人と地球と、こころひとつ。
明和工業
MEIWA CO.,LTD.

# Waste to Black Gold: Brief Summary on Environmental Solutions By a Biomass Carbonization Technology of Japan

## 1. Environmental issues to be addressed

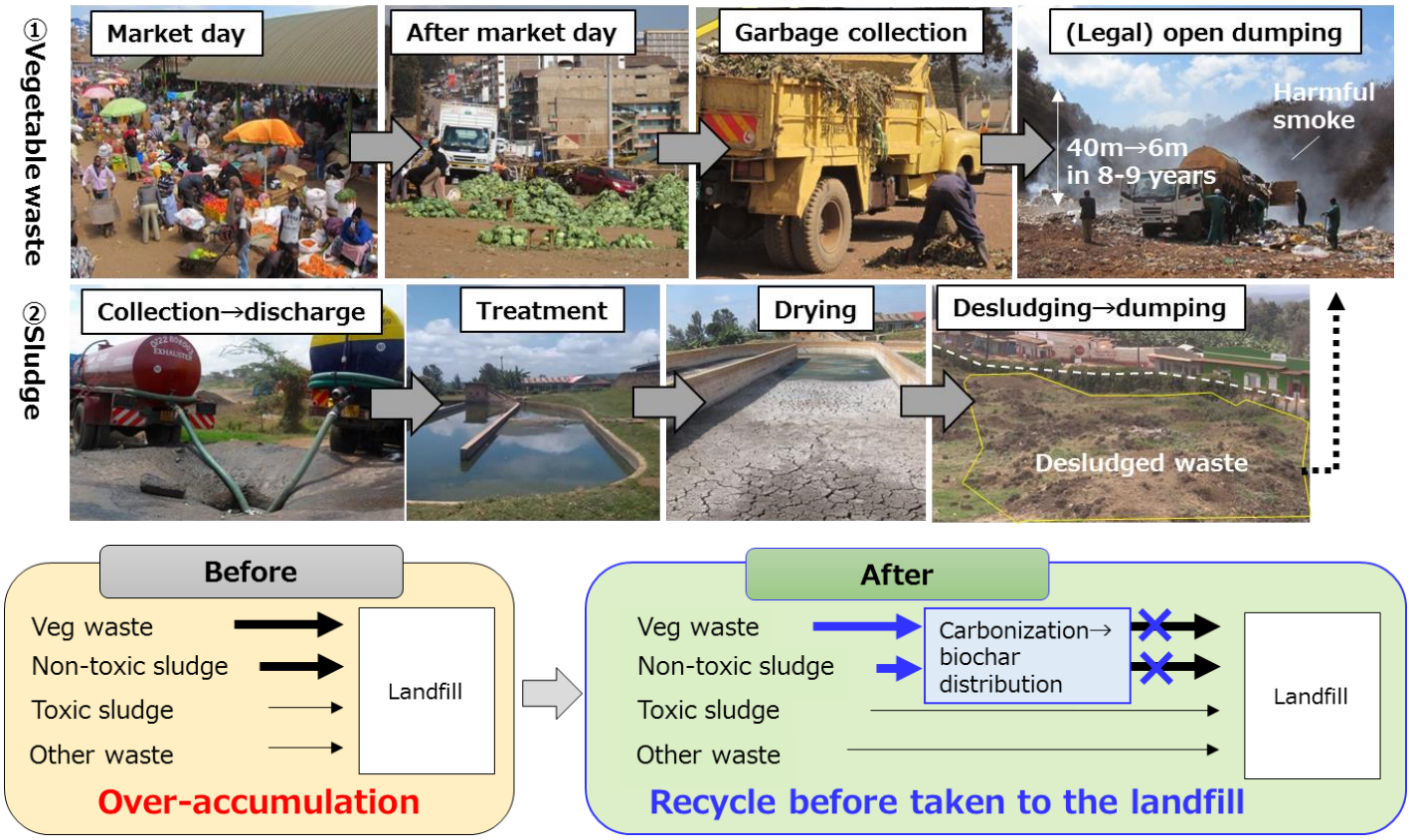
**A municipal truck dumping waste onto an already-full landfill in their daily operation in a non-capital city in Kenya**

Waste accumulation in municipal landfill

In most developing countries, municipal waste management has become a major problem as the result of population growth and rapid urbanization. In Nigeria for example, the most populous African country, major municipal landfills are almost filled up and there are no promising sites for constructing new ones due to urban sprawl. Many cities therefore keep over-relying on existing landfills while reducing waste volume by open burning with toxic smoke.

The solution

Mostly, municipal solid waste is comprised of organic waste such as vegetable waste and paper. For example, the organic fraction covered 70 – 80 % of municipal solid waste in Abuja in 2012, according to Abuja Environmental Protection Agency. As described in next chapters, Meiwa's biomass carbonization technology can convert organic waste into charcoal as natural fertilizer and soil conditioner. Meiwa therefore suggests targeting major organic waste source, such as (i) vegetable waste generated in city market or (ii) household sludge collected by trucks to sewerage treatment lagoon, before they are taken to landfills and mixed with non-organic waste and other contaminants. By carbonizing (i) and (ii) on site, the amount of waste arriving at landfills and illegal dumpsite is expected to decrease significantly.

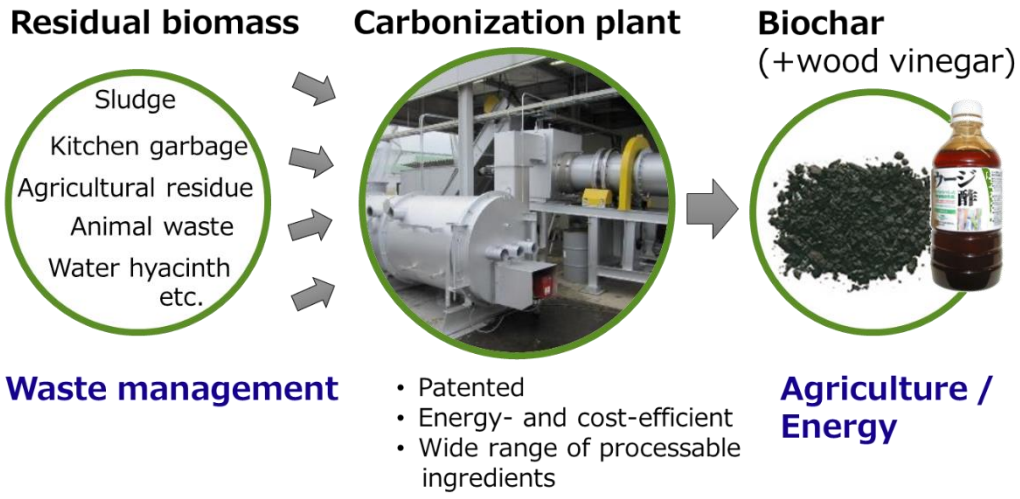



**A new solution to mitigating waste pressure with Meiwa's carbonization plant**

**2. Biomass carbonization technology**

Function of biomass carbonization plant

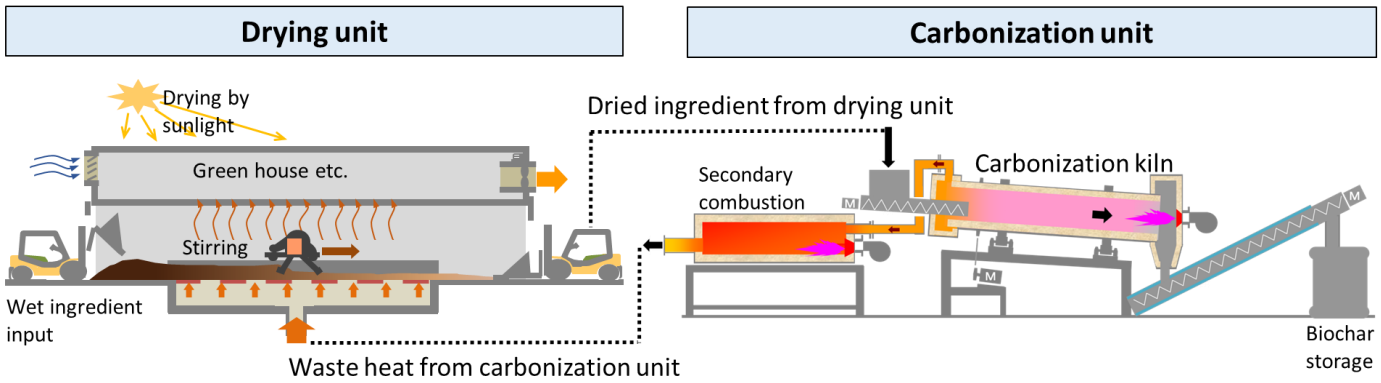
Simply put, biomass carbonization plant is a waste recycling plant that can convert almost anything organic into charcoal (called biochar). Processable ingredients include sludge, human waste, chicken manure, scrap wood, agricultural residue, food waste and water hyacinth among others. As biochar can work as a natural fertilizer, soil conditioner, fuel etc., Meiwa's biomass carbonization technology provides solutions to waste management and agriculture, environment and/or energy at the same time.




**Flowchart of biomass carbonization**

Mechanism and capacity

Meiwa's carbonization plant can efficiently process wet biomass by (1) the drying unit where wet ingredient is dried by the waste heat from the carbonization unit and (2) patented carbonization method. Although it depends on type and water content of raw material, climate and many other factors, typical drying and carbonization capacities range from 250kg/hour to 5ton/hour (drying sludge with approx. 80-85% of water content) and from 50kg/hour to 1ton/hour (carbonizing dried biomass) respectively. Biochar yield is 1/4 to 1/3 of dried biomass on weight basis.



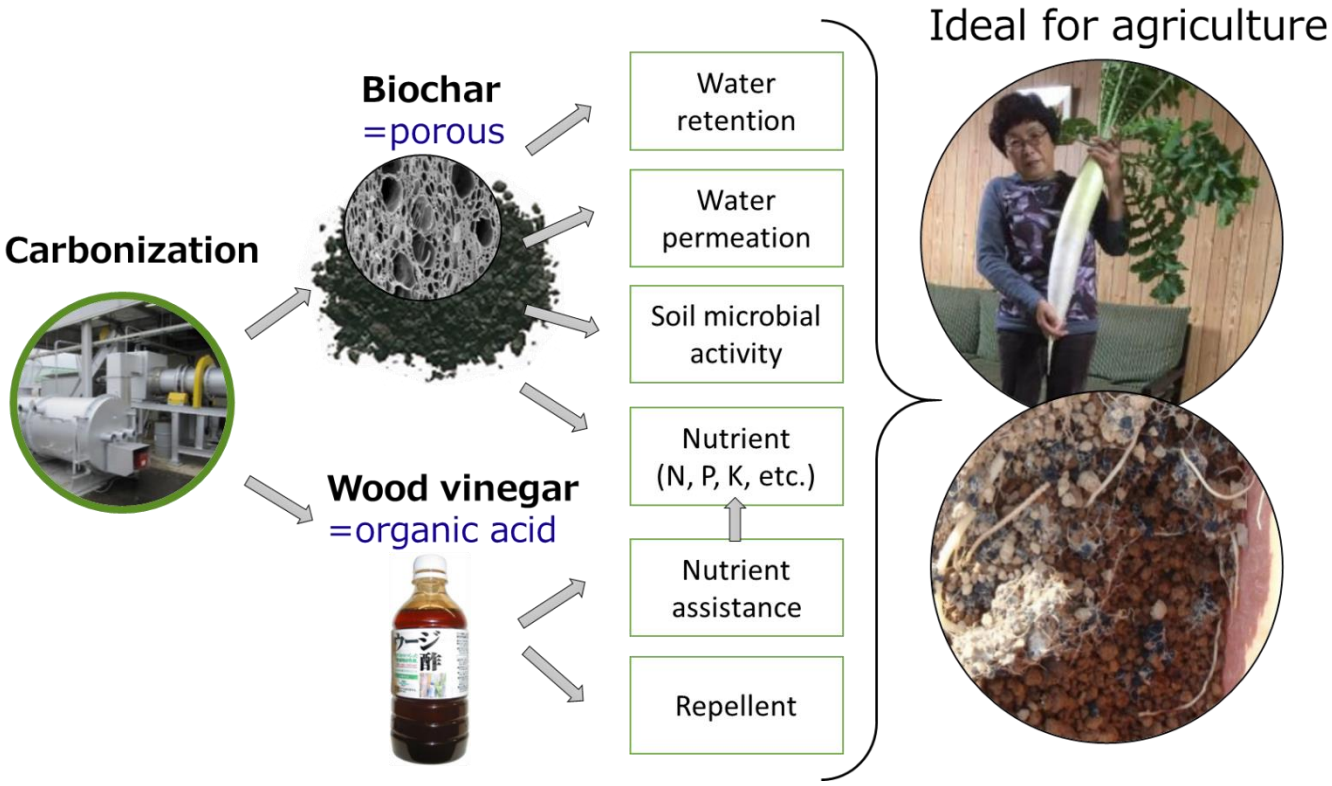



**Mechanism of biomass carbonization (wet ingredient, large scale)**

### 3. Biochar for agriculture

How carbonization works for sustainable agriculture

As shown in the following chart, biochar works as (1) soil conditioner and (2) natural fertilizer at the same time. Also, wood vinegar (optional byproduct) performs as fertilizer assistance and repellent for insect and animals. In sum, they are an ideal mean to practice closed-loop agriculture while reducing the amount of imported agricultural chemicals, which are often expensive for vast and/or land-locked countries due to long-distance transportation.




**Functions of biochar and wood vinegar for sustainable agriculture**

Study examples on crop yield

There are numerous agricultural studies on biochar conducted by research institutes and universities. Even though the effects of biochar amendment largely depend on different factors (climate, crop, raw material, carbonization process, soil, etc.), just like conventional fertilizers and composts, many researches have shown positive impacts. Some of them are summarized in the table below:

**Examples of effects of biochar amendment on crop yield**

| Biochar ingredient | Application rate | Type of experiment | Crop | Soil type | Results | Location | Reference |
|---|---|---|---|---|---|---|---|
| Bark of Acacia | 37 t/ha | Field | Maize | Acidic soil | +50% | Indonesia | Yamato et al., 2006 |
| Eucalyptus deglupta | 25 g/kg soil | Green house | Rice | Volcanic ash inccptisol | +294% | Colombia | Noguera et al., 2010 |
| Poultry litter | 10t/ha | Pot | Radish | Alfisol | +42% | Australia | Chan et al., 2008 |
| Rice husk | 4.13kg/m2 | Field | Rice | Anthraquic gleysols | Slightly decreased | Philippines | Haefele et al., 2011 |
| Rice husk | 4.13kg/m2 | Field | Rice | Humic nitisols | +16-35% | Philippines | Haefele et al., 2011 |
| Rice straw | 4.5t/ha | Pot | Rice | Gleyi-Stagnic Anthrosol | +5.8% | China | Zhao et al., 2014 |
| Wheat straw | 40t/ha | Field | Rice | Hydroagric Anthrosol | +22% | China | Zhang A et al., 2013 |

*Overall data source: Mubshar Hussain et al., 2016, Journal of Soils and Sediments*

Biochar for dryland agriculture

It has been well known that biochar is a good soil conditioner for water retention due to its high porosity. This is especially effective in Arid and Semi-Arid Land (ASAL) regions where water resource is quite scarce. Some field studies show approx. 10 – 25% of increase in water holding capacity of soils in Ethiopia and Australia. This means countries with a lot of drylands, such as Botswana, can now reconsider the area of arable lands as biochar enables agriculture to be practiced with less water consumption.

**4. Benefits in sum under an example scenario**

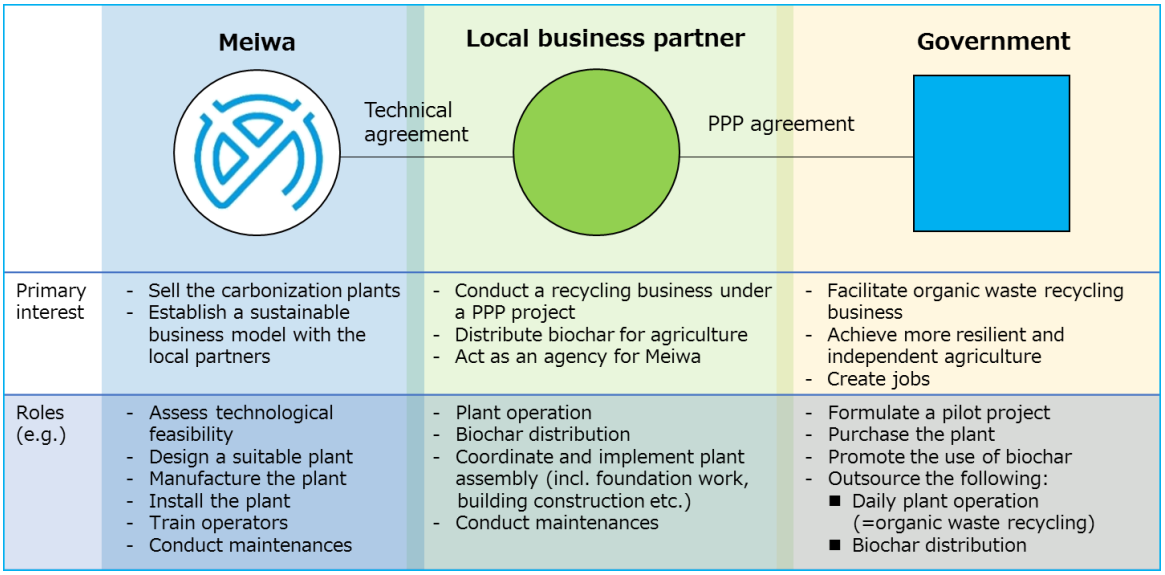
Assuming that a carbonization plant with the carbonization capacity of 1t/hour is used to carbonize sludge (with approx. 80-85% of water content) for 24hours for 6 days a week, expected benefits would include the followings.

- Waste to be taken to municipal landfill can be reduced up to about 30,000 ton/year.
- About 2,000 ton/year of biochar can be domestically produced as natural fertilizer / soil conditioner from organic waste.
- Return on investment (ROI) significantly depends on labor cost and selling price of biochar among many other factors. Meiwa strongly recommends to set the biochar selling price at the same price as that of chemical fertilizer or slightly higher than that price. In Kenya, for example, expected ROI can range from less than 2 years (assuming the price of biochar = chemical fertilizer price ≒ 0.6 USD/kg) to longer than 8 years (price of biochar ≒ 0.1 USD/kg as smokeless fuel). It is therefore good to consider an off-take contract for (1) biochar procurement for agriculture and (2) service fee for organic waste recycling by plant operation with the government, wastewater treatment facility, agricultural association, etc.
- Biochar production and distribution will create employment and new recycling / agriculture industry.
- Technology transfer will be achieved through local production and/or installment of the carbonization plant.

***Note: all the values above are strictly for referential purpose and significantly depend on each actual condition.***

**5. Business modalities**

Our primary interest as a for-profit company based in Japan is to sell the equipment, at least for now. To achieve long-lasting business and benefit on both sides, Meiwa considers the involvement of local private sector as a key. For example, the following chart illustrates the expected role of each party when developing a PPP (public-private partnership) project.




| | Meiwa | Local business partner | Government |
|---|---|---|---|
| Primary interest | - Sell the carbonization plants<br>- Establish a sustainable business model with the local partners | - Conduct a recycling business under a PPP project<br>- Distribute biochar for agriculture<br>- Act as an agency for Meiwa | - Facilitate organic waste recycling business<br>- Achieve more resilient and independent agriculture<br>- Create jobs |
| Roles (e.g.) | - Assess technological feasibility<br>- Design a suitable plant<br>- Manufacture the plant<br>- Install the plant<br>- Train operators<br>- Conduct maintenances | - Plant operation<br>- Biochar distribution<br>- Coordinate and implement plant assembly (incl. foundation work, building construction etc.)<br>- Conduct maintenances | - Formulate a pilot project<br>- Purchase the plant<br>- Promote the use of biochar<br>- Outsource the following:<br>■ Daily plant operation (=organic waste recycling)<br>■ Biochar distribution |

**An example of the expected roles for each party**

- Upon the purchase agreement, Meiwa will usually (1) conduct a site investigation to determine the most suitable design, (2) manufacture the plant parts, (3) ship them to the country, (4) come to the site again to supervise the plant assembly and installation in collaboration with local engineering company, (5) train a few local operators and (6) conduct a test operation and pass it over to the project owner.
- Meiwa is not always equipped with a particular advice on how to finance the initial investment. However following the outcome of TICAD VI, we generally recommend to contact the regional headquarters of Japan International Cooperation Agency (JICA), Japan External Trade Organization (JETRO) and Embassy of Japan for their advice. Depending on the project objectives, international development banks (e.g. African Development Bank (AfDB) and World Bank / International Finance Corporation) and international organizations (e.g. UNIDO, UNDP, UNEP, UN-HABITAT and other agencies) may be interested in formulating a project.
- When considering the introduction of a carbonization plant for the first time, Meiwa recommends a feasibility study to make sure the target material can be efficiently carbonized and biochar does not contain toxic components unsuitable for agricultural use or fuel use.

**6. Meiwa Co., Ltd.**

Meiwa Co., Ltd. is a technology-oriented Japanese company and one of the exhibitors at the Sixth Tokyo International Conference on African Development (TICAD VI) in Nairobi, Kenya in August 2016. It aims to achieve a sustainable world with its unique technologies co-developed with prominent research institutes and ministries ranging from Tokyo University to Ministry of Environment.

Year of incorporation: 1965
Number of employees: about 50
Location: Kanazawa, Ishikawa, Japan
Main business area: Environment / Waste / Agriculture / Renewable energy / Climate change
Main products: Biomass carbonization plants (to be discussed in detail here), effluent treatment systems, exhaust gas treatment systems, dust collectors, etc.
Recent R&D outcomes: Bio-oil plants, freeze concentration devices, methane fermentation system, etc.


**Meiwa's office and its technical laboratory**

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http://www.meiwa-ind.co.jp/en/

**Appendix: Contribution to the Sustainable Development Goals (SDGs)**

Because of the wide range of processable ingredients and biochar application, our biomass carbonization technology can assist developing countries to achieve various development goals. The following table illustrates selected examples of technology application to contribute to the Sustainable Development Goals (SDGs).

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<td>Reducing sanitation problem<br>In many developing countries, inadequate human waste management has been one of major causes for sanitation problem. For example in Kenya, human waste is collected from septic tanks and pit latrines at each household by exhauster service providers or municipalities. The human waste is transported to a certain site, but the treatment is often inadequate, causing pollution and sanitation problem in the surrounding water system. By recycling human waste by our carbonization plant at the drop-off point, less waterborne diseases will be expected.<br>  <br>Human waste directly discharged to the environment near a river in Kenya</td>
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<td>Reducing air pollution by cleaner energy<br>There are more and more health concerns arising from air pollution in developing countries. In Mongolia, households, schools and other buildings depend on low-quality coal as fuel. As the urban concentration continues, the level of $PM_{2.5}$ in winter has become one of the most serious environmental issues of the country, drastically increasing the number of asthma patients. Meiwa’s carbonization technology can process the low-quality coal into non-smoke emitting coal and combustible gas both as alternative and cleaner heat source preventing air pollution and related diseases.<br>  <br>Traditional houses in Mongolia burning low-quality coal, causing serious air pollution in winter</td>
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<td>Minimizing waste to be taken to landfills<br>There is tons of organic waste generated through consumption and production activities, but currently many of them are dumped or burned with fuel. Biomass carbonization technology encourages medium- to large-scale producers and municipalities to recycle their residual biomass, such as agricultural residue, food waste and animal waste. As a result, the amount of waste to be taken to landfill as a whole will be significantly reduced.<br>  <br>Rice husk piled up like a mountain in Nigeria</td>
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<td>Climate change mitigation by economic cycle<br>On macro scale, fixing biochar (which used to be just another organic waste to be dumped and burnt with fuel) into soil is a carbon negative behavior. By using biochar, farmers will be a driving force to mitigate climate change even if they are not yet environmentally aware. Although exact number depends on ingredient type and other conditions, generally the application of 100g of biochar approximately equals to reducing 160-170g of atmospheric carbon dioxide as compared to burning.</td>
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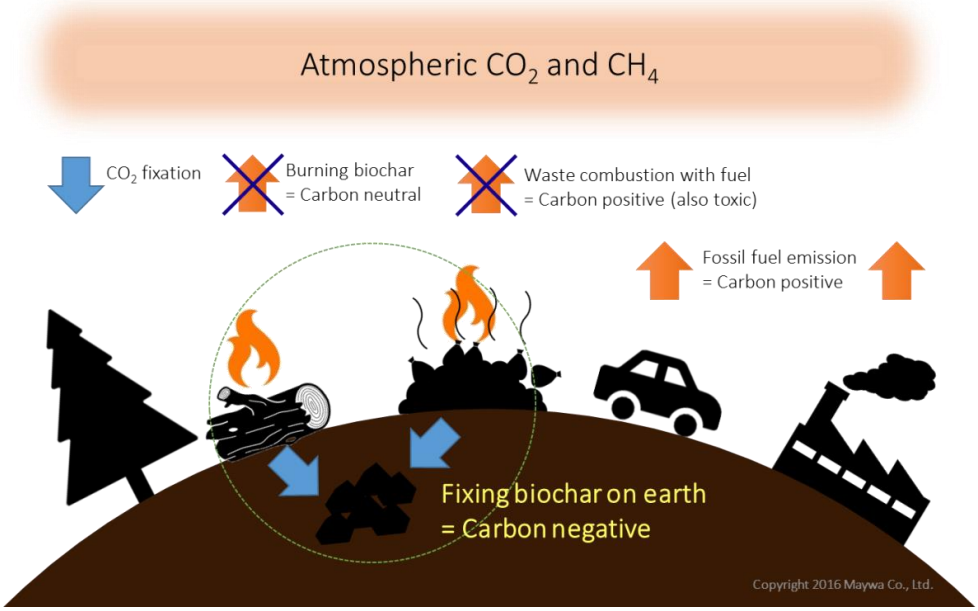


**Simplified illustration of global carbon cycle**

<u>Climate change adaptation by more resilient agriculture</u>

Also, because of the high porosity, biochar works as soil conditioner for moisture control. Since **biochar can make rainfed agriculture more resilient** to irregular rainfall pattern, it has huge potential to contribute as climate change adaptation countermeasure as well.

**Dead maize field that could not survive under unusual rainfall pattern**

<u>Mitigating nutrient pollution</u>

If chemical fertilizer is overused, only a part of them can be absorbed by the target plants and many of them will remain in the soil. Nutrients, such as nitrogen and phosphorus easily get eroded during rainy season and go to the downstream, causing **eutrophication in closed water system**. Water hyacinth invasion in lakes is one of the real-world examples, resulting in huge losses for fishery and transport industries as well as aquatic ecosystem. By replacing chemical fertilizer by biochar in upstream, this impact is likely to be mitigated in downstream.

**Lake Victoria all covered by water hyacinth, interrupting local business and aquatic ecosystem**




Combating desertification

One of the known causes of deforestation is **tree cutting for energy use** driven by poverty. By producing biochar as an alternative for wood charcoal and firewood, deforestation can be mitigated.

Halting land degradation

Also, desertification and overuse of agricultural chemicals often result in **land degradation**. Biochar as soil conditioner and natural fertilizer can help halt the degradation and sustain or improve agricultural productivity and afforestation.

Charcoal possibly made of illegally-harvested woods on sale for daily income



Transferring environmentally sound technologies

While large-size carbonization plant (with the capacity of 25 t/day per plant) is essential to process organic waste as a centralized recycling center of the country / municipality, there are other plants specifically designed for developing countries. Meiwa's small to medium-sized plants (for 50kg to 1t a day) can run without electricity or water and are transportable by truck. Also, while it is technologically-demanding to design the products, they are relatively easy to manufacture. With locally-procurable materials such as iron sheet, used containers of cargo ship and/or drum containers and local technicians experienced in welding, most parts can be manufactured on-site. While the country benefits from **local employment** and **technology transfer**, Meiwa can also enlarge its potential market by reducing the cost for production, operation and maintenance by partnering with locals.

- No electricity
- No water
- Smoke-free
- Odor-free
- Transportable

= Usable anywhere in the world

- On-site raw material procurement
- On-site production with local partners

= Local employment, technology transfer and cost reduction

**Viable solution across the world**