Life cycle assessment of Ecuadorian cocoa biowaste

Degree programme: BSc in Industrial Engineering and Management Science
Specialisation: Supply Chain and Process Engineering
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Cocoa waste is often discarded in open fields, causing environmental and health risks while missing opportunities for extra income through by-product sales. This study assesses the environmental impacts of chocolate with cocoa waste disposed of in open fields, transformed into biochar, or transformed into spray-dried pulp used as a sugar replacement within the Swiss Ecuadorian cocoa value chain.

Introduction and objectives

Ecuador's economy relies heavily on agriculture, with cocoa as a key crop, covering 4% of total land use as of 2019. Switzerland is an important trading partner, importing about 143,233 tons of cocoa and cocoa products in 2023, primarily from Ghana (40%) and Ecuador (18%). Most cocoa in Ecuador is produced by small-scale farmers, with around 100,000 families involved, 99% of whom cultivate less than 10 hectares. This study is conducted within a BFH project exploring the valorisation of cocoa by-products in the Swiss Ecuadorian cocoa value chain. The aim is to compare the environmental impact of chocolate where…

A) …cocoa pod husks (CPH) are disposed in open field: Uncontrolled disposal of cocoa pod husks (i.e., the outer, hard layer of the cocoa fruit).

B) …CPH are transformed into biochar: A type of charcoal made by burning biomass in a controlled process, used as a fertilizer.

C) …cocoa pulp/juice is transformed into spray-dried pulp used as a sugar replacement.

Research Design

A midpoint Life Cycle Assessment (LCA) was conducted according to ISO 14040/14044 standards, measuring impacts in 18 categories defined by the ReCiPE 2016 Midpoint (H) method . Inputs (materials and energy) and outputs (waste) are primarily estimated based on existing literature, mostly comparable LCA studies found through online research.

The functional unit is 1 kg of dark chocolate from CCN51 cocoa cultivated in Ecuador and manufactured in Switzerland (cradle to gate).

Results

Figure 1 displays the global warming potential of the respective chocolate variants. Biochar shows the greatest potential to improve environmental impact compared to open field disposal. In terms of global warming, but also across most other categories. A downside is its high impacts on fine particulate matter (figure 2) and ozone formation compared to the other two options due to the emissions from biochar production. The pulp/juice scenario is not suitable to reduce the environmental impact of the open field disposal, as the benefits of avoided sugar production do not outweigh the emissions from production and transport of the spray-dried pulp. It shows, however, social benefits through additional income from selling pulp.

Implications and recommendations

Adopting biochar in the Ecuadorian cocoa industry can significantly reduce environmental impact. Future research should focus on finding the best way farmers can produce and apply biochar while also profiting financially from this investment. The simultaneous valorisation of biochar and pulp/juice combines environmental benefits from biochar with social benefits from selling pulp. For Swiss industries, valorising cocoa waste also creates new market opportunities.

Melanie Xenia Boillat

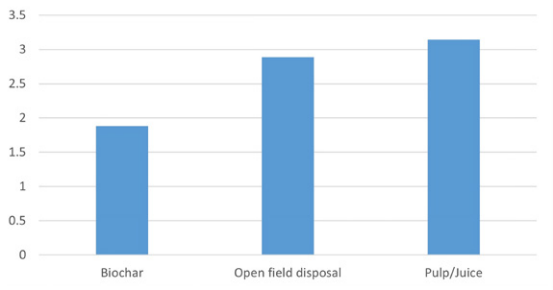

Figure 1: Global warming impact in CO2 eq for the three options

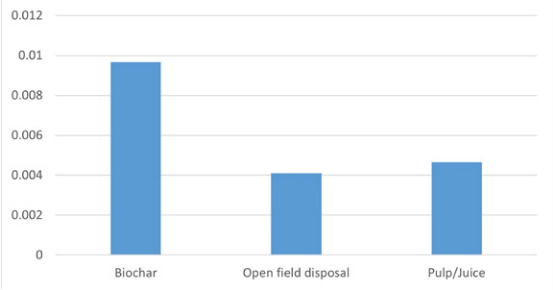

Figure 2: Fine particulate matter formation in kg PM2.5 eq for the three options