

Circular economy solutions to close water, energy and food loops in West Africa

The context

Across West Africa, climate change, rapid urbanization and population growth are threatening access to adequate quantities of acceptable quality water for agricultural, industrial and domestic purposes. Addressing these threats requires new solutions to reduce the gap between water supply and demand. Circular economy approaches aim to optimize resource recovery and reuse and minimize the generation of waste. In the context of water resources, the circular economy model focuses on sustainable practices for reducing the waste burden – from wastewater, fecal sludge and solid waste – while increasing the supply of resource inputs from waste materials. If followed correctly, these practices can generate considerable benefits, notably improved sanitation, enhanced water, energy and food security, and the creation of new waste-based industries.

Key messages

- Off-grid urban and peri-urban communities offer prime opportunities for waste management innovations that are people-centered, sustainable, equitable and contribute to economic growth.
- Systematically evaluating the socioeconomic impact of circular economy approaches and mainstreaming these in public/private sector organizations and donor initiatives will enhance the scaling of viable solutions.
- Policy strengthening and capacity development are crucial for the uptake of circular economy approaches.

Key issues

In many developing countries, where costly sewerage systems are uncommon, people routinely depend on pit latrines and septic tanks to dispose of human waste. Often, this waste is leaked or discharged in the form of fecal sludge into the environment, where it can contaminate groundwater, surface water and soil. Of particular concern is the use of contaminated water for irrigation, as farming expands in and around towns and cities.

The generation of wastewater and fecal sludge is increasing with population growth, urbanization, industrialization and changes in consumption patterns. In West Africa, excreta generation is estimated at 100-1,000 liters per capita per year, and wastewater generation is between 20 and 150 liters per capita per day (UNEP and IWMI 2020). Therefore, authorities urgently need to find new ways to manage waste if they are to prevent a major health hazard. In Ghana alone, as many as 19,000 people, including 5,100 children under the age of five, die prematurely each year because of poor water, sanitation and hygiene (WSP 2012a). Moreover, poor sanitation has negative economic impacts. A study in 18 African countries revealed that about USD 5.5 billion is lost every year due to poor sanitation (WSP 2012b).



Workers at the Fortifer™ co-composting facility in Accra, Ghana (photo: Hamish John Appleby/IWMI).

Building on decades of research in the sanitation value chain, the International Water Management Institute (IWMI) has developed a [range of innovative approaches](#) for safe waste management. These approaches aim to strengthen sanitation and enhance water, energy and food security in urban areas while reducing environmental pollution. Using appropriate and [inclusive waste-based business models](#), technologies, decision support tools and guidelines, we are now investigating options to scale these approaches in ways that support a circular economy.

Mapping health risks from wastewater

A study conducted by IWMI (Thebo et al. 2017) helped to better define the scope of the wastewater challenge. Employing geographic information system (GIS)-based modeling techniques, we derived the first estimate of the global extent of croplands irrigated with urban wastewater flows, including indirect wastewater use. The study found that 65% of downstream irrigated croplands are located in catchments with high dependence on urban wastewater flows. This equates to almost 36 million hectares of farmland. We were able to estimate that the health of 885 million people is at risk within the food chain because most wastewater remains untreated.

The 2017 IWMI study built on earlier research conducted in Ghana (Drechsel and Keraita 2014). This earlier research revealed that around the city of Kumasi alone, the area under farmer-led irrigation is larger than all formal irrigation systems in the country, and that most of these peri-urban water sources are highly polluted by domestic wastewater.

Further studies were then conducted to identify actions that can help reduce the risks to health when insufficiently treated wastewater is used for irrigation. One method involved directing irrigation water into furrows, so that it is taken up by plant roots but not splashed onto the leaves. Laboratory experiments were conducted to identify different ways to reduce the contamination of food prior to consumption by households, such as boiling

water to wash the vegetables. It was identified that combining several actions [on farms and in households](#) through a 'multi-barrier' approach significantly reduced pathogen levels in vegetables. This research has informed safety guidelines prepared by the World Health Organization (WHO) as well as the Food and Agriculture Organization of the United Nations (FAO).

Developing viable business models

Many municipalities are interested in developing circular economies but often lack the knowledge and capacity to do so. Achieving self-sustaining solutions requires robust business plans based on [detailed feasibility studies](#). IWMI's studies on resource recovery and reuse identified a major gap between the sanitation sector, which manages waste, and the agriculture sector that might benefit from products derived from waste. To help bridge this gap, we moved beyond knowledge gathering to developing [viable business models for reusing different waste products](#) (wastewater, fecal sludge and solid waste). In recent years, we have worked with various partners, including municipalities and private companies, to implement these business models and gain considerable experience in establishing commercial waste-based ventures. These are described below.

Integrating aquaculture into wastewater treatment

In Kumasi, Ghana, domestic wastewater from a community of about 1,800 people is directed through sewers to a series of stabilization ponds. These ponds offer a low-cost option for treating domestic wastewater. However, for the public sector, raising funds to maintain the ponds and providing incentives for their operation are a challenge.

IWMI scientists found the African catfish (*Clarias gariepinus*) to be appropriate for rearing in treated wastewater ponds because of its ability to tolerate low oxygen levels. The scientists further identified



As urban agriculture expands, IWMI research is ensuring safe water reuse for irrigation in Ghana and beyond (photo: Nana Kofi Acquah/IWMI).

that transferring fish to freshwater prior to harvesting reduces contaminant levels, as does smoking the fish, bringing levels of pathogens deposited on fish skin within acceptable ranges. Furthermore, the research showed that heavy metals in fish are low and the impacts of emerging contaminants such as estrogens are not noticeable.

A public-private partnership was established, with local authorities providing the ponds and a private partner co-investing with donors in the plant upgrade. The private entity is also responsible for producing fish fingerlings, and the operation and maintenance of the ponds. In trials to ascertain the [most profitable scenario](#), scientists found that stocking fingerlings at three per square meter and smoking the fish postharvest gave the best return. By the second year, the revenue generated from fish sales was sufficient to cover 60% of the plant's operation and maintenance costs.

In 2020, a greenhouse was installed at the plant. Wastewater generated by the hatchery and grow-out tanks is channeled to the greenhouse to grow vegetables in aquaponics. These vegetables are also sold, helping to diversify the plant's revenue streams.

From fecal sludge to fertilizer

For more than 15 years, IWMI worked with various partners to develop a profitable business producing fertilizer from fecal sludge. Following extensive research and testing, our efforts culminated in May 2017 with the establishment of Ghana's first large-scale, public-private enterprise dedicated to the manufacture and commercialization of *Fortifer*[™], an affordable organic fertilizer.

The fertilizer is produced by drying fecal sludge on beds of sand and gravel. The dried sludge is then mixed with organic waste, mainly food waste collected from local markets, and 'co-composted' for three months. This involves regular heaping, moistening and turning of the material as it decomposes. Heat generated in the process kills any pathogens, resulting in a product that meets the safety standards set by WHO for the reuse of human excreta. The product is also certified by Ghana's Ministry of Food and Agriculture as an organic soil amendment. In tests carried out on crops such as cabbage, maize, okra, tomato, lettuce and rice, *Fortifer*[™] performed well against alternative nutrient sources, including inorganic fertilizers, poultry manure and locally produced compost from other sources.

Production of *Fortifer*[™] is now being scaled up through a second composting facility in Yilo Krobo Municipal District in Ghana's Eastern Region. When fully operational, the facility will employ around 40 people and be able to produce 200 tonnes of fertilizer annually, transforming up to 5,000 cubic meters of municipal fecal sludge and at least 300 tonnes of organic waste. At the national level, IWMI's work in this area has resulted in composting and organic fertilizer becoming part of the government's fertilizer subsidy program.



Briquettes made from solid waste are a low-cost source of sustainable fuel in Ghana (photo: Eric Nartey/IWMI).

Converting solid waste into low-cost fuel

A briquette plant has been established on the same site as the composting facility in Yilo Krobo Municipal District. This will convert solid waste (sawdust, wood shavings and rice husks sourced from local mills) into 1,000 tonnes of low-cost fuel per year. IWMI conducted surveys to identify [potential markets for the briquettes](#), with food processing factories, fish smokers and bead producers all expressing an interest. General retail for household use is also a possibility, providing the plant with several income-generating options.

The aim is to [replicate these approaches elsewhere in West Africa and beyond](#), applying IWMI's research and practical expertise in all aspects of the sanitation value chain to convert waste into marketable products.

Boosting local capacity

Insufficient funding and a lack of capacity are among the main barriers to safe waste management. Therefore, IWMI has developed a [training manual](#), [business model curricula](#) and a series of [trainings](#) for public and private sector actors. Depending on the stakeholders, the trainings are designed to increase awareness of safe waste management solutions or enhance the ability of participants to identify appropriate models for reusing different waste products. Specific attention is given to the various [partnership and financing options](#) for starting and scaling up viable circular economy initiatives.

The way forward

IWMI's work has shown that materials traditionally considered as waste can be used to make marketable products that support farmers, create jobs, provide renewable fuel and potentially generate funds to improve sanitation facilities. 'Closing the loop' on waste in this way can help overcome some of the major challenges across the developing world: how to manage increasing human waste from expanding cities; what to do about overflowing landfills; and how to ensure water, energy and

food security. Having developed and tested circular economy approaches in Ghana, India and Sri Lanka, we are expanding this work across West Africa and beyond in collaboration with public and private sector partners. Our efforts are geared toward identifying and prioritizing circular economy solutions to match

country-specific challenges and needs. These solutions can range from providing sustainable financing options to make waste-based businesses economically viable to conducting research on behavior change to ensure the benefits of resource recovery and reuse are inclusive and long-lasting.

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Citation

International Water Management Institute (IWMI). 2021. *Circular economy solutions to close water, energy and food loops in West Africa*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 4p. (IWMI Water Issue Brief 17).
doi: <https://doi.org/10.5337/2021.222>

/ circular economy / waste management / wastewater / energy generation / food security / resource recovery / reuse / business models / solid wastes / faecal sludge / organic fertilizers / aquaculture / ponds / public-private partnerships / capacity development / donors / sustainability / socioeconomic impact / health hazards / sanitation / urban areas / West Africa / Ghana /

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