

Circular Bioeconomy Solutions in Refugee-Hosting Landscapes: Drivers, Enablers, and Lessons Learned

Solomie Gebrezgabher, Desta Woldetsadik, Tosin Somorin, Sandra Ruckstuhl

December 2025



The Authors

Solomie Gebrezgabher, Senior Researcher - Economics, International Water Management Institute (IWMI), Ghana
Desta Woldetsadik, Research Associate II, College of Southern Nevada, USA
Tosin Somorin, Researcher, Circular Economy and Waste Management, IWMI, Ghana
Sandra Ruckstuhl, Research Group Leader - Fragility, Conflict, Livelihoods and Water, IWMI, Egypt

Acknowledgments

This work was carried out under the CGIAR Food Frontiers and Security Program. We want to thank all funders who support this research through their contributions to the CGIAR Trust Fund (www.cgiar.org/funders).

CGIAR Food Frontiers and Security Program

The CGIAR Food Frontiers and Security Program is a transdisciplinary science program focused on catalyzing systemic transformation across three frontier food systems: fragile and conflict-affected settings, urban and peri-urban environments, and small island states. The Program is anchored in four Areas of Work, including the Future Food Systems Lab, which synthesizes insights across geographies to drive innovation, resilience, and equity. Its research addresses compounding risks like climate shocks, displacement, and urbanization, working through inclusive partnerships to co-create solutions that are locally grounded and globally relevant. To learn more about the CGIAR Research Portfolio, please visit www.cgiar.org/cgi-ar-portfolio.

Citation

Gebrezgabher, S.; Woldetsadik, D.; Somorin, T.; Ruckstuhl, S. 2025. *Circular bioeconomy solutions in refugee-hosting landscapes: drivers, enablers, and lessons learned*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Food Frontiers and Security Program. 20p.

Copyright © 2025, International Water Management Institute (IWMI). All rights reserved. IWMI encourages the use of its material provided that the organization is acknowledged and kept informed in all such instances.

Front cover photo credit: Edwin Okoth
Back cover photo credit: Jonathan Dickson/IWMI

Disclaimer

This publication has been prepared as an output of the CGIAR Food Frontiers and Security Program. And has not been independently peer reviewed. Responsibility for editing, proofreading and layout, opinions expressed, and any possible errors lies with the authors and not the institutions involved.

Contents

| | |
|---|-----------|
| 1. Background | 1 |
| 2. Circular bioeconomy solutions in refugee-hosting landscapes in Jordan | 2 |
| 2.1. Context | 2 |
| 2.2. Desert Garden for food production in refugee-hosting landscapes in Jordan | 3 |
| 2.3. Energy and nutrient recovery in refugee camps in Jordan | 3 |
| 2.4. Drivers of CBE solutions in Jordan refugee-hosting landscapes | 4 |
| 3. Circular bioeconomy solutions in refugee-hosting landscapes in Bangladesh | 5 |
| 3.1. Context | 5 |
| 3.2. Gardening for food production in refugee camp settlements in Bangladesh | 5 |
| 3.3. Energy solutions - Biogas production in refugee camp settlements in Bangladesh | 6 |
| 3.4. Drivers of CBE solutions in Bangladesh refugee hosting landscape | 6 |
| 4. Circular bioeconomy solutions in refugee-hosting landscapes in Uganda | 6 |
| 4.1. Gardening and resource recovery initiatives in refugee camp settlements in Uganda | 7 |
| 4.2. Biomass briquettes for cooking in refugee settlements in Uganda | 8 |
| 4.3. Drivers of CBE solutions in Uganda refugee hosting landscapes | 9 |
| 5. Key enablers of transitioning to a CBE approach in refugee-hosting landscapes | 10 |
| 6. Lessons learned and recommendations | 11 |
| References | 12 |

1. Background

Globally, the number of people affected by conflicts is rising rapidly. By the end of June 2024, the United Nations High Commissioner for Refugees (UNHCR) reported 122.6 million internally displaced people (IDPs) and refugees (UNHCR, 2024a). Nearly 90% of the IDPs and refugees live in low- and middle-income countries. Both forms of displacement severely disrupt living conditions, particularly access to food, water, energy and sanitation service. UNHCR focuses its interventions in three key areas: protection, assistance, and services, while the UN World Food Programme (WFP) provides food aid, either in-kind or as cash transfers, delivering life-saving assistance during crises and supporting resilient livelihoods. Although humanitarian aid addresses urgent needs, sustainable solutions are required for sourcing and circulating goods and materials in these settings. A circular bioeconomy (CBE), driven by nature, promotes a shift toward nature-positive, circular, and equitable economic systems. These CBE approaches align with societal goals such as poverty reduction, social inclusion, gender equality, and community resilience while delivering ecosystem services and enhancing

resilience (McQuaid et al., 2022). Circular bioeconomy solutions in refugee and IDPs hosting landscapes offer multiple benefits (Figure 1). These include:

- i. enhancing food security and promoting healthier diets through waste recovery and reuse (Adam-Bradford et al., 2022),
- ii. reconnecting refugees with their food systems (Woldetsadik et al., 2022),
- iii. shifting settlement energy models toward sustainable and green energy solutions, including energy efficient stoves (Njenga et al., 2020; Gebrezgabher et al., 2024), and
- iv. creating pathways for environmental peacebuilding in protracted displacement situations. Overall, transitioning to CBE approaches in refugee settlements can significantly contribute to restoring and revitalizing degraded landscapes while supporting resilient livelihoods.

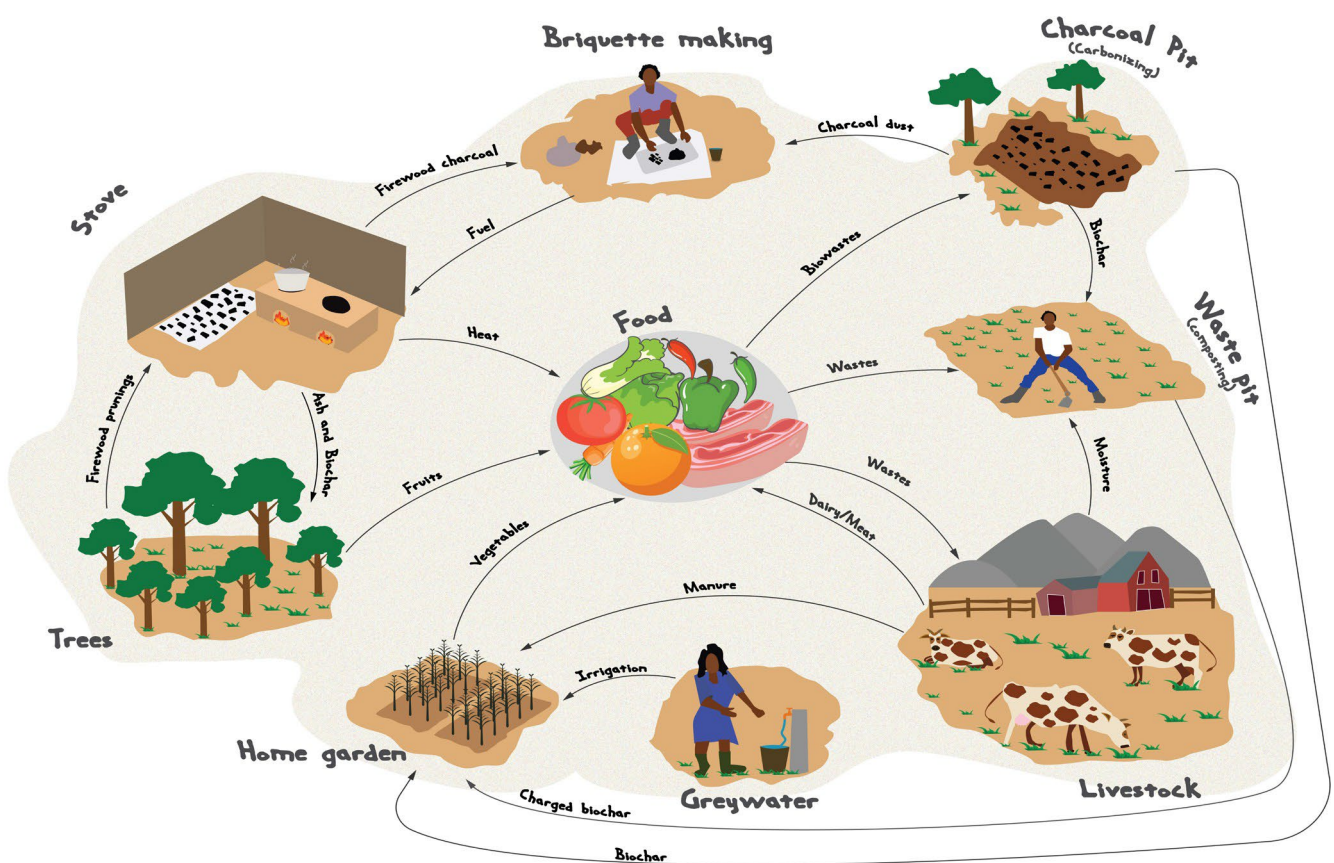


Illustration by: Jonathan Dickson | @letsU!

Figure 1: Synergies of water, nutrient, and energy flows between CBE practices at household or community in a refugee setting (adapted from Adam-Bradford et al. 2022; designed by Jonathan Dickson)

To promote development led by IDPs and refugees, it is essential to assess how circular bioeconomy (CBE) solutions can strengthen resilience in landscapes hosting displaced populations. However, more case studies are needed to inform decision-makers, including authorities managing refugee settlements, humanitarian agencies, and local and international NGOs, as baseline data for implementing CBE solutions remains limited. To date, limited attention has been given to the potential benefits of CBE solutions in these contexts. This report aims to fill that gap by presenting case studies of CBE solutions supporting refugee-led development in three countries - Bangladesh, Jordan, and Uganda - which together represent South Asia, the Middle East and North Africa (MENA) and East Africa region and host some of the world's largest refugee populations. The analysis examines the local contexts, the CBE innovations implemented, and key factors driving their success. Given the interconnected nature of CBE interventions in refugee settlements, progress in one area often generates co-benefits across others, amplifying their overall impact.

2. Circular bioeconomy solutions in refugee-hosting landscapes in Jordan

2.1 Context

Jordan has one of the highest refugee populations per capita in the world, including a significant number of Syrian refugees that arrived in the wake of the Syrian civil war that started in 2011. Jordan has a longstanding history of hosting refugees from the Arab world. As of December 2024, Jordan hosted around 675,000 refugees, of which 90 per cent were from Syria. Other significant refugee populations included Iraqis, Yemenis, Somalis, and Sudanese (UNHCR, 2024b). Jordan's primary refugee response policy is centered around the "Jordan Response Plan", a national strategy that integrates support for Syrian refugees and Jordanian communities affected by the Syrian refugee crisis. Areas of action include healthcare, education, livelihoods, and protection. However, significant needs remain for Syrian refugees, access to land for agricultural use and balanced diets, access to sustainable cooking energy, and employment opportunities. To address these ongoing challenges, Jordan is working in close collaboration with UN agencies and implementing partners to implement a solution-oriented approach through prioritizing resilience-building and aligning with Regional Refugee and Resilience Plan and

Development Goals (ISWG, 2024).

The CBE model for solid waste management in refugee hosting landscapes in Jordan demonstrates how resource-constrained environments can turn waste into valuable resources through innovative approaches. By integrating hydroponics system, biogas production and composting into the camp's waste management system, the CBE approach helps improve sanitation, diversify diets, enhance energy access, and promote sustainability. With strong donor and host government engagements, public-private partnerships, and policy support,

this approach has the potential to be scaled up in other refugee settings and host landscapes across the MENA region, offering a sustainable solution to energy and waste management crisis.



Compost from organic waste and manure (photo: Grisha Buev)

2.2 Desert Garden for food production in refugee-hosting landscapes in Jordan

In 2018, the University of Sheffield's unique Desert Garden project helped to create hydroponics systems in Za'atari camp (Meselmani et al., 2020; University of Sheffield, 2022), which hosts more than 70,000 Syrian refugees. Historically Syrians have a deep connection to creating gardens. In collaboration with the University of Sheffield, International Relief and Development Inc., Blumont and Norwegian Refugee Council, UNHCR alongside refugee volunteers have conducted several training sessions on hydroponics cultivation for residents in the camp.

Under conventional cultivation processes, soil supports a plant's roots, but in a hydroponics system plants are supported artificially and suspended away from the ground. The hydroponics systems are constructed using used polyurethane foam mattresses as a soilless growing media, yoghurt cans, discarded pipes and plastic containers; nutrients running through a recycled water-based system. The foam provided the artificial support for the plant. Nutrient solutions and water can then be pumped into the foam for the plant. In fact, recycling used polyurethane foam mattresses as soilless growing media in the camp was inspired by flexible polyurethane foams mechanical strength to anchor plants and their highly porous nature for liquid and gas transfer in the polymer foam cells (Meselmani et al., 2020). Seedlings are prepared in trays of soil, wrapped in foam cubes from recycled mattresses and then transferred to the closed hydroponic system where recycled water is cycled round pipes. Therefore, hydroponic systems are extremely water efficient, they can use up to 10 times less water than traditional field crop watering methods. They also provide the option for vertical farming technology, reducing space, as trays of plants can be stacked on top of each other.

Desert garden flourishes at Za'atari refugee camp initially, providing access to fruits and vegetables, including tomatoes, cucumbers, lettuce and herbs, to eat and sell, healing spaces from trauma, gaining new innovative skills, and maintaining important cultural and social traditions. Hydroponics systems have now extended their reach to host urban landscapes and Azraq camp, bringing benefits to host community as well (Meselmani et al., 2020). An important aspect of the Desert Garden project is the camp's residents applied their years of farming experiences to the principles of hydroponics and soon after the system went live and the project took on a life of its own. This nature-positive solution

aim to bridge the divide between host and refugee communities, whereby creating refugee-host link via experience and knowledge sharing.

2.3 Energy and nutrient recovery in refugee camps in Jordan

Since 2019, the circular waste management project in the Zaatari refugee camp has been implemented by the UN Food and Agriculture Organization (FAO) in partnership with the Ministry of Agriculture of Jordan, the Syrian Refugee Affairs Directorate (SRAD), UNHCR, the Jordanian National Agriculture Research Center (NARC), the Jordanian Energy Research Center (NERC), Oxfam, and GIZ. The project integrates waste management, sludge treatment, and biogas energy generation with seedling production to support the rehabilitation of forests and rangelands in host communities (FAO, 2024). Direct beneficiaries have received training on waste sorting, particularly in extracting organic matter from collected solid waste for composting. Organic waste accounts for the largest portion of total solid waste at 53% (Saidan et al., 2017). In addition, a public outreach campaign continuously encourages refugee households to separate dry waste (plastics, cardboard, and electronics) from wet waste (kitchen and food waste), facilitating more efficient sorting at the material recovery facility.

The biogas technology implemented at the Za'atari refugee camp utilizes anaerobic co-digestion of organic waste recovered from the solid waste separation facility together with sewage sludge, producing methane-rich biogas and a nutrient-dense digestate rich in nitrogen and phosphorus. As a key component of CBE solutions, biogas offers a sustainable pathway to address the energy challenges in refugee-hosting landscapes. Ongoing green energy initiatives in Jordan illustrate that biogas generation can diversify and stabilize energy access in such settings. The circular waste management project aims to meet 25–50% of Za'atari camp's daily energy demand through biogas production while promoting a transition toward a low-carbon economy. Similarly, the use of portable biogas digesters in Jordanian villages enables households to utilize methane for cooking, thereby reducing energy costs. According to Alkhalidi et al. (2019), a small-scale digester (0.54 m³) fed with food and human waste can meet the cooking energy needs of a five-member household. These small-scale systems help overcome the high upfront investment barriers typically associated with large-scale biogas technologies.



photo: Sadekhusein

To address environmental and food safety concerns related to the use of waste-derived compost in agriculture, appropriate certification and quality assurance are essential. The compost produced in the Za’atari camp has been approved and certified by the National Agricultural Research Center (NARC) for agricultural use, based on scientific evidence and compliance with national standards. By equipping camp and local authorities with scientific data, FAO and NARC aim to promote the safe reuse of treated wastewater in agriculture, particularly in hydroponic systems. The circular waste management project has also generated temporary employment for 315 individuals—40% women, 59% refugees, and 41% host community members—reflecting a strong gender and social inclusion dimension. Moreover, the project illustrates how refugees and host community members can collaborate to develop new productive sectors, fostering economic integration and shared resilience within host economies (FAO, 2024).

2.4 Drivers of CBE solutions in Jordan refugee-hosting landscapes

In Jordan, humanitarian aid—whether provided as food assistance or cash transfers—has proven insufficient to ensure sustainable food and nutrition security for most refugees. Compounding this challenge is acute water scarcity, as Jordan ranks among the world’s most water-poor countries, posing significant constraints to crop cultivation. Recognizing these challenges, the UNHCR, Syrian Refugee Affairs Directorate (SRAD), and other implementing partners advocate for the adoption of nature-positive and circular bioeconomy (CBE) solutions within refugee camps to harness local resources and create livelihood opportunities (UNHCR Jordan, 2019).

One promising entry point has been the recycling of solid waste to establish small-scale desert gardens near homesteads. Such household or community gardens are accessible, low-cost, and manageable within existing refugee camp structures, requiring minimal permissions from camp authorities. These activities not only enhance food self-sufficiency but also promote resource recovery and environmental stewardship, making them a key driver of CBE adoption.

The vast majority of refugee and displaced people after almost no access to sustainable energy solutions and depend heavily on unsustainable energy sources, often leading to resource conflicts

between refugee and host communities (GPA, 2022; Ferguson et al., 2022). Implementing CBE-based energy solutions, such as biogas production and organic waste-to-energy systems, offers a pathway to clean, reliable, and inclusive energy access while reducing environmental pressures.

Additionally, waste management remains a critical concern in refugee-hosting landscapes. For instance, the Za’atari camp generates approximately 34 metric tons of solid waste daily, placing immense strain on infrastructure, municipal services, and the environment (FAO, 2024). Addressing such challenges through integrated CBE frameworks that link waste management, energy generation, and food production is therefore essential to advancing both humanitarian resilience and environmental sustainability.



Growing vegetables with raised beds (photo: Adam-Bradford)

3. Circular bioeconomy solutions in refugee-hosting landscapes in Bangladesh

3.1 Context

Bangladesh hosts one of the largest refugee populations in the world, with over one million Rohingya refugees residing in Cox's Bazar, home to the world's largest refugee camp (UNHCR, 2024c). The Rohingya fled ethnic and religious persecution in neighboring Myanmar, where they were rendered stateless under the 1982 Myanmar Nationality Law. In 2017, a mass influx of refugees transformed Kutupalong from an informal settlement into a vast refugee complex in Cox's Bazar district. Since then, the WFP has been providing food assistance to nearly one million Rohingya refugees through a combination of in-kind food aid (such as rice and beans) and e-voucher systems, which allow refugees to purchase food from WFP-contracted shops within the camps. However, recent funding shortfalls have forced a 33% reduction in both in-kind aid and e-voucher allocations, exacerbating food insecurity and malnutrition risks. The camps also face severe overcrowding and limited land availability, leaving little room for conventional agriculture or livelihood activities. At the same time, access to cooking energy remains highly constrained due to the lack of affordable and sustainable energy sources, intensifying environmental pressures and dependence on external aid.

3.2 Gardening for food production in refugee camp settlements in Bangladesh

In the Rohingya refugee-hosting landscape, humanitarian agencies have actively promoted camp greening and household gardening initiatives. Since 2018, nearly 60,000 households have participated in gardening activities annually (FAO, 2022). Interest in these initiatives is rapidly growing, with efforts centered on six production systems specifically designed to suit the unique conditions of the camps, including limited land, topography, and resource constraints. According to FAO's household gardening assessment, two innovations, sack gardening and trellis gardening, are considered highly suitable, based on four key criteria: environmental friendliness, productivity, water efficiency, and species suitability.

Sack Gardening is particularly well-suited to the camp context due to its low cost, accessibility, and adaptability. Cereal or grain sacks can be obtained with little or no financial expense. The

sacks are filled layer by layer with a soil and compost or cow dung mixture (approximately 2:1 ratio), with moderate rinsing and soaking between layers. Seeds or seedlings can be planted on the surface or on top of the sack, with thinning and transplantation along the sides to maximize space. The vertical structure of sack gardens allows the use of a central basket and planting through the sides and top of the sack, with staggered 2–3 cm holes spaced 30 cm apart, enabling increased cultivation area despite limited soil depth. Due to these constraints, leafy vegetables such as spinach (recommended during dry spells) and radish (during the rainy season) are most suitable. Sack gardens do not require direct attachment to land, making them ideal for stressed environments. Rohingya refugees have demonstrated that sack gardening is water-efficient, utilizing household greywater, and is accessible to individuals with varying physical abilities. The orientation and structure of sack gardens minimize labor and handling requirements, making them practical for daily use. Overall, sack gardening has been widely adopted by Rohingya households, providing an effective way to grow food even in very small or constrained spaces.

Trellis Gardening complements sack gardening by enabling plants to grow vertically on bamboo-framed structures. Climbing surfaces, such as recycled netting or nylon, support plants like cucumbers, bottle gourd, sweet gourd, bitter gourd, and tomatoes. Non-climbing species, such as tomatoes, are trained upward to keep fruits and leaves clean and dry, which improves yield quality and reduces spoilage. Vertical growth also promotes better air circulation, reducing disease pressure and facilitating easier harvesting. Trellis gardening has a strong adoption rate among Rohingya households, combining functional and architectural innovation to maximize productivity in constrained spaces. Together, these household gardening innovations provide practical, low-cost, and resource-efficient solutions to enhance food security, nutrition, and livelihoods in refugee camps, while enabling refugees to engage with the land and improve their daily food production.

3.3 Energy solutions - Biogas production in refugee camp settlements in Bangladesh

Efforts to explore alternative cooking energy sources in Rohingya refugee camps have been expanding. One notable initiative, implemented by UNHCR and Oxfam in Cox's Bazar, involves a human waste treatment facility that simultaneously treats waste and produces biogas. This facility is the largest of its kind in any refugee settlement, with the capacity to process waste from up to 150,000 people, handling approximately 40 cubic meters per day. The project collects sludge from multiple locations and channels it into tightly covered lagoons, where biological treatment generates biogas, which is then distributed for cooking purposes. The biogas production potential in Rohingya camps is estimated at 14.43 million cubic meters, which could replace nearly 500,000 LPG cylinders, providing a sustainable, cost-effective, and environmentally friendly alternative to conventional cooking fuel (Chowdhury et al., 2022).

3.4 Drivers of CBE solutions in Bangladesh refugee hosting landscape

The Rohingya refugee camps are located within nationally designated protected forest areas and are among the most densely populated refugee settlements in the world, hosting nearly 1 million people across approximately 25 km² of temporary homesteads (MSF, 2020). This extreme density limits space and resources for conventional cultivation, making home gardening innovations a practical solution. These innovations also align with Bangladesh's urban agriculture policy, which forms part of the country's broader framework for sustainable environmental management (Ministry of Agriculture, 2018).

The refugee crisis has severely depleted local forest resources, exacerbating environmental stresses. This has raised contradictions between the government's conservation efforts and the humanitarian response. For example, in 2018, refugees were relying on estimated 700 tonnes of firewood daily. (UNHCR, 2021). This situation exacerbated social tensions between the Rohingyas and host communities due to increased land degradation, fuelwood scarcity, reduced foraging area and associated risks of gender-based violence. In response UN agencies in coordination with the Government of Bangladesh (GOB) initiated Safe

Access to Fuel and Energy programme to provide practical and safe cooking fuel, primarily in the form of liquefied petroleum gas (LPG) to both refugees and host communities.

Bangladesh's National Action Plan for Clean Cooking (2020–2030) highlights a diverse energy mix for cooking, including biomass, biogas, LPG, natural gas, and electricity, with a priority on sustaining LPG production. However, LPG supply remains insufficient to meet refugee household needs, and relying on emergency funding for continuous provision is not feasible, particularly given the protracted and uncertain timeline of Rohingya repatriation to Myanmar. Another key driver of camp-scale energy solutions is the link between energy access and sanitation and waste management, as inefficient fuel use and unmanaged waste exacerbate environmental and public health risks.

Solar electrification at the household level has not been prioritized by the host government due to the fragile nature of refugee camp sites, potential disruption to forest lands, and national energy security challenges (Rafa et al., 2024). In contrast, the National Biogas and Manure Management Programme (NBMMP) assigns medium to high priority to developing an enabling environment for biogas production. Currently, Bangladesh has nearly 100,000 biogas plants, with most biogas generated from cow and chicken manure, illustrating the existing infrastructure and potential for scaling biogas-based solutions in refugee camps.

4. Circular bioeconomy solutions in refugee-hosting landscapes in Uganda

As of September 30, 2024, Uganda hosts over 1.6 million refugees (UNHCR, 2024d), most having fled civil conflicts in neighboring South Sudan and the Democratic Republic of the Congo (UNHCR, 2024). Nearly 90% of refugees reside in 13 major settlements across ten refugee-hosting districts (World Bank, 2018). Uganda's long-standing open-door policy and recognition of the protracted nature of displacement have fostered nationally led initiatives, such as the Refugee and Host Population Empowerment (ReHoPE) programme, which operationalizes the Comprehensive Refugee Response Framework (CRRF) outlined in the New York Declaration on Refugees and Migrants (2016) (World Bank and GoU, 2017). The 2006 Refugee



photo: IWMI

Act, the 2010 Refugee Regulations, and the CRRF guarantee a broad set of rights, including freedom of movement, registration and documentation, access to social services (education and health), land for shelter and agriculture, the right to work, and the right to establish businesses. The World Food Programme (WFP) provides additional food assistance to complement these protections. Despite these frameworks, refugees face practical constraints, particularly in land tenure, and cooking fuel is not included in food distributions or cash assistance, creating persistent energy poverty. Consequently, refugee and host communities in Uganda continue to struggle with food insecurity, limited access to sustainable energy, and livelihood challenges. These constraints highlight the need for integrated CBE solutions, which can link waste management, food production, and renewable energy to create sustainable, locally driven pathways for food security, energy access, and economic resilience within refugee settlements.

4.1 Gardening and resource recovery initiatives in refugee camp settlements in Uganda

In Uganda's refugee-hosting landscapes, several gardening and resource recovery initiatives are already underway. One notable example is the Resource Recovery and Reuse (RRR) in Refugee Settlements in Africa project, implemented across refugee-hosting areas in Kenya and Uganda. Led by the International Water Management Institute (IWMI), the project aimed to enhance resilience in refugee-hosting landscapes through the application of CBE solutions. Its focus was on capturing energy, water, and nutrients to build sustainable food and energy systems for both refugee and host communities.

Key project activities include hands-on training on home gardening innovations, safe reuse of greywater, composting, and the production of briquettes and biochar. These interventions have been delivered to refugees and host households through a network of local community-based facilitators (Gebrezgabher et al., 2024). The project has also contributed to gender transformation within households, empowering women with skills to optimize small plots of land around their homesteads for vegetable cultivation using innovative gardening technologies (Adam-Bradford et al., 2022; Mendum et al., 2022).

The introduction of charcoal briquettes, produced from organic biomass and charcoal dust, has shown promising results, with refugees reporting reduced fuel consumption and cooking time, particularly for slow-cooking crops included in the WFP food basket. In addition, this approach reduces pressure on local biomass resources, fostering greater cohesion with host communities by minimizing competition for fuelwood.



Harvesting amaranth leaves from a greywater-irrigated home garden in Kalobeyei Settlement in Kenya (photo: IWMI).

Raised beds in refugee camp settlements in Uganda

In refugee-hosting landscapes, raised beds have been implemented as innovative solutions to address limited land, poor soil quality, and water scarcity. Raised beds elevate the growing surface above the ground, improving soil drainage, root development, and nutrient management. They are often constructed using locally available or recycled materials and filled with nutrient-rich soil-compost mixtures. A practical example comes from the Resource Recovery and Reuse (RRR) in Refugee Settlements in Africa project, where host community households established home gardens through safe reuse of greywater as well as individual and communal gardens adjacent to water points. Spillage from these water points is harvested and used to irrigate the gardens. This approach has demonstrated that small, simply constructed vegetable beds can be maintained throughout all seasons, enhancing diet diversification and, in some cases, providing opportunities for income generation (Adam-Bradford et al., 2022).

Trench gardens in refugee settlements in Uganda

Trench gardens provide a complementary solution, particularly suited for dry and resource-constrained environments. These gardens use layered substrates to retain moisture, improve fertility, and create favorable growing conditions for a variety of crops, including species that would not naturally thrive in arid conditions. By integrating organic matter, manure, and topsoil in layered configurations, trench gardens enhance plant growth, water efficiency, and soil health, enabling refugees to produce diverse and nutritious crops on limited land.

Together, raised beds and trench gardens represent practical, resilient, and context-appropriate home gardening solutions that improve food security, nutrition, and livelihoods, while promoting efficient use of water and land resources in refugee settlements.

4.2 Biomass briquettes for cooking in refugee settlements in Uganda

Most refugee settlements in Africa depend on unsustainable fuel sources, primarily firewood and charcoal, to meet their cooking energy needs (UN-Habitat and UNHCR, 2016). Firewood is burned directly for energy, while charcoal is produced through the partial combustion of wood under limited oxygen. Despite their prevalence, energy provision in refugee settlements remains underfunded, inefficient, and unsafe. For instance, UNHCR provides only 10 kg of firewood per person every two months in Kakuma and Kalobeyi settlements, equivalent to 0.03 kg per capita per day, compared to the 1 kg per capita per day typically required for a household in East Africa (Njenga et al., 2019). The food aid provided, mostly cereals and pulses, requires long cooking times, further intensifying the demand for cooking fuel. To address this, biomass briquettes have emerged as a viable and affordable alternative energy source. These briquettes are typically made from charcoal dust and other available organic waste combined with locally available binders such as red soil or organic matter, then compacted by hand or with simple molds and dried in shaded areas. The use of charcoal briquettes has shown promising results under the RRR in refugee project - women report reduced fuel use and cooking time, particularly for energy-intensive foods like beans. In addition, briquette stoves emit less smoke, helping to reduce indoor air pollution and associated health risks. Furthermore, the introduction of dual-purpose stoves, which can use both briquettes and firewood, has further enhanced flexibility and adoption (Adam-Bradford et al., 2022). In many refugee-hosting areas, charcoal briquette production and use, often led by women's groups, have emerged as a practical CBE solution, reducing dependence on unsustainable biomass, mitigating tensions over fuelwood, and providing a modest source of income.



Charcoal briquettes produced by a refugee used for cooking in Imvepi settlement in Uganda (photo: IWMI).

4.3 Drivers of CBE solutions in Uganda refugee hosting landscapes

Following the Refugee and Host Population Empowerment (ReHoPE) initiative, Uganda's Office of the Prime Minister (OPM) began allocating approximately one acre of land to each refugee household for settlement and cultivation. This allocation aimed to enable refugees, many of whom were agrarian or pastoralist, to complement food assistance through subsistence rainfed farming. However, refugees continue to face multiple challenges, including climate variability, poor soil fertility, and limited agricultural input support. With the arrival of tens of thousands of South Sudanese refugees by mid-2016, land allocations were reduced to plots as small as 30 m by 30 m. Even the original one-acre plots provided to earlier arrivals have been subdivided to accommodate new refugees, leading to tensions among refugee groups. The combination of land scarcity, declining food assistance, and rising food prices has sharply increased food insecurity, disproportionately affecting women and children.

Access to clean cooking energy remains critically low, with less than 1% of refugee and host households in rural areas using modern energy sources (NPA, 2020). Most refugee settlements still depend on biomass fuels such as firewood and charcoal (Rafa et al., 2022), causing deforestation, land degradation, and resource competition between refugees and host communities. This dependence also heightens gender-related vulnerabilities, as women and girls primarily responsible for firewood collection, must walk long

distances, often through unsafe areas, exposing them to gender-based violence.



Pruning a tree for firewood in Rhino Refugee Settlement in Uganda (photo: CIFOR-ICRAF).

Although several district bylaws prohibit charcoal production, enforcement remains weak (Täuber et al., 2023). In response, the Government of Uganda (GoU) launched the Sustainable Energy Response Plan to improve access to clean and sustainable energy in displacement settings, aligning with the country's Third National Development Plan (NDP III). The plan promotes the adoption of alternative and efficient cooking technologies and liquefied petroleum gas (LPG). However, LPG use in settlements is minimal, as the high upfront cost of stoves and cylinders and the recurring expense of refilling (around USD 23 per month for a six-member family) render it economically unviable compared to food aid allocations (Täuber et al., 2023; WFP).

Collectively, these conditions highlight the urgent need for small-scale gardening innovations and sustainable cooking energy interventions at the micro-scale, implemented within gender-sensitive and circular bioeconomy (CBE) frameworks to enhance food security, reduce environmental pressure, and promote resilience in refugee-hosting landscapes.

5. Key enablers of transitioning to a CBE approach in refugee-hosting landscapes

The transition to a circular bioeconomy in refugee-hosting landscapes relies on key enablers, including aligned government policies, collaborative frameworks, inclusive refugee participation, and innovation-driven public-private partnerships. Support from UN agencies and implementing partners further strengthens CBE initiatives through capacity building, skill development, and community-based learning, ensuring sustainable and impactful outcomes while promoting social cohesion. The following enablers are critical to the successful design and implementation of CBE practices in refugee-hosting landscapes:

- **Policy alignment and integration:** Sustainable energy, agriculture, and environmental policies of host governments should align with CBE principles, explicitly recognizing the value of converting waste into cooking energy and soil amendments. Coherent policy alignment across these sectors creates a strong foundation for CBE adoption.
- **Collaborative frameworks:** The Comprehensive Refugee Response Framework (CRRF) for instance provides opportunities for inter-sectoral and inter-agency collaboration, enabling

organizations - including UN agencies - to leverage their comparative advantages and expand sustainable agriculture and energy initiatives in refugee settings.

- **Inclusive governance and refugee participation:** Involving refugees in the co-design and decision-making of CBE interventions strengthens ownership, relevance, and sustainability of outcomes by embedding local knowledge and community priorities.
- **Public-private innovation partnerships:** Effective CBE transitions require strong public-private collaboration. For instance, green cooking fuel interventions benefit from private sector engagement in providing technical expertise, ensuring the design, construction, and operation of efficient and safe energy recovery systems.
- **Capacity building and community-based learning:** UN agencies, CGIAR centers, and implementing partners bring valuable experience in designing capacity development strategies that combine extension services, community facilitators, and peer-to-peer learning. Such mechanisms enhance local skills, innovation, and adaptive management, reinforcing long-term CBE sustainability.



photo: Freepik

6. Lessons learned and recommendations

Innovations in CBE solutions demonstrate strong potential for transformative change in refugee-hosting landscapes, particularly when driven by refugee engagement, knowledge sharing, and supportive policy integration. By incorporating local traditions and endogenous knowledge, these initiatives highlight refugee leadership in resilience building and collaboration with host communities. Advocacy and evidence-based approaches have further aligned CBE practices with national policies, while targeted capacity-building activities have enhanced awareness and scalability of sustainable solutions. The following lessons and recommendations emerge:

- **Harnessing local knowledge and peer learning:** Substantial innovation and broader impacts were achieved through peer-to-peer skill sharing that integrated local traditions and ancestral knowledge, helping preserve cultural values and foster refugee-led engagement in CBE initiatives.
- **Harnessing local knowledge and peer learning:** Substantial innovation and broader impacts were achieved through peer-to-peer skill sharing that integrated local traditions and ancestral knowledge, helping preserve cultural values and foster refugee-led engagement in CBE initiatives.
- **Scaling through awareness and capacity building:** Producing educational and demonstration videos is valuable in raising awareness, documenting implementation procedures, and showcasing success stories. These tools support knowledge dissemination and advocacy for scaling up CBE solutions across refugee-hosting landscapes.
- **Leveraging refugee and host community expertise:** Refugees bring diverse skills and experience to host countries. Easing restrictions on economic activities can unlock synergies between refugee and host community know-how, strengthening local CBE enterprises and value chains.
- **Integrating CBE into policy frameworks:** Sustained advocacy efforts are essential to embed CBE approaches within host government, UNHCR, and implementing partner policies particularly across environment, agriculture, energy and climate frameworks, to ensure long-term institutional uptake.



photo: Freepik | EyeEm

References

- Adam-Bradford, A.; Mendum, R.; Njenga, M.; Woldetsadik, D.; Acanakwo, E.F.; Gebrezgabherm S., 2022. Circular bio-economy innovations for resilient refugee and host communities in East Africa. IWM Resource Recovery and Reuse (RRR) in Refugee Settlements in Africa Project Brief Series - No. 3. p 1-12. <https://hdl.handle.net/10568/122008>
- Alkhalidi, A.; Khawaja, M.K.; Amer, K.A.; Nawafleh, A.S.; Al-Safadi, M.A. 2019. Portable biogas digesters for domestic use in Jordanian Villages. *Recycling*, 4(2), p.21. <https://doi.org/10.3390/recycling4020021>
- Chowdhury, H.; Chowdhury, T.; Sharifi, A.; Corkish, R.; Sait, S.M. 2022. Role of biogas in achieving sustainable development goals in Rohingya refugee camps in Bangladesh. *Sustainability*, 14(19), p.11842. <https://doi.org/10.3390/su141911842>
- FAO, 2024. Circular waste management in Zaatari - refugee camp Turning waste into compost, energy, and job creation. Available at <https://www.fao.org/neareast/news/stories/details/circular-waste-management-in-zaatari-refugee-camp--turning-waste-into-compost--energy--and-job-creation/en> (accessed on October 2, 2025).
- FAO, WFP, FSS 2022. Homestead gardening guidelines: Vegetable production for household consumption using minimal space in Rohingya camps and host communities. Cox's Bazar. Available at https://fscluster.org/sites/default/files/documents/homestead_gardening_guidelines_for_rohingya_camps_and_host_communities_1.pdf (accessed on Nov 5, 2025).
- Ferguson, Neil T. N.; Wolfe, Rebecca J.; Amine, Laila; Ramadi, Eric; Shahin, Lina. 2022. Building Stability Between Host and Refugee Communities: Evidence from a TVET Program in Jordan and Lebanon. Policy Research Working Papers; World Bank. <http://hdl.handle.net/10986/37593>
- Gebrezgabher, S.; Gitau, J.; ; Acanakwo, E.F.; Adam-Bradford, A.; Mendum, R.; Njenga, M. 2024. Scaling circular bio-economy solutions in refugee settings: a peer-to-peer capacity building approach. IWM Resource Recovery and Reuse (RRR) in Refugee Settlements in Africa Project Brief Series - No. 4. p 1-8. <https://hdl.handle.net/10568/141590>
- GPA, 2022. The State of the Humanitarian Energy Sector: Challenges, Progress and Issues in 2022. Global Platform for Action on Sustainable Energy in Displacement Settings. UNITAR Publishing. Geneva, Switzerland. Document - The State of the Humanitarian Energy Sector; Challenges, Progress and Issues in 2022
- ISWG (Inter Sector Working Group), 2024. Refugee Response and Resilience Strategy 2024 – 2025. Available at <https://data.unhcr.org/en/documents/details/109752> (accessed on Nov 4, 2025).
- McQuaid, S.; Kooijman, E.; Rizzi, D.; Andersson, T.; Schanté, J. 2022. The vital role of nature-based solutions in a nature positive economy, Publications Office of the European Union, 2022. <https://doi.org/10.2777/307761>
- Médecins sans frontières (MSF). 2020. COVID-19: Five challenges in Bangladesh and the Rohingya refugee camps. Available at <https://www.msf.org/five-challenges-bangladesh-amid-covid-19> (accessed on August 1, 2025).
- Meselmani, M. A. A.; Wright, H. C.; Cameron, D. D.; Ryan, A. J. 2020. How scientists and refugees brought green to the Desert Garden. *Nature Reviews Earth & Environment*. <https://doi.org/10.1038/s43017-020-0081-7>
- Ministry of Agriculture, 2018. National Agriculture Policy, Government of Bangladesh, 2018. Available at https://dae.gov.bd/sites/default/files/files/dae.portal.gov.bd/policies/7875ac7a_f83e_43d8_a954_812c1e54acd3/2021-08-25-06-28-af70354a1dd6d900542970fb44c4603d.pdf (accessed on Nov 2, 2024).

National Planning Authority (NPA), 2020. Third National Development Plan (2020/21 - 2024/25). Available at http://www.npa.go.ug/wp-content/uploads/2020/08/NDPIII-Finale_Compressed.pdf (accessed on August 20, 2025).

Njenga, M.; Gebrezgabher, Solomie; Mendum, R.; Adam-Bradford, A.; Woldetsadik, D.; Okia, C. 2020. Circular economy solutions for resilient refugee and host communities in East Africa. Colombo, Sri Lanka: International Water Management Institute (IWMI). 8p. (Resource Recovery and Reuse (RRR) in Refugee Settlements in Africa: Project Brief Series 1). <https://hdl.handle.net/10568/109549>

Njenga, M.; Gitau, J. K.; Iiyama, M.; Jamnadass, R.; Mahmoud, Y.; Karanja, N. 2019. Innovative biomass cooking approaches for sub-Saharan Africa. *Afr. J. Food Agric. Nutr. Dev.*, 19(1), 14066–14087. <https://doi.org/10.18697/ajfand.84.BLFB1031>

Oxfam GB. 2017. Trash talk turning waste into work in Jordan's Za'atari refugee camp. OXFAM discussion paper. Available at <https://policy-practice.oxfam.org/resources/trash-talk-turning-waste-into-work-in-jordans-zaatari-refugee-camp-620329/> (accessed on August 6, 2025)

Rafa, N.; Khalid, R.; Uddin, S.M.N. 2024. Energy access and sustainable development for displaced populations: Achieving energy justice in the Rohingya refugee camps of Cox's Bazar, Bangladesh. *Energy Research & Social Science*, 114, p.103621. <https://doi.org/10.1016/j.erss.2024.103621>

Saidan, M.N.; Drais, A.A.; Al-Manaseer, E. 2017. Solid waste composition analysis and recycling evaluation: Za'atari Syrian Refugees Camp, Jordan. *Waste Management*, 61, pp.58-66. <https://doi.org/10.1016/j.wasman.2016.12.026>

Täuber, M.; Sandwell, P.; Ndahimana E. 2023. A Roadmap for Energy Access in Displacement Settings: Uganda. UNITAR. Geneva, Switzerland. Available at <https://www.mercycorps.org/research-resources/roadmap-for-energy-access> (accessed on August 15, 2025)

UN-Habitat and UNHCR. 2016. Socio-economic and mapping baseline survey report 2016. KISEDIP (Kalobeyei integrated socio-economic development Programme). UN-Habitat Nairobi. Available at <https://alnap.org/help-library/resources/socio-economic-and-mapping-baseline-survey-report-kalobeyei-integrated-socio-economic/> (accessed on September 23, 2025)

UNHCR, 2019. Growing A Sustainable Community-How hydroponics are bringing an innovative approach to refugees. Available at <https://www.unhcr.org/jo/12200-growing-a-sustainable-community.html> (accessed on Nov 2, 2025).

UNHCR 2021. Rohingya refugees restore depleted forest in Bangladesh. Available at Rohingya refugees restore depleted forest in Bangladesh (accessed on Oct 1, 2025).

UNHCR, 2024a. Key displacement and solutions trends in the first half of 2024. Available at <https://www.unhcr.org/us/mid-year-trends> (accessed on Nov 11, 2025).

UNHCR, 2024b. Annual results report, 2024. Jordan. Available at <https://www.unhcr.org/media/jordan-annual-results-report-2024> (accessed on Nov 5, 2025).

UNHCR, 2024c. Annual results report, 2024. Bangladesh. Available at <https://www.unhcr.org/media/bangladesh-annual-results-report-2024> (accessed on Nov 5, 2025).

UNHCR, 2024d. Uganda - Refugee statistics map 2024. Available at <https://data.unhcr.org/en/documents/details/111561> (accessed on Nov 11, 2025).

University of Sheffield, 2022. How can we feed the world with foam? Available at <https://www.sheffield.ac.uk/research/features/sheffield-zaatari-and-back-feeding-world-foam> (accessed on Oct 11, 2025).

Woldetsadik, D.; Llorent-Martínez, E.J.; Gebrezgabher, S.; Njenga, M.; Mendum, R.; Castillo-López, R.; Fernández-de Córdova, M.L.; Hailu, H.; Evans, C.T.; Madani, N.; Mafika, T.P. 2022.

Okra (*Abelmoschus esculentus*) in a refugee context in East Africa: Kitchen gardening helps with mineral provision. *SN Applied Sciences*, 4(1), p.32. <https://doi.org/10.1007/s42452-021-04898-6>

World Bank and GoU, 2017. ReHoPE — Refugee and host population empowerment strategic framework - Uganda (June 2018). Available at <https://reliefweb.int/report/uganda/rehope-refugee-and-host-population-empowerment-strategic-framework-uganda-june-2018-0> (accessed on Nov 10, 2025).

World Bank, 2018. Informing the Refugee Policy Response in Uganda: Results from the Uganda Refugee and Host Communities 2018 Household Survey. Washington, D.C. Available at <http://documents.worldbank.org/curated/en/571081569598919068> (accessed on Oct 15, 2025).



CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations, and the private sector. www.cgiar.org.

To learn more about this program, please visit: <https://www.cgiar.org/cgiar-research-portfolio-2025-2030/food-frontiers-and-security>

Contact

Solomie Gebrezgabher, Senior Researcher - Economics, International Water Management Institute (IWMI), Ghana
(S.Gebrezgabher@cgiar.org)



CGIAR

FOOD FRONTIERS
AND SECURITY

IWMI

International Water
Management Institute