes individuals to air pollution levels that can be 5 to 20 times higher than the World Health Organization's Air Quality Guideline. Prevalent reliance on solid fuels for cooking, coupled with the use of unimproved stoves, intensifies this issue. Ultimately, there needs to be innovative and sustainable solutions to address this challenge, improve public health outcomes, and reduce the environmental impact of cooking practices in Haiti: One of the possible approaches is to consider sustainable cooking materials.

3.2. Current State–Unimproved Cookstoves VS Improved Cookstoves

Unimproved cookstoves usually refer to traditional cooking devices that are less efficient but generate more emissions and pollution into the environment largely due to their burning fuels, which are mostly wood and charcoal. On the other hand, there are improved cookstoves or even advanced cookstoves that are designed with more efficient materials and technology to solve these issues. Although there has been much research dedicated to switching from unimproved to improved stoves, the real progress seems less exciting as there are some issues preventing this from happening (such as costs, local practices, etc.) [8].

3.3. Experimentation Analysis

An experiment comparing a group of 5 cookstoves was done by a team from Lawrence Berkeley National Lab (LBNL) and UC Berkeley [9]. It will focus on the primary results (time to boil, thermal

efficiency, specific fuel consumption, and parts of emissions) and the implication of the results on the cookstoves' performance.

When it comes to thermal efficiency, specific fuel consumption, and emission (number not provided in this report), all the improved stoves outperformed the traditional cookstove, but they sacrifice their boiling time in both scenarios, meaning they take longer to boil. To be more specific, Prakti had the best thermal efficiency and EcoRecho had the best specific fuel consumption. Although they are all relatively better stoves than the traditional one, (surprisingly), there is not much of a huge difference in terms of their percentages.

Some of the takeaways from this experiment are on selecting appropriate materials for improved cookstoves to enhance their overall performance. Materials with excellent heat conductivity, such as metals like stainless steel or cast iron, facilitate the even distribution of heat across cooking surfaces, reducing fuel consumption. Additionally, improving combustion efficiency is also essential for materials like firebricks or refractory materials can also maximize energy extraction from the fuel source.

Still, factors such as accessibility to the proper materials, higher costs of the stoves, and Haitians' willingness to accept using improved cookstoves, are problems that would need to be addressed. Fortunately, many grassroots organizations and international foundations such as The World Bank have been working on providing improved stoves to many developing countries across the world. With such transformation, the ultimate goals (deforestation, health conditions, etc.) would have the potential to head toward a more hopeful direction.

4. Haiti's Potential in Renewable Energy (Solar and Wind)

Renewable energies are essential for Haiti to improve its environmental situation. Currently, less than half of Haiti's population (about 45%) has access to electricity and the majority of Haitians rely on expensive, unsustainable, and inefficient energy generators powered by "dirty solutions", which not only burden the country's economy but also contribute to environmental degradation [10]. By investing in renewable energy sources such as solar and wind, Haiti can not only expand electricity access to more communities but also reduce its dependency on limited fossil fuels.

Haiti's tropical and relatively hot climate provides solar energy with more potential. In 2012, Haiti established the first privately operated pre-pay microgrid in Les Anglais, a town that did not have access to grid electricity before: Initially serving a modest 14 customers, the grid rapidly expanded to 54 customers, and quickly reached more than 400 by 2015. The establishment of microgrids kept developing in Haiti and it founded its second microgrid in 2019. The Tiburon grid is a 95kW solar smart grid that offers a clean, 24-hour, and affordable electricity for homes and businesses [10]. This transition led to significant energy cost reductions of up to 80% compared to previous energy sources.

In addition to solar energy, wind energy can also be a potential target. Although Haiti's wind speed can vary based on its geographic location and season, "Estimates suggest that wind power can deliver electricity at 30-50% of the cost of solar energy in windier areas. When considering a wind farm (where the turbine blades rotate to generate electricity) and a power plant (where it uses a variety of energy sources to generate electricity), the second option seems more idealistic for Haiti now. While wind farms might have less emission than power plants, they require relatively higher investment costs and rely on the state of the wind speed. Wind farms, on the other hand, have a more diverse energy source, and are better at providing consistent electricity generation, a problem that Haiti has struggled with. In fact, Haiti began launching a power plant in 2017: "It will also be the first to utilize a mixture of wind, solar and diesel energy will be able to produce up to 160 kilowatts of electricity.

5. Lining Up with Costa Rica

Costa Rica is considered as one of the most ideal countries for its effort to fight against climate change in the Caribbean. Although Costa Rica and Haiti do not share the exact same geographic

location or climate situation, Costa Rica could potentially be a target island that Haiti aims for. One of the climate approaches that Costa Rica is agroforestry, which involves integrating trees and other vegetation with crops and livestock on the same land. Deforestation is a significant problem in Haiti, but by adopting agroforestry practices similar to those in Costa Rica, Haitian farmers can plant trees alongside crops, which helps stabilize soil and reduce erosion. Some research suggests that agroforestry can "[generate] up to eight times more profit than a traditional row crop operation". This approach would help mitigate deforestation and increase agriculture productivity, facilitating Haiti's economic prosperity too.

Another area that Haiti could work on is its infrastructure. As mentioned earlier, Haitians constantly experience natural disasters and the significant physical damage to the island leaves the place constantly in the recovery process instead of investing in the development of the country. By restoring and protecting wetlands, and forests, these ecosystems serve as natural defenses, mitigating the effects of severe weather events such as storm surges, floods, and erosion, thereby lessening their impact. By the same principle, if Haiti constructed better infrastructure (roads, buildings, etc.), it would reduce disruptions and allow for a quicker recovery after disasters.

6. Conclusion

Although there are many pressing problems that exist in Haiti, there are various approaches to improve the situation. This report mainly focuses on the use of pyrolysis as a waste management system to reduce deforestation and increase energy production, but there are potential drawbacks to this method as more research needs to be done to examine more aspects of the three substances; it also examines the cookstove materials circumstance in Haiti, and it has much potential, but it would require public investment and effort; it also briefly elaborates on Haiti's opportunities in solar and wind energy to rely less on fossil fuels and for a more efficient energy generation system; and this report concludes with lessons learned from Costa Rica's climate plan focusing on agroforestry and infrastructure. It is important to note that in order to help with Haiti's environmental conditions, more investment and research from the rest of the world are needed to fight climate change together.

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