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Review Article

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Demonstrating Farmer Interest in the Distributed Production of Biochar: Warm Heart Foundation in Mae Chaem

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ABSTRACT

Research and behavior change efforts have largely passed over the role of developing world small farmers in the fight against climate change, smog in the megacities, and "haze" or smoke pollution. Either their role has been missed or underestimated, or the problem of enlisting them in stopping burning overestimated. Research by the Warm Heart Foundation, however, demonstrates that by burning just 25 percent of their crop wastes annually, small farmers add as much eCO_2 to the atmosphere as the United Kingdom [1]. It also shows that given small financial incentives, small farmers will convert crop waste to biochar, preventing the emission of eCO_2, smog precursors, and particulates, and sequestering millions of tons of CO_2 annually. This research has huge implications for slowing climate change, improving public health and reducing poverty among the world's poorest: very small, rural farmers.

December 2016 to March 2017, the Warm Heart Foundation field-tested farmers' willingness to make biochar from corn crop waste in Mae Chaem District, Chiang Mai Province, North Thailand. The project demonstrates that with a small financial incentive and a market farmers will produce biochar in volume; without both, they will not. The results show that using homemade technology farmers can easily produce enough biochar for their own needs from a tiny portion of available biomass. If provided a small financial incentive to convert additional biomass into biochar and a market for it, they will do so enthusiastically; without them, the biomass will burn, contributing to climate change, degrading public health and wasting a valuable agricultural resource.

Background

Mae Chaem District, Chiang Mai Province, North Thailand produces 95,000 tons of corn crop waste annually. All 95,000 tons burn, conservatively producing 102,000 tons of eCO_2 and 595 tons of PM2.5 [2]. Twenty-five percent of Mae Chaem's corn is raised in Mae Na Chon Sub-district and twenty-two percent in adjoining Mae Suek Sub-district. Because Mae Chaem is isolated from a dynamic market by a tortuous road over the highest mountain in Thailand, no market exists for any of the three corn waste products, stalk, cob or husk, none of which have significant local uses.

Figure 1: Smoke from a Typical Cornfield Burn

Smoke from Mae Chaem contributes to the deadly "haze" that blankets North Thailand during the annual "burning season" in early spring. In May 2016, Warm Heart Foundation sought

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funding from the Canadian Fund for Local Initiatives (CFLI) to address the problem. Warm Heart had previously designed biochar making machines that even the poorest farmer can afford. It had also conducted tests in farmers' fields that demonstrated the superiority of biochar-based fertilizer to the synthetic fertilizers farmers use [3]. This project proposed to test whether farmers informed about the superiority of biochar-based fertilizer would select to make it themselves, reduce their costs, and increase their yields and incomes. In August 2016, CFLI approved the Warm Heart proposal to enlist ten farmers in each of five villages in Sub-district Mae Na Chon. Farmers would be trained to make biochar and biochar-based fertilizer. The project aimed to address the haze problem by tapping farmers' financial self-interest rather than by shifting the cost of climate change remediation to them by jailing or fining them for burning or requiring them to acquire the means to manage field waste on their own. The project proposed, instead, providing sustainable, market-based incentives to farmers that depend on neither government largesse nor foreign charity.

Figure 2: View of cornfields in Mae Na Chon

At the start of all projects, Warm Heart convenes a local Advisory Committee of village headmen, elders and respected farmers. When the Foundation presented this project to Mae Na Chon Committee members, they rejected it unanimously. First, they argued, in Mae Na Chon, extended family groups move from one member's farm to the next as a single group. The pressure to finish picking does not permit pausing to make biochar from the stalk, as Warm Heart proposed, and as soon as the picking concludes, someone fires the fields. Better, the Committee said, farmers should complete picking and then come to the village where corn is de-kernelled and make biochar from the piles of waste corncob. Corn stalk should wait until the project showed proof-of-concept. Second, they argued that farmers require little biochar compared to the amount of biomass and would stop making it when they had enough for their own farms. This would leave most of the biomass to be burned as before. Farmers, they observed, had other things to do and would not make biochar for no reason at the expense of completing other tasks. The Advisory Committee thus required Warm Heart to purchase every kilogram (kg) of biochar produced or they would not permit the project to go forward. "We are farmers," one said, "not salesmen." Third, the Committee required that Warm Heart remain during the project. It reported that the community had been sold many projects by outsiders, done its share in good faith, only to have the other parties disappear. Either Warm Heart stayed or they would not start. Warm Heart rented an office and kept staff on site.

In late October 2016, Warm Heart began transporting 250 200 l. drums to Mae Na Chon to make modified barrel TLUDs (Top Lit, Up Draft biochar pyrolyzers or "Jolly Rogers" (JRo's) for their inventor, John Rogers). Staff ran training sessions and local men made TLUDs. Warm Heart staff trained farmers to use them.

Figure 3: Project Manager Kwampirom (Aom) Suksri teaching farmers to make barrel TLUD

Figure 4: Farmers collect the dry whole cobs

How it works

In Mae Na Chon, as in much of Southeast Asia, feed corn is left to dry on the stalk. Farmers collect the dry whole cobs in bags that they pile on pickups. Once the trucks are full, a happy, overloaded procession heads to the village where the de-kernellers have set up. A de-kerneller has a truck-mounted machine that chews the kernels from the cobs and pours them out into a waiting pickup, while flinging the husk and cob in a high arch onto a huge, rapidly growing pile. The roar is deafening; the air is dense with dust. Pickups back up to the machine one after another and loaders hurl the corn into the machine as more pickups wait impatiently. De-kernelling done and his pickup full of corn, the farmer gets a colored card to take to the broker.

De-kerneller in action

De-kerneller's Card

The broker weighs the farmer's corn and records the weight against his name and the name of the de-kerneller. The broker deducts the de-kerneller's fee from the farmer's take at the end of the season. The scene continues uninterrupted from noon until the last truck is emptied, often long after dark.

The Experimental Set-Up: Day-to-Day Operations

Until the end of December, a single, elderly gentleman by the name of Loong Ai (Uncle Big Brother), made biochar. His family considered him too old to pick corn and he was bored. He arrived at 6:00 AM and filled ten barrels, lit them, waited an

hour, quenched and emptied them. He completed eight cycles a day, 100 kg of biochar per cycle, 800 kg per day, 1,600 Thai baht per day at the 2 baht per kg price Warm Heart set with the Advisory Committee. The Thai national minimum wage is 300 baht per day. In rural areas such as Mae Na Chon, few laborers earn better than 150 baht per day.

Figure 5: Loong Ai's barrels with the District Head taking photos in the background

At 1,600 baht a day, Loong Ai earned a fortune while his family picked corn (4 baht per kg at the broker's). In early January, when the rest of the villagers finished picking and began to make biochar, he bought a pair of water buffalo. He named them "Oon" and "Jai", Thai for "Warm" and "Heart".

Figure 6: Different families' stacks of bagged biochar with replacement barrels in foreground

As families finished picking in early January, they began to make biochar. The site started to hum at dawn. By 7:00 AM all 250 barrels were fired and people swarmed the corncob mountain filling bags with cob for the next round. At 8:00, the entire scene disappeared in steam as families quenched 250 barrels. The area became a swamp dotted with piles of biochar.

Grandmothers and kids slipped and slid carrying bags of cob for the next loads. It might have been hell, except there were no flames or smoke, just laughter and joking. Mountains of bagged biochar grew around the site, each belonging to a family. At meal times, families built cook fires around the perimeter and shared food – and white whiskey – freely. At night, faces lit by camp fires ringed the site in a great circle and purple flames from the TLUDs roared up into a sky so black that the Milky Way seemed to dim the other stars.

Figure 7: Yai (Granny) quenching the first burn of the morning

Figure 8: Bagging cob at the top of the corncob mountain. Bagged biochar in background.

Figure 9: Three generations: Granny, her daughters and two grandchildren with bagged cob and char on the ground.

Natural Experiment: Farmers Respond to Financial Incentives

As if to confirm Warm Heart's central propositions, the Thai government (GOT) arrived in February to create a natural experiment. Elsewhere in Mae Chaem, piles of corncob were already burning; in Mae Na Chon, farmers guarded theirs carefully. Waste had become cash. The GOT established its project in the adjoining Sub-District of Mae Suek, identical to the Warm Heart project in all but the important ways. It also provided residents with 250 barrel TLUDs and training. The program received heavy national, regional and local media coverage; local officials mobilized residents to attend. GOT officials arrived in the morning, delivered pre-constructed TLUDs, lectured residents about stopping crop waste burning

and biochar, conducted the training, and left. Residents were left on their own to sell any biochar they made.

Figure 10: The typical fate of corncob and husk piles.

The residents of Mae Suek made no biochar. As the Advisory Committee warned Warm Heart, the Mae Suek farmers had other things to do and were farmers, not salesmen. In interviews, farmers reported that the government had often told them to do this or that, but when they did, there was never a waiting supply chain. Others said they liked the idea of producing a new "crop" from their corn waste, but they had no idea how to sell it. They grow corn and sell it to corn brokers at home; they know nothing about biochar and no one at home will buy it. How are they supposed to go to Chiang Mai, three hours away, to find buyers for a product they do not understand?

In the end, Warm Heart staff bowed to pressure from the residents of Mae Suek and agreed to buy biochar from them – which they produced immediately.

Conclusions

Warm Heart's Mae Chaem project suggests three conclusions of interest to the climate change, global public health and poverty reduction communities. First, while developed countries struggle to reduce new carbon emissions, little progress has been made to remove existing carbon from the atmosphere. Biochar production is the cheapest, most readily available carbon negative technology, but to date no developed world business model has proved capable of scaling sufficiently to serve. At the same time, crop waste burning by small farmers in the developing world is a huge, unmanaged source of eCO2. (The biggest 25 developing countries annually produce 1.4 billion tons of crop waste from just corn, rice, soy and wheat. Burning 25 percent of this – 350,000,000 tons, a conservative estimate – releases 2,040,500 tons of methane and 1.088,500 tons of NOx with a combined eCO2 of 375,385,500 tons, slightly less than the annual emissions of the UK [4].

The Warm Heart findings challenge the long-held assumption that small farmers cannot be recruited to help stop climate change. Rather, the Mae Chaem experiment shows that small farmers will actively prevent crop waste burning by others in order to be able to produce biochar from it – if provided a small incentive to do so. The Warm Heart experiment suggests that programs aimed at small farmers in the developing world represent a very high value new approach to climate change, one that can remove large quantities of CO2 from the atmosphere annually and of eliminate the emission of large quantities of eCO2 [5].

Figure 11: All charring, no smoke, no methane, no NOx, nothing but CO and H2.

Second, the Warm Heart experiment has public health and poverty reduction implications because it suggests an effective way to reduce crop waste burning on a very large scale. Crop waste burning emits not only greenhouse gases, but also smog precursors and particulates. Burning the same 350,000,000 tons of crop waste produces 2,191,000 tons of PM2.5 and, in addition to methane and NOx (both smog precursors), 759,500 tons of ammonia, 224,000 tons of SOx and tons of NMOCs [6].

PM2.5 is the third biggest killer in the world today [7,8]. In June and July, the notorious Beijing smog is fifty percent smoke from crop fires; following every harvest season, burning wheat straw in the Punjab blankets New Delhi. A big reduction in smoke and smog would reduce morbidity and mortality, productivity losses and public health costs across the developing world. Adding biochar sales to small farmers' incomes could decrease rural poverty, would improve agricultural productivity from use of biochar in fields, and improved labor-productivity and lower healthcare costs from cleaner air.

Third, without a market for biochar, the crop waste to biochar project cannot work. From the start, this has been the problem that has doomed biochar in the developed world. Production costs are too high and few markets for biochar exist at the required prices, wonderful though it may be. The Warm Heart model, however, is not factory-based and production costs are minimal. Distributed production by small farmers reduces biochar cost to a point where a large potential developing world market awaits. Despite heavy government subsidization of synthetics, biochar-based fertilizers can be priced competitively [9]. Synthetics are import-, energy- and carbon-intensive, while biochar addresses many soil problems that synthetics cannot, and the local production and sale of biochar has broad-based, local economic stimulus effects. Equally important, the developing world suffers widespread heavy metal, industrial and agro-chemical contamination problems. Biochar constitutes one of the only low-cost means available to address such contamination.

On a cautionary note, the existence of potential demand is not the same as the existence of a market. As Warm Heart found, Mae Chaem farmers had no clue what biochar was, did not

care and had no idea what to do with it. But if Warm Heart wanted to buy it, they would make it. Without anyone there to buy biochar, the identical farmers of Mae Suek would not. The challenge in the "biochar solution," therefore, lies not in the field where millions of small farmers are ready and waiting to earn extra income making biochar and so slowing climate change and improving public health. The problem resides at the level of international organizations, INGOs, official development agencies and governments. Here is where the initial demand must arise mobilizing private markets. An OXFAM, an ASEAN or the government of China, any one of which could get the ball rolling by placing a single, multi-year order for biochar-based fertilizer from a dozen local fertilizer companies with the sole stipulation that all biochar had to be certifiably made from crop waste. This not a call for a gift; it is a call for public authorities to take public action – as they have so often before – to invest where the social welfare benefits are large, but the profits are too public or too small for private capital to be the first mover.

References

1. For emissions factors and calculations, see below. Note, when "eCO_2" is used in this paper, it refers to the impact of GHGs emitted in addition to CO and CO_2, both of which are treated as carbon neutral.
2. Akagi SK, Yokelson RJ, Wiedinmyer C, Alvarado MJ, Reid JS, et al. Emission factors for open and domestic biomass burning for use in atmospheric models. Atmospheric Chemistry and Physics. 2011. 11: 4039-4072.
3. Technical drawings, instructional materials (print and video), as well as field-test research designs, results and video interview with farmers. http://warmheartworldwide.org/biochar-research-environment/.
4. Wikipedia, 2015 figures, original source Netherlands Environmental Assessment Agency. 2017. https://en.wikipedia.org/wiki/Netherlands_Environmental_Assessment_Agency.
5. It also suggests why traditional government and NGO efforts to punish or educate farmers into giving up the only means they have for clearing cropland will continue to fail.
6. Guoliang CA, Zhang X, Sunling GO, Zheng F. Investigation on emission factors of particulate matter and gaseous pollutants from crop residue burning. Journal of Environmental Sciences. 2008. 20: 50-55.
7. Pope Iii CA, Burnett RT, Thun MJ, Calle EE, Krewski D, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. Jama. 2002. 287: 1132-1141.
8. Franklin M, Zeka A, Schwartz J. Association between PM2. 5 and all-cause and specific-cause mortality in 27 US communities. Journal of exposure science & environmental epidemiology. 2007. 17: 279-287.
9. In some instances, subsidies reflect honest, if misdirected, pro-agriculture policies. In most, it is a function of corruption; control of the agrochemicals industry and distribution are central to the power of many political and economic elites. Venality is not, however, amenable to rational argument nor is it confined to Thailand.