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CIRCULAR ECONOMY BUSINESS CASE STUDIES IN SOUTHEAST ASIA

Binh Minh Cooperative (Vietnam)

Vietnam - Cư Suê village, Cư M'gar District, Đắk Lắk Province

Food & Beverage

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Converting agriculture waste into a clean energy source and biochar: Drying coffee using pyrolysis technology at Binh Minh Cooperative, Vietnam

Business Spotlight

The Vietnamese coffee sector is facing several environmental and economic challenges calling for concrete changes, including in the technology of coffee processing, in particular the drying of coffee cherries. Pyrolysis technology was successfully introduced in Vietnam in 2016 to convert agricultural waste (rice and coffee husks) into thermal energy and biochar, which can contribute to:

- replacement of fossil fuels used in drying processes
- prevention of environmental pollution caused by accumulation of previously disposed agricultural waste
- new income and livelihood opportunities from the production of biochar
- higher yield provided by the application of biochar and long-term maintenance of soil fertility.

Binh Minh Cooperative – a group of ethnic minority farmers who grow and produce coffee in the Central Highlands of Vietnam – piloted pyrolysis and has achieved:

- increases in coffee annual income of USD 15,000 to USD 31,000 due to better quality coffee from mechanical drying
- increases in coffee yield using biochar by 5%–25%
- reduction of 2.45 tons of CO_2/per ton of biochar and 0.73 tons of CO_2/per ton of coffee husks
- reduction of USD 230 in chemical fertiliser use
- energy and maintenance/labour cost savings of USD 6,900.

Binh Minh Cooperative has thus demonstrated that pyrolysis technology is a circular economy solution that can improve the quality of agricultural products and improve soil fertility, while minimising CO_2 emissions and waste generation.

Keywords

Agriculture waste, Biochar, Pyrolysis technology, Coffee processing

Innovation

Innovative Manufacturing and End-of-Life management, Circular Economy impact in Resource circularity, Resource efficiency, Resource substitution

Analysis of Binh Minh Cooperative, Vietnam

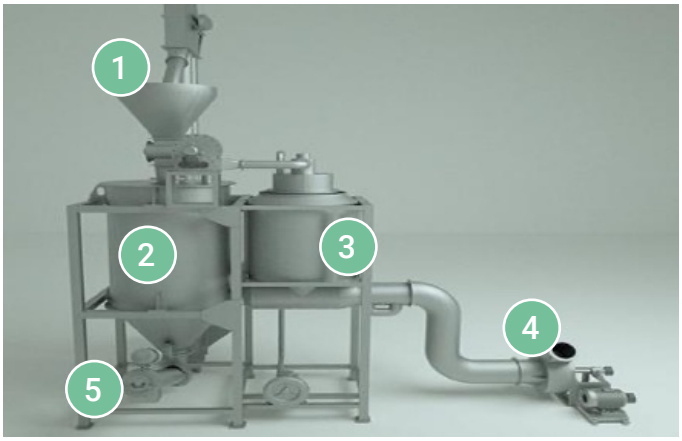
Context and baseline

Vietnam is the second largest coffee exporter in the world and was ranked first in coffee cultivation yield with 2.4 tons/hectare in the International Coffee Organization's Annual Review 2021/2022. Those yields were composed of Robusta, Arabica, Cherri, Moka, and Culi beans, which are among the most popular coffee beans produced in Vietnam. Vietnam's coffee industry in general and Binh Minh Cooperative in particular are currently facing environmental and economic challenges. From an environmental perspective, it rains in the Central highland of Vietnam more and more often during the coffee harvest season, causing mould in fresh coffee cherries after harvest, leading to a decrease in coffee quality while also reducing farmers' income. In addition, a large volume of unused biomass (such as coffee husks) accumulates and then decomposes uncontrolled, or is burned in primitive incinerators, causing smoke pollution, CH_4, CO_2, and dust soot and NOx. Meanwhile, farmers are also facing other problems such as the serious degradation of coffee farmlands. Coffee production depends heavily on chemical fertilisers, while climate change in the form of droughts or flooding is more and more frequently taking an adverse toll on coffee growing. Protecting soil quality has become a more serious issue. It was also estimated that farmers of Binh Minh Cooperative suffered a loss rate of up to 60% in coffee prices compared to world coffee prices caused by the unstable natural drying conditions in the 2016–2017 coffee season. This situation fuelled a change from traditional sun drying to artificial beds or tower driers using coffee husks as fuel. However, husk-fired driers are inefficient, and the smoke negatively affects the quality of the coffee beans and the health of the local people, and is a source of conflict with local communities and authorities.

In 2016, the United Nations Industrial Development Organization (UNIDO) with support from the Government of Switzerland identified pyrolysis as a promising technology to create value from agricultural waste in the form of heat for coffee drying, and biochar for the soil fertility management of coffee farms. This technology has been further customised and piloted in collaboration with the Binh Minh Cooperative.

Innovation

The circular innovation in this Cooperative is based on the customised application of pyrolysis in the coffee sector with the triple objective of the environmentally sound utilisation of waste biomass, improved coffee drying and improved soil fertility management. Pyrolysis is an established thermochemical decomposition process for biomass under oxygen-limiting conditions with the potential to produce different combinations of solid carbonaceous materials (biochar), bio-oils and synthesis gas. The Swiss project partners designed a pyrolysis system suited to the properties of coffee husks, and custom engineered the system for maximising the production of synthesis gas (also known as 'syngas'; clean fuel for coffee drying) and biochar (as soil improver for coffee plantations), each to about 50% of the calorific value of the rice husk, and at a scale typical for coffee plants in rural Vietnam. The pyrolysis plant design was transferred and locally manufactured by Viet Hien Mechanical Company Limited (www.viethien.vn) and successively piloted and validated at Binh Minh Cooperative. The system design and its application at Binh Minh Cooperative are displayed in Figures 1 and 2, below.



Pyrolysis technology. 1: Agricultural waste input. 2: Reactor: thermal decomposition of organic compounds and production of gas, and transferred to the burner. 3: Burner: biomass heat produced. 4: Heat transfer to drum dryer for drying coffee cherries. 5: Biochar output.

Pyrolysis system with drum dryer (left) manufactured by Viet Hien Co. and implemented at Binh Minh Cooperative

Circular economy impact

The utilisation of coffee husks in a pyrolysis system for coffee cherry drying at Binh Minh Cooperative has resulted in multiple environmental benefits compared to traditional sun drying, and contributes to each of three main circular economy strategies. First, pyrolysis converts the previously discarded coffee husk into valuable heat and biochar, which demonstrates resource circularity. Second, resource efficiency is achieved in coffee farming – as biochar reduces the consumption of fertilisers and maintains soil fertility – and in berry drying – because controlled drying with synthesis gas from pyrolysis improves drying and reduces off-specification of dried berries. Third, synthesis gas is a renewable fuel for coffee berry drying, illustrating resource substitution strategy.

The pyrolysis of coffee husks thus contributes to the mitigation of greenhouse gas (GHG) emissions. The use of biochar reduces GHG emissions by 2.45 tons GHG/ton biochar, while the production of biochar reduces GHG emissions by 0.73 tons GHG/ton of coffee husk.

Coffee husks (left) & Biochar (right)

High coffee quality made by Binh Minh Cooperative

Business and market impact

The positive economic effects of adopting pyrolysis technology in coffee cherry drying at Binh Minh Cooperative are remarkable in terms of cost, revenue and reduced loss.

The pyrolysis system caters to 36 ha of collective coffee plantations. Thanks to local manufacturing of the system, procurement and installation costs were low at USD 49,000, achieving a payback period of 2 years. Installing the system improved coffee sales due to better berry quality and lower loss rates, and better soil fertility has contributed nearly equally to the total economic benefit. As Binh Minh Cooperative reports, a 10%–20% price range increase has been observed from better quality coffee produced by mechanical drying, compared to coffee from sun-drying conditions with some rainy days, resulting in mouldy, lower quality coffee. Higher annual coffee income as a result of the better quality from mechanical drying ranges from USD 15,000–31,000. Using biochar has improved an additional coffee yield of between 5%–25%, the equivalent of USD 4,400–23,200. Binh Minh Cooperative uses a mix of biochar and chemical fertiliser based on availability and specific requirements. The company has been able to save USD 230 per year on fertiliser costs as a result of the application of the new process. In addition, Binh Minh Cooperative is significantly reducing annual energy costs of USD 900 as well as maintenance and labour costs of USD 6000.

Stakeholders

The new technology is providing benefits not only for Binh Minh Cooperative but for other stakeholders as well. The improvements in the drying process prevent the uncontrolled disposal and/or burning of coffee husks, reducing smoke and other emissions that would otherwise adversely affect farmers, laborers, and the community. The improvements in berry drying benefit other supply chain actors as well, including packhouses workers and exporters who are better able to meet current market requirements, thereby attracting better prices for their coffee and profitability for the coffee value chain.

The operation of the pyrolysis equipment requires trained personnel. The system must be loaded with sufficient input material, and the biochar produced must be correctly processed. The adoption of pyrolysis technology at Binh Minh cooperative has created a new job for one skilled technician who runs the system with a higher salary compared to unskilled workers engaged in traditional sun drying.

Implementation

The beneficial adoption of pyrolysis for coffee berry drying at Binh Minh Cooperative Vietnam was made possible by significant upstream enabling technology customisation and development, which combined Swiss and Vietnamese expertise, namely Vietnam National Cleaner Production Centre,

Viet Hien Mechanical Manufacturing Company (Vietnam), Sofies SA (Switzerland) and Ökozentrum (Switzerland), coordinated by UNIDO with funding from the Government of Switzerland. This enabled Binh Minh Cooperative to overcome the barriers that are commonly encountered by enterprises in Vietnam in developing and implementing circular economy solutions, specifically:

- lack of information and technical guidance for adopting novel technology applications supporting the circular economy
- high investment costs for circular economy and absence of specific risk mitigation and or financing incentives for circular economy
- lack of success stories in Vietnam that demonstrate the benefits of transitions to CE to encourage industries to apply CE policies and practices in their operations.
- The journey of Binh Minh Cooperative in implementing circular economy is continuing and expanding. To reduce the operating costs, Binh Minh is looking at the potential use of biochar and other high-value produce such as durian to increase yield, thus income.

Takeaways

- Pyrolysis technology is showing good potential to achieve a circular economy in agriculture and agro-processing to simultaneously improve the quality of agricultural products and improve soil fertility, while minimising uncontrolled waste disposal and CO_2 emissions. The support from the external technology partners was crucial for customising the pyrolysis technology to coffee waste and the operating context and scale of the Binh Minh Cooperative, and indeed for the acceptance of the technology itself.
- Trust-building communication within the cooperative and among its stakeholders on the circular economy was critical for the successful deployment of pyrolysis and may generally require more policy effort and action.
- Understanding the features and constraints of small and medium-sized enterprises in adopting new technology is vital and needs more attention at the policy, research, and practical levels.

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