A RURAL REVITALIZATION SCHEME IN JAPAN UTILIZING BIOCHAR AND ECO-BRANDING: THE CARBON MINUS PROJECT, KAMEOKA CITY

Steven R. McGreevy[1*] and Akira Shibata[2]

[1] Kyoto University, Graduate School of Agriculture, Department of Natural Resource Economics, Kyoto City, Sakyouku, Kitashirakawa Oimachi 611-8502, Japan
[2] Ritsumeikan University, Regional Information Center, Kyoto City, Kita-ku, Kitamachi, 56-1 Toji-in 603-8577, Japan

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ABSTRACT

Like rural areas in many countries, Japanese rural society is experiencing decline in all spheres (depopulation, aging, lack of economic opportunity, and so on). Uncertainty in the future viability of agricultural livelihoods coupled with the collapse of the forestry sector has decreased the ecological resilience of the Japanese countryside, increasing overgrown forests, habitat and biodiversity loss, and costly wildlife damage to crops. As these rural crises are compounded by the climate crisis, the need for multifunctional solutions that increase the sustainability of rural society and environment as well as promote a shift to a low-carbon economy is great. Biochar implementation projects have the promise of such a solution, although it is still unclear what role they will play in the actual context of rural socio-ecological systems. Also, little is known about how biochar as a technology and food-related product will be accepted by the public. This study looks at these concerns by illustrating the cases of the "Carbon Minus Project," a multi-actor regional revitalization scheme, and COOL VEGE™, an eco-brand for produce cultivated with biochar in a rural area of Japan (Kameoka City, Kyoto Prefecture). In this paper, the socio-economic impacts of biochar as a soil amendment, eco-brand, and traditional technology are examined through the experiences of vegetable farmers (biochar producers), food retailers, and consumers. The potential economic, social, and ecological impact of the Kameoka project are evaluated and the need for biochar projects to drive multifunctional socio-economic structural change are stressed.

Keywords: biochar, rural revitalization, eco-branding, COOL VEGE™, socio-economic change

1. INTRODUCTION

In 2007, the world's urban population officially became larger than its rural population [1]. This event opens a new chapter in human history and unleashes a flurry of questions regarding the continued interchange of resources between urban and rural centers and the overall sustainability of cities and their rural counterparts. Rural areas traditionally have supplied critical resources (food, building materials, energy, etc.) and provided numerous ecosystem services that make life in urban areas possible. This unidirectional flow of natural and human capital has left many rural areas the world over either over-exploited and ecologically degraded or defunct and marginalized. Rural poverty is epidemic- of the 1.2 billion people living on less than a US dollar per day, three-fourths reside in rural areas [1]. These trends have only quickened with the growth of the global economy [2].

Ameliorative efforts through rural development in both developing and developed countries have had mixed results at best. In Japan, the promise of rural development has yet to come to fruition, and depopulation, aging, and economic marginalization remain problematic. From 1965 to 2005, rural farming households decreased 50% (from 5.66 million to 2.85 million) [3], while urban and suburban populations have doubled since 1950 [4]. Japan as a nation is aging (17.7% of its overall population are aged 65 or older [4]), but this trend is alarmingly evident in rural areas where 59% (1.85 million persons) of the population engaged in farming is aged 65 or older [3]. The small scale of Japanese agriculture[†] and cheap SE Asian lumber prices have undercut the Japanese agricultural and forestry industries in global markets [3]. Concurrently, the under-use and under-management of forested, mountainous lands has unbalanced the traditional ecological landscape, causing an increase in costly wildlife damage to crops,

[*] Corresponding author: Email: <srmcgreevy@gmail.com>

[†] Japanese farms averaged 1.8 ha per farm household in 2006 compared to 180.2 ha average in the US [3]. This average factors-in the agricultural lands in the northern-most island of Hokkaido, where large-scale, highly mechanized agriculture is practiced, meaning that the majority of farmers probably farm areas smaller than 1.8 ha.

the spread of disease within overly-mature tree plantations, declines in plant and animal biodiversity, and a countryside characterized by crops encircled with electric fences and surrounded by jungle-like overgrowth [5].

In addition to the need to address these issues, there exists a much larger, interconnected climate crisis that will affect not only rural areas but also the entire world. Global warming poses a threat to the viability of virtually every critical industry and will permanently reduce the quality of life worldwide [6]. In order to mitigate climate change, potential countermeasures are being explored, one of which is carbon sequestration in soils via biochar.[‡] Not only may biochar prove to be essential in the stabilization of the climate, it may also be a multifunctional development tool for rural areas struggling to survive.

Conservative estimates see biochar as having the potential to sequester carbon in soils at a rate of 1 Gt/yr near-indefinitely by 2050 [7]. What makes biochar so intriguing is that while sequestering carbon, it has the potential to address other economic and ecological problems that exist in the countryside. First, in areas with ready access to waste biomass from agriculture or the forestry industry, biochar can be produced and sold as a soil amendment. When used as a soil amendment, biochar can retain water in soils, increase soil nutrient retention, and enhance crop yields [8]. These types of activities support a diversified, robust agriculture and forestry sector and provide economic opportunities that are the first steps in revitalizing marginalized rural communities.

Further economic possibilities exist for biochar activities with the creation of emission-offset credits and the utilization of carbon markets. Conceivably, any amount of carbon sequestered in soil in the form of biochar can be measured, valued, and sold by rural actors on carbon markets for profit. If a mandatory cap and trade scheme were adopted worldwide, the price of carbon is expected to stabilize and, most likely, increase. This could be the start of a new industry and an influx of income-making opportunities to rural areas.

On the other hand, with the growth of new global carbon markets, rural biomass resources and the communities that maintain them will be retargeted as a source of capital to be utilized by urban centers. While, this new "revaluing" of rural natural resources could act as a much-needed opportunity for economic revival, others see the further destruction of rural communities, especially in developing countries, into monoculture "biochar plantations" competing on another "race-to-the-bottom" global marketplace [9,10]. Therefore, it is critically important that biochar projects are implemented in a way that is sensitive and sustainable for both rural society and environment as well as promoting a shift to a low-carbon economy [11]. This requires biochar projects to be better incorporated into the larger socio-economic, regional and structural framework in which they operate and act as a driver for the *whole society*, both urban and rural, toward a low carbon if not carbon-negative economy.

This study looks at one such scheme in rural Japan that focuses on rural revitalization through carbon sequestration with biochar. An explanation of the project, its goals, details of its activities, and future plans are presented followed by a deeper look into the cultivation of COOL VEGE™, an eco-brand used in the sale of vegetables produced with biochar. An examination of the actors engaged in biochar and COOL VEGE™ production, sales, and consumption is offered as well as an analysis of the potential economic, social and ecological impact of the project at large.

2. "CARBON MINUS PROJECT" AND RURAL REVITALIZATION IN KAMEOKA CITY, KYOTO PREFECTURE

The "Carbon Minus Project" is a pilot project started in Kameoka City, Kyoto Prefecture, Japan (see Figure 1) in 2008 through a partnership between Ritsumeikan University, the Kameoka City government and the Hozu farming cooperative. A variety of other actor groups are participating in the project, including local and prefectural government officials, citizens, corporations and places of business, farmers, environmental NPOs,[§] and schools with the overall plan of reducing Kameoka City's carbon emissions by promoting a low-carbon lifestyle. The goals of the Carbon Minus Project are to utilize unused local biomass as a source of biochar for carbon sequestration and soil conditioning, while at the same time promoting rural revitalization.

The movement to revitalize rural areas in Japan has been underway since the 1980s and rural

[‡] Biochar is defined simply as "the carbon-rich product obtained when biomass, such as wood, manure or leaves, is heated in a closed container with little or no available air" [8], but is commonly understood as charcoal that is used as an agricultural soil amendment. For more information on biochar see the International Biochar Initiative's homepage: www.biochar-international.org

[§] NPO stands for "non-profit organization," which in the Japanese context refers to something similar to a local non-governmental organization.

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municipalities and their population bases have struggled to maintain a sense of social and economic coherence in the face of massive depopulation to urban areas [12]. One of the overall economic goals of rural revitalization is the influx of capital from urban to rural areas. Rural revitalization projects are oftentimes supported and promoted by both local and national governments and have, until recent years, come in the form of efforts to increase tourism by revalorizing local natural and cultural assets such as hot springs, abundant nature, traditional delicacies, and religious landmarks. A boom in environmental awareness and concern over food safety has led to a rise in rural revitalization focused on eco-friendly lifestyles, renewable energy, organic agriculture, and local production of food for local consumption [13-15]. It is within this new ecologically-minded rural, social and economic context that the Carbon Minus Project has been positioned.

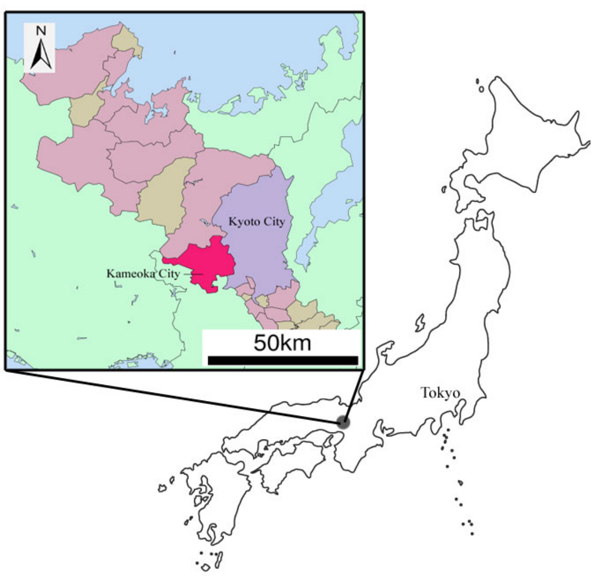

Figure 1 Map of Japan, Kyoto Prefecture, and Kameoka City

Kameoka City has a relatively large land area (224.90 km^2) much of which is forested, an extensive flatland agricultural area (2100 ha), a stable population (94,540 in 2008), and is located near major metropolitan areas (Kyoto City, Osaka City, and Kobe City), making it an ideal initial trial site. In this way, Kameoka City has many advantages over upland rural communities located deeper in the interior, where heavy depopulation, smaller agricultural land size, lack of economic opportunity, and distance to markets has hollowed out farming communities to a greater degree. Despite these geographic advantages, the agricultural industry in Kameoka City is in decline and various countermeasures have been enacted.

One of the ways farmers in Kameoka City have been able to remain economically viable is through the formation of farming cooperatives, where small, individual agricultural plots are conglomerated and managed as a whole. This allows farmers to "scale-up" production, incorporate more labor-saving machinery, form contracts with retailers, and takes away some of the labor demands for the vast elderly population still engaged in farming. The Kameoka City government has supported the formation of numerous cooperatives, one of which is the Hozu farming cooperative.

The Hozu farming cooperative was established in 2005 and comprises 150 ha of the 154 ha of agricultural land that make up the Hozu municipality. Currently, 338 of 352 farming households in the hamlet are taking part in the cooperative (This equates to 0.44 ha per household.). Agricultural products include rice, wheat, soybeans, vegetables and cut flowers. A single hectare of this cooperative is now engaged in COOL VEGE™ research and cultivation, a component of the larger Carbon Minus Project, and utilizes biochar in the agricultural production process.

A schematic of the Carbon Minus Project is presented in Figure 2. The scheme is envisioned in two parts: a biochar and agricultural production system and a consumption/transaction system. The biochar and agricultural production system is simple: local biomass (bamboo) is charred, applied to soils and, in the process, carbon is sequestered in the ground. These soils are then planted with vegetables that are sold under a unique eco-brand, COOL VEGE™, as they help to mitigate global warming. Two "products" are obtained and circulated in the consumption/transaction system: agricultural produce and emission-offset credits. The agricultural produce is sold to food retailers, who in turn sell them to consumers. CO_2-capped corporations purchase the emission-offset credits to comply with emission reduction commitments. Those corporations and industries that are found to be in compliance with emission reduction commitments are then eligible to participate in an eco-point system that rewards consumers for purchasing goods and services from eco-conscious companies and rewards industry for enacting green innovation and corporate responsibility.

Ultimately, this scheme increases monetary flow from urban areas and urban consumers to rural areas through the added value of eco-branding and climate mitigation benefits of carbon sequestration through using biochar.

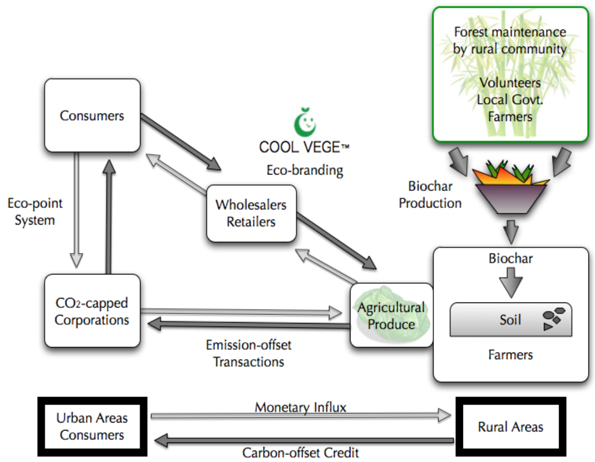

Figure 2 Carbon minus project scheme

3. COOL VEGE™ PRODUCTION

3.1 The Production Process in Detail

Overgrown stands of fast-growing bamboo have become a nuisance to rural Japanese, causing structural damage to homes and roads as well as being a general eyesore for communities everywhere. Once used regularly in the construction of farming and household tools and as a food source, bamboo stands were continuously managed and thinned. Bamboo makes an ideal feedstock for biochar production because it grows very quickly and is abundant throughout Japan. A local bamboo processing plant operating in Hozu is currently providing waste bamboo for use as the feedstock in biochar production for COOL VEGE™.

A stainless steel, sloped-sided ring, the name of which directly translates as "smokeless carbonizing kiln," is used to char bamboo in what can best be described as a "modified-pit method" for carbonization (see Figure 3). A Japanese ironworks company manufactures the kilns.[**] Biomass is set alight within the ring, left to carbonize, and doused with water when finished.

Once the biochar is produced, it is transported to a composting facility within the hamlet, mixed with manure and rice husks, and left to mature, producing slightly fermented compost.

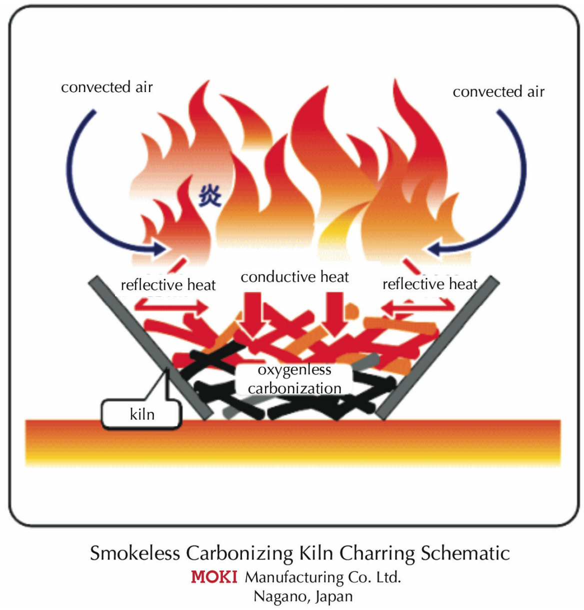

Figure 3 Schematic of smokeless carbonizing kiln

In the first season of cultivation, various compost mixtures were created with different amounts of biochar in each to facilitate plant growth effect and greenhouse gas (CO_2, CH_4, N_2O) emission experiments. The composts were then applied to agricultural fields and planted with vegetables. At present, a tentative minimum standard of 100 kg of carbon must be sequestered per 0.1 ha per year [††] to be eligible for COOL VEGE™ branding.[‡‡] This initial requirement ensures that the costs associated with applying biochar to agricultural lands are not exceedingly high, aiding in the diffusion of COOL VEGE™ and biochar production. Increasing this minimum standard would be ideal, but at this initial stage in the project, requirements have been set purposely low for the above-mentioned reasons. It should be noted that the amount of carbon sequestered is measured "per year," which encourages farmers to integrate biochar application into their usual agricultural practices, thus facilitating the creation of carbon sinks in a continuous manner.

COOL VEGE™ cabbages harvested in the winter of 2009 were sold to retailer Coop Kobe at a slightly elevated price (+3% to 5%). The cabbages were then processed into a variety of salads, marked

[**] MOKI Manufacturing Co. Ltd. based in Nagano Prefecture manufactures the kilns and sells them in four sizes: 18 L, 144 L, 505 L, 2100 L.

[††] This is the equivalent of 1 ton of carbon per ha. As the scale of Japanese agriculture is so small, 0.1 ha is a common measurement.

[‡‡] Farmers may apply more than the minimum and are encouraged to incorporate biochar into their soil management regime in a way that works best with their soil conditions.

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with the COOL VEGE™ brand, and sold to the public. Only cabbage and onions were cultivated during the first year. Chinese cabbage, cucumber, a local variety of onion, carrot, potato, and wheat in addition to cabbage and onion are planned on being planted this year.

3.2 Future Plans for COOL VEGE™

As COOL VEGE™ eco-branding effort has just begun, there is little to report in the way of definitive conclusions as to the efficacy of biochar production and plant growth effects associated with vegetable cultivation. The short-term plans (one to two years) for the project include:

- increase the number of local varieties of vegetables
- increase the area of COOL VEGE™ production (2.5 ha in 2010)
- expand sales of COOL VEGE™ products to other food retailers and supermarkets
- harvest bamboo from local forests directly by volunteers and local governmental employees, and
- use household organic wastes as an additional biochar feedstock

The long-term plans (three to six years) for the project include:

- establish a local governmental body to regulate biochar production and the soil amending protocol, testing, and approval of COOL VEGE™ branding applications by local farmers and farming cooperatives
- increase the area of COOL VEGE™ production to include all Hozu farming cooperative land (150 ha)
- spread COOL VEGE™ farming practices to other areas of Kameoka City
- consider purchasing or renting bamboo harvesting machinery
- begin COOL VEGE™ branding on other agricultural products grown in Kameoka City (rice, wheat, beef, flowers, etc.) by integrating biochar into their production systems, and
- expand sales of COOL VEGE™ products to other supermarkets and food networks

4. COOL VEGE™ ACTORS: FARMERS/ PRODUCERS, RETAILERS, AND CONSUMERS

The three primary actor groups involved in the COOL VEGE™ eco-branding effort-- farmers/producers, retailers, and consumers-- will be outlined below. Participant observation, informal interviews, and secondary data (academic presentations, newspaper articles and a marketing survey) were used in the collection of these responses.

4.1 Farmers/Producers

At present, only a small core of Hozu cooperative farmers (~10 individuals) are involved in the production of biochar and experimentation with crop cultivation. Among the core group, motivation is high and there is a sense of pride in their work as they've garnered attention from the media (newspapers) and their farming peers. This core group is active in promoting biochar use among other cooperative members and has given away bags of biochar to those interested in experimenting with it in their fields.

While the primary motivation for incorporating biochar production into crop cultivation is economic, a secondary motivation is to create a sense of identity and community in Hozu and Kameoka City at large. This identity stems less from a sentiment of environmental protection than from the re-embracing of local resources and traditional practices. The practice of treating fields with small pieces of charcoal is not a new idea—Japanese farmers have customarily amended soils with charred rice husks or wood scraps, called *kuntan* and *barazumi* respectively, for hundreds of years and they are well aware of the beneficial properties charcoal has on crop production and soil health [16] (see Figure 4). *Barazumi*, for example, was traditionally produced via the pit method. Farmers are excited about revitalizing Kameoka City through COOL VEGE™ because the tools and means are endogenous elements with which they are familiar: bamboo, charcoal making, and charcoal as a soil amendment.

Unkempt and neglected stands of bamboo have become an eyesore in Hozu, as they have all over Japan, and to have a way to use them effectively is seen as a universal positive. Charcoal has been an integral part of rural life in Japan for a very long time and charcoal making is something many farmers do annually as a hobby. To think that a key to revitalizing their agricultural community could be found in what they already are doing without the need to introduce some unfamiliar, external practice is thrilling for many farmers and their families in Hozu.

Farmers are still uncertain about the economic benefits of eco-branding their produce, but many are optimistic. Global warming and what to do about it has become a topic of interest in the national media and farmers feel positive about doing what they can to counter climate change.

Figure 4 Making *barazumi* in the 1950s (top); Making biochar in 2010 (bottom)

4.2 Retailers

During the winter of 2009, COOL VEGE™ cabbages from the Hozu farming cooperative were supplied to Coop Kobe, a supermarket chain. As the total volume of the cabbages was low, the products derived from them were sold out in under a week. Ultimately, this is an insignificant occurrence within the constant inflow and outflow of food products to a large supermarket chain. Retailers are concerned, first and foremost, with issues of cost and supply. Coop Kobe representatives were supportive of COOL VEGE™, but they pointed out that they have a standardized system of stocking produce year-round and need assurances as to when the produce can be delivered, at what volume, and at what price it can be sold.

Figure 5 COOL VEGE™ brand and in-store promotional display

During their time on the shelves, COOL VEGE™ products were promoted with signage and explanatory pamphlets (see Figure 5). Many ecologically-friendly agricultural products are sold at Coop Kobe, making it a good choice for retail as customers who frequent the Coop are generally supportive of environmentally-sensitive products.

Other supermarket chains will take part in selling COOL VEGE™ products during the next harvest season and some ecologically-minded restaurants in Kyoto City are interested in purchasing COOL VEGE™.

4.3 Consumers

The influence of consumers within the COOL VEGE™ scheme remains an unknown since it is unsure how they will react to yet another ecologically-friendly, healthy food option, especially in times of economic downturn. Education plays a critical role in promoting a lifestyle with a small carbon footprint and the Carbon Minus Project has incorporated a number of educational activities into its overall scheme.

In order to better gauge why consumers purchased COOL VEGE™, a survey was distributed and the answers were returned by mail [17]. 750 surveys were distributed and 78 were returned (10.4% return rate). The survey asked questions related to how they first learned about COOL VEGE™, how they would feel about paying extra for “climate-friendly food,” their awareness of environmental issues, and other basic demographic information. A summary of the survey results is presented below in Table 1.

Table 1 Summary of COOL VEGE™ marketing survey results (Source: [17])

Question	Predominant responses
First time you learned about COOL VEGE™	79.4% At the store, that day, via the promotion materials
Reason you purchased COOL VEGE™	68.9% It looked delicious 11.9% It looked environmentally-friendly 10.4% I want to stop global warming
Willingness to pay more for "global - warming countermeasure food"	14.5% Willing to pay more (31% of these respondents have children) 47.4% Willing to pay the same 38.2% Willing to pay less

While there is some indication of the existence of a group of ecologically-minded consumers, many of whom have children, the overall response from consumers to COOL VEGE™ has yet to be determined. One of the most important conclusions from the survey is that more education is needed to inform consumers about biochar and COOL VEGE™ production, the Carbon Minus Project and the need to live a low-carbon lifestyle.

Project representatives have taken this point seriously and have promoted a variety of educational activities: newspaper articles, signage, symposia, farming experience events, festivals, and children's education in schools. In particular, the effort to educate children and students on the science of the carbon cycle and the importance of reducing carbon emissions has been especially poignant. For younger children, a picture book and live-action presentation has been developed by a local NPO under the supervision of Ryukoku University and focusing on food and environmental education. In the book, children learn from "Dr. Cool Vegetables," who teaches them how biochar sequesters carbon and how children and their parents can reduce their carbon consumption (see Figure 6). School lunches throughout Kameoka City include COOL VEGE™ in the menu. Many students have participated in COOL VEGE™ cultivation through farming experience projects with help of the Hozu farming cooperation. Further involvement from students is envisioned for the future to assist in the thinning of stands of local bamboo and in biochar production.

Figure 6 Pages from the "Dr. Cool Vegetables" children's book

5. GAUGING POTENTIAL IMPACTS

Since the Carbon Minus Project has only just begun, it is difficult to predict exactly what kind of impact it will have on Kameoka City's local economy, society, and environment. Keeping in mind the project's overarching goals of revitalizing rural areas and promoting a shift to a low-carbon regional economy, we will summarize some initial findings and calculations in order to gauge the project's progression. The following sections are outlined in Table 2.

5.1 Economic Impacts

Of the target groups in the project's rural revitalization efforts, farming households are of primary interest. Although a full economic analysis of farmer livelihoods in Kameoka City is not available at this time, we can offer some arguments to better illustrate the potential economic impact from eco-branding, improvements in biochar production efficiency, and emission offset credit sales.

5.1.1 COOL VEGE™ Eco-branding and Yield Increases

The business of growing and selling vegetables in a small-scale agricultural setting is very difficult to generalize in economic terms. This is because production fluctuates annually in response to ever-changing growing conditions.

Table 2 Summary of plausible positive and negative economic, social, and environmental impacts of the Carbon Minus Project for Kameoka City

Economic	Social	Environmental
Positive: • "COOL VEGE™" eco-branding may decrease the amount of product loss and buffer annual fluctuations associated with growing conditions • "COOL VEGE™" sell at a slight premium price • Emission-offset credits may be sold for additional income for farming households and regional economy	Positive: • Foster sense of community through bamboo harvesting and biochar making • Unsightly over-grown bamboo forests thinned • Foster sense of identity through eco-branding • Environmentally-friendly and carbon-conscious behavior and lifestyle promoted	Positive: • Agricultural lands retain water and nutrients better • Chemical fertilizer use may decrease • Overgrown forests are thinned—can absorb more CO_2 • Habitat and food for wildlife is created in thinned forests (may reduce damage to crops)
Negative: • Cost to produce biochar high	Negative: • Some might resent eco-branding scheme • Confusion over biochar could lead to problems	Negative: • If biochar sequestration becomes profitable, there could be pressure to over-harvest biomass or over-apply biochar

The price farmers receive for vegetables, for example, is determined by the grade or quality of the produce, which is tied to these same growing conditions. Another factor influencing the economic well-being of farming households is a certain percentage of loss on fresh produce that goes unsold because of limited shelf-life and over-production necessary to meet food retailer's contractual obligations. This loss typically ranges from 20 to 40% of total annual production [18].

Farming households that are able to conglomerate into a cooperatively managed operation, as is the case in Kameoka's Hozu municipality, are able to buffer some of these income fluctuations through increasing the relative scale of production. However, even after scaling-up production through a cooperative, many operations rely on government subsidies to break even financially. The Hozu farming cooperative operated at a 12,224,219 yen ($122,242 US)[§§] loss in 2009, has operated at a loss every year since it was formed in 2005, and relies on national and prefectural agricultural subsidies to survive [19]. Any economic improvement in agricultural livelihoods through using biochar in production should be measured in terms of whether or not the cooperative can be profitable without government subsidies.

The COOL VEGE™ brand may give Kameoka City vegetable farmers the added value they need to sell more vegetables more quickly to both eliminate a percentage of loss and some of the instability associated with fluctuating growing conditions. A critical factor in how effective the branding of vegetables will be is how much consumers are willing to pay. The marketing survey performed revealed that the majority of consumers are not willing to pay high price premiums, but would pay for COOL VEGE™ products if prices were competitive with other agricultural produce. The 3% to 5% price premium COOL VEGE™ cabbages were sold for during the period of December 2009 to January 2010 is most likely to remain consistent. This means that a strategy that sells more vegetables at an average price is likely to be more effective than selling fewer vegetables at a higher price.

Experiments are underway to determine to what extent biochar application will affect vegetable yields, but have yet to be finalized. Significant increases in yield are not expected, however, since soils in Kameoka and Japan in general are nutrient rich, dark soils many of which have been maintained with organic and nutrient inputs for hundreds of years. Even if significant yield increases were experienced, the market for vegetables and produce is quite saturated, which would further support the need for an eco-brand to distinguish one's produce from a competitor.

5.1.2 Improving Charring and Economic Efficiency

Another element in determining the overall economic impact of the Carbon Minus Project is in improving the charring efficiency and reducing the cost of

[§§] All currency conversion from Japanese yen to US dollars is calculated at the exchange rate of 100 yen to the dollar for the sake of expediency. At the time of this writing, the exchange rate was 83 yen to the dollar. In recent years, this rate has ranged from 82 to 120 yen to the dollar.

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biochar production. A summary of charring efficacy experiments conducted over a total of five days in 2009 is presented in Table 3 [20]. The dry weight of bamboo feedstock charred over that period was 1,798 kg, producing 423.7 kg biochar dry weight. This translates to an average carbonization ratio of 23.53% dry weight. Obviously, a higher carbonization ratio is ideal and steps to increase the efficacy of the biochar production process are under consideration within the current modified-pit, batch production method.

An economic analysis of biochar production experiments conducted over the same five-day period in 2009 concluded that biochar was produced at 245 yen ($2.45 US) per kg dry weight[***] [20]. This price is less than the 443 yen ($4.43 US) per kg average cost estimate for biochar-like charcoal products sold on the market, but is considered high when an application of 100 kg C per 0.1 ha would require 119 kg of 84% carbon content biochar, which would cost 29,155 yen ($291 US) to produce. After consulting with representatives from the Hozu farming cooperative, 84 yen ($0.84 US) per kg dry weight, which would make the same application rate near 10,000 yen ($100 US) to produce, was deemed to be a financially accessible target price for Japanese farming households.

Table 3 Summary of charring efficacy experiments over a five-day period (adapted from [20])

Feedstock (bamboo)	(weight when charred)	3,391 kg
	(dry weight)	1,798 kg
Biochar produced	(doused with water)	1,318 kg
	(dry weight)	423.7 kg
Average moisture content of doused biochar		67.84%
Carbonized ratio	(wet/wet)	38.86%
	(dry/dry)	23.53%
Average biochar carbon content		84%

Biochar is only one of four co-products derived through the pyrolysis process, the other three being syngas, wood vinegar, and bio-oil. Utilization of syngas and bio-oil as a fuel for generating electricity, in the refinement of bio-gasoline, or in other energy services is another potential source of revenue in the biochar production process and usually involves increasing the scale of operation [21,22]. The decision to capture or ignore these other co-products for use involves two economic trade-offs: facility costs associated with production and the costs related to a sustainably harvested, stable feedstock supply. In many countries and rural areas, the economics of those trade-offs warrant a large scale-operation able to capture and utilize other pyrolysis co-products; in other circumstances this is not the case and a small-scale, diffused production system unable to handle these other co-products is warranted. The Carbon Minus Project falls into this latter category.

Within the envisioned scheme, farming households are both the consumers of biochar as well as the producers, which means that the production process itself needs to be simple, low cost, and involve low labor inputs. The current modified-pit method of production meets all of those requirements. The charring of agricultural wastes is a customary practice of rural Japanese farmers that suits biochar production via a simple method, which we believe lends to greater diffusion and adoption of biochar use. Unused bamboo feedstock is abundant, but is often located on sloping terrain or in remote areas that make extraction difficult and costly. This highlights the importance of highly-mobile, compact production systems that don't allow for easy capture and utilization of syngas and bio-oil.

5.1.3 Emission Offset Credits

A third economic factor that could influence farming household income as well as income on a regional level is through emission-offset credit sales. Three uncertainties remain as to the practicality of this stream of income: 1) the stability and viability of carbon markets; 2) the price of emission-offset credits; and 3) what percentage of emission-offset credit sale monies will actually reach farming households assuming that some system of aggregation is at work. Japan has yet to establish a national voluntary carbon market, but it is in the planning and testing process to achieve such a market. International markets exist, but standard protocol for carbon sequestration through biochar soil amendments has yet to be completed, and until that hurdle is overcome emission-offset credits cannot be sold. Assuming that protocols exist and buyers are available, the price at which the credits will be sold is unknown, as is the percentage of emission-offset credit sale monies that will be consumed in aggregation fees.

[***] The cost of production included elements such as rental of the carbonizer, employing two laborers, rental of a chainsaw, and the purchase of fuel and equipment. These costs came to a total of 103,633 yen ($1,036 US) for the five-day period. Feedstock was assumed to be free as feedstock extraction costs have not yet been determined.

Table 4 Estimated amount of CO_2 reduction in Kameoka City through biochar utilization (translated and adapted from [23])

• General land area of dry fields and rice paddies in Kameoka City: 2,100 ha • Annual application rate: 25 t per 1 ha (10,000m2 x 0.2m (cultivation depth) x5% (injection amount v/v) x 0.25 (specific gravity)) • Biochar carbon content: assume 80%
Amount of biochar to be applied: 52,500 t Amount of carbon sequestered: 42,000 t Amount of carbon dioxide equivalent: 154,000 t
Annual CO_2 emissions in Kameoka City: 458,000 t (in 2000) • Approximately one third of Kameoka City's CO_2 emissions can be offset
Maximum amount of funding available to Kameoka City via offset emission credits (estimation): 580,000,000 yen (about $5,800,000 US)[a]

[a](calculations are based on 3,757 yen per t CO_2 price for European Union Emission Trading Scheme emission credits on August 2008)

In a simulation estimating a best case scenario of a high application rate and high price for emissions credits, calculations indicate that if the entire area of Kameoka City's agricultural land (2,100 ha) was applied with 25 t of 80% carbon content biochar per ha, 154,000 t of CO_2 could be sequestered[†††] and 580,000,000 yen ($5.8 million US) worth of emission-offset credits could be sold for 3,757 yen ($37.57 US) per t CO_2 without aggregation fees [23] (see Table 4). This would offset a third of the carbon emissions for Kameoka City and be a source of revenue. This calculation only includes offsetting functions through carbon sequestration and does not take into account avoided emissions from conventional use of feedstock, reduction of emissions from soils, or reductions in the use of fertilizers and agricultural chemicals.

5.2 Social Impacts

As social and environmental impacts are tied to economic impacts, it is extremely difficult to make any concrete predictions. That said, a number of plausible outcomes could occur. Socially, the eco-branding effort alone creates a sense of identity within Kameoka City that has the potential to create synergy between various sectors of the economic and social community. Educational efforts to promote a lifestyle of reduced carbon consumption raises environmental awareness and can synergize into activities aimed at renewable energy use and nature conservation. Sales from emission-offset credits strengthen the possibility of pursuing agriculture or forestry-related livelihoods, which are an important cultural element to rural society, and protect natural resources.

Conceivably, there could be a sector of the population of Kameoka City that feels left out of or resents the COOL VEGE™ eco-brand and low-carbon movement. They may not fully understand how biochar works as a carbon sequestration agent or the emission-offset credit system. It is up to the local government and those in the Carbon Minus Project to redouble their efforts to better educate the public on the need for a shift to a low-carbon economy and what the average citizen can do to help.

5.3 Environmental Impacts

Through the application of biochar, agricultural land becomes better able to retain water and nutrients and the overall amount of chemical fertilizer needed for crop growth may be reduced. Overgrown bamboo forests will be thinned, making space for new growth to absorb more CO_2 from the atmosphere. If a diversified feedstock of biomass is utilized, other overgrown softwood forests may be thinned, creating habitat and food for wildlife that may reduce the amount of wildlife damage to agricultural crops.

The biggest danger to the environment is for the project to be too successful and the demand for biomass to increase substantially. This would put pressure on biochar producers to over-harvest biomass resources or for farmers to over-apply biochar to their fields. While this possibility exists, it is unlikely in Japan because access to and harvest of biomass, the majority of which is located in mountainous areas, is costly [24,25]. Efforts to stress the importance of harvesting within the bounds of the overall volume of biomass regenerated annually are needed to ensure a sustainable harvest without permanently damaging the natural environment.

6. CONCLUSION

The Carbon Minus Project attempts to revitalize rural areas through activities that shift Kameoka City to a low-carbon economy. Agricultural production is re-

[†††] These calculations do not take into account recalcitrant and labile carbon fractions.

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envisioned to incorporate new ecological services such as climate-mitigating carbon sequestration. Withering local communities are invigorated with a sense of identity and purpose, and neglected environmental resources are once again managed in a way that benefits humans and nature. The critical material common to all of these is biochar.

An area of particular interest to those engaged in biochar projects and research is "biochar systems," encompassing the process of biochar production from feedstock to end use within varied social, economic, and ecological contexts [26]. The general tendency for researchers and project managers is to focus more on the component parts of biochar systems (feedstock, processing, charring, end use) and less on the more often than not overlapping, interlinked, and slippery contextual frameworks within which biochar systems must operate. We would like to stress with this paper that in order for biochar systems to be truly sustainable, they must broaden their perimeter of concern to better integrate local and regional contexts. Indeed, biochar systems require careful positioning and sensitivity for synergy in order to achieve positive outcomes for all parties involved. In this way biochar projects can act not only as a means for carbon sequestration, but also as multifunctional drivers of sustainable rural socio-economic change.

Returning to the idea of linking up urban and rural areas to "share the wealth" extracted from the countryside and accumulated in cities, we see that shifting agricultural production to be organized around local sources of natural and cultural capital, as the Carbon Minus Project does, is one way of revaluing what has been marginalized from externalized extraction streams. One of the more recent attempts to illustrate the lopsided nature of wealth between urban and rural areas is the debate on ecosystem services remuneration [27,28]. In this debate, ecological services such as flood prevention, erosion control, air purification, water conservation, organic waste disposal, and climate mitigation are given economic value as a way to better understand the critical life-sustaining services functioning ecosystems provide to society. The monetary values are estimates, but even conservative calculations are staggering in their size. One estimate puts the monetary value of ecosystem services in Japan per year at $68.8 billion US [29]. Rural communities play an important role in maintaining the ecosystems and natural capital that exist in rural areas, but there is much difficulty in incorporating ecosystem services into the everyday marketplace that would allow for some form of remuneration.

However, through the added value derived from eco-branding and the spread of carbon markets that measure and value carbon monetarily, the situation may change at least for one ecological service: climate regulation. This active recognition of value is the means by which the urban-rural relationship can be better balanced and increase the viability of rural society and livelihoods. The Carbon Minus Project, while far from fully realized, may mark the beginning of a new phase in rural development in which ecological services provided by agriculture and the countryside are recognized and compensated for by their urban users.

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AES 100801