Alternative organic resources for soil health in Africa

Addressing soil health is recognised as a key strategy to improve fertiliser efficiency, and this is particularly important in Africa, where fertiliser is a scarce resource. Our authors have established the potential contribution of externally sourced organic fertilisers and biofertilisers in the context of a scoping study.

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Achieving and maintaining high soil productivity and crop yields requires investing in soil health. Organic inputs offer a means to reconnect carbon and nutrient supply, a crucial aspect for optimising crop response to nutrients. On-farm adjustments in organic matter management, such as implementing proper crop rotations with legumes, agroforestry practices like alley cropping, utilising compost and animal manure, and adopting appropriate soil tillage practices are pivotal for maintaining soil health and effective nutrient management. In addition, off-farm produced organic fertilisers recycled from organic wastes can serve as valuable resources for composting and bioslurry production, addressing carbon and nutrient deficiencies in soils. Their proper utilisation not only benefits farms but also alleviates environmental and public health burdens associated with their mismanagement in many regions.

Biofertilisers (based on fungi and bacteria), including rhizobia, and soil amendments (such as lime and biochar) can enhance nutrient availability, improve soil characteristics and bolster crop health. By ensuring soil health and thus soil responsiveness through the above-mentioned measures, thoughtful and strategic use of inorganic fertilisers can target specific nutrient deficiencies while providing readily available nitrogen, thereby enhancing both yield and soil health.

Open dumping of organic and other wastes in Ghana. Photo: Pierre Ellssel

Current status of off-farm produced organic fertilisers

To understand the current state of off-farm organic fertilisers, soil amendments, and biofertilisers (biostimulants) in Africa, a scoping study was conducted across twelve African countries. This included a desktop review of existing literature, own calculations and interviewing 89 key informants across the organic and biofertiliser value chain. The countries spanned all African regions: Egypt (North), Cameroon, Côte d'Ivoire, Ghana, Senegal (West/Central), Ethiopia, Kenya, Rwanda, Uganda (East), and Malawi, South Africa and Zimbabwe (South).

In Africa, the production and use of off-farm produced organic fertilisers and soil amendments are still in their early stages. In many countries, organic waste recycling lacks policy prioritisation, often due to non-existent policies, inadequate enforcement or unfavourable incentives. Currently, with some exceptions, only a small fraction of organic waste is being processed into organic fertilisers or soil amendments across the twelve case study countries. In South Africa, some communities are currently diverting up to 50 per cent of organic waste from landfills. The country formulated a National Organic Waste Composting Strategy in 2013. Nigeria has one of the highest production capacities, at about 500,000 tons/year, yet only 50 per cent of this capacity is currently utilised. Egypt is home to one of the largest single producers, with a production capacity of 120,000 t/year. Key organic waste streams include household food and green waste, market waste, agro-processing residues, and human excreta. These are processed into compost or liquid organic fertilisers. Non-source segregated organic waste composts typically contain nutrient levels below one per cent for nitrogen (N), phosphorus (P) and potassium (K), serving primarily as soil amendments. Higher nutrient values are achieved through waste sorting and treatment with biodigesters, black soldier flies (frass fertiliser) or worms (vermicompost). Co-composting household or agricultural waste with human excreta can also boost nutrient content, but outcomes vary depending on various factors. Sometimes, composts are enriched with chicken manure or inorganic fertilisers to elevate nutrient concentrations.

"Various existing technologies are effective, but the challenge lies in producing a high-quality product and implementing policy measures that encourage farmers to utilise them. The primary concern is not the technology itself but the entire value chain, from sourcing waste as a resource to delivering the final product to the market. This includes considerations of waste quality, related issues affecting waste quality, and the logistical challenges in waste collection and treatment." *(International consultant)*

Economic sustainability and pricing of organic fertilisers

Generally, we found that companies with access to knowledge, finances, technology and supportive local municipalities – such as those providing land close to waste streams – are key factors for success. Specifically, the involvement of international donors and/or research institutions played a crucial role for some companies. Additionally, active engagement with farmers and the establishment of field demonstrations are key success factors.

"We are profitable largely due to the scale that we operate at, with our largest costs being feed stock, the purchasing of organic materials and transporting it to our site. There isn't high quality enough equipment that matches what we need domestically, so we import it. The same for spare parts. And then you pay at least 30 per cent import tax on a vehicle that's assembled outside of the country. The biggest challenge was to convince and educate farmers on the importance and usefulness of the product [fortified compost]." *(Organic fertiliser producer, Kenya)*

Prices for organic fertiliser exhibit great variations across countries, ranging from 0.72 euros to 65 euros for 50 kg, respectively. In Senegal, one ton of inorganic NPK (nitrogen, phosphorus, potassium; 15:15:15) fertiliser was priced at approximately 800 to 1,100 euros (2023). To match the nutrient values of this fertiliser, one would need about four to five times the amount of a compost fortified with chicken manure and phosphate with NPK (4:3:3), which was priced at about 300 euros/t in Senegal. However, conducting such a simplified calculation may not account for all relevant costs and benefits, such as potential improvements in soil health, micronutrients and different levels of soil responsiveness to different types of fertilisers.

Potential supply of macronutrients from wastes

There is high potential for the (re)circulation of organic matter and its nutrients. In many contexts, substantial amounts of organic matter and nutrients could return to agriculture if systems were appropriately designed or adjusted.

"If you were really restructuring the system, you could meet between 20 per cent and 40 per cent of the nutrient requirements of an agricultural system within a specific boundary. In most cases I'm comfortable saying that somewhere around a quarter of the nutrient needs could be met through recycled nutrients." *(Researcher, ETH Zurich)*

Human excreta contain significant amounts of nutrients that, if captured, could contribute about 28 per cent of the world's current NPK consumption in agriculture or 22 per cent of global phosphorus demand. The potential for nutrient recirculation from human excreta is substantial, especially in sub-Saharan Africa, where 80 to 95 per cent of the population use onsite sanitation systems that require regular emptying. Unlike sewage systems, septage from on-site sanitation systems is generally not contaminated with heavy metals, and co-composting can effectively eliminate pathogens.

When assessing the theoretical nutrient potential present in human excreta across the twelve case study countries, the estimated nutrient quantities amount to approximately 3.4 million t/year of NPK. In comparison, the total agricultural consumption of inorganic fertilisers (NPK) in these countries reached 3.6 million tons in 2019. Additionally, the collection and recycling of household food and green waste could theoretically recover 71,000 t/N year, 71,000 t/P year and 141,000 t/K year across the twelve African countries (see Figure). In theory, the combined human excreta and household food and green waste produced in the case study countries could match the current NPK consumption. However, it is important to note that the current inorganic fertiliser application rate in Africa is low, at about 20 kg/ha. Under practice conditions, and after including potential losses, the contribution of NPK from off-farm produced organic fertilisers could be between 50 and 80 per cent of current inorganic fertiliser consumption.

Market wastes, slaughterhouse residues and other agro-processing by-products are additional sources. However, data on these wastes are limited. A study by the UN Food and Agriculture Organization (FAO) estimated that Ethiopia has about 1 million t/year (dry matter) of unused agro-processing by-products. Assuming a nutrient content of about 1 per cent, depending on waste type and treatment process, this translates to an estimated 10,000 tons of NPK.

In addition to the recirculation of macronutrients, the value of adding organic matter and micronutrients from recycled organic wastes should also be considered.

Current status of production and use of biofertilisers

The term "biofertiliser" (biostimulant) refers to a diverse array of microbial-based products incorporating plant teas, mycorrhizal fungi and beneficial bacteria, including nitrogen-fixing and phosphate solubilising bacteria. Biofertilisers can stimulate plant nutrition processes, are used as plant strengthener to enhance plant defence mechanisms, and indicate potential for yield improvements, specifically in dry and tropical climates, and carbon and nutrient poor soils.

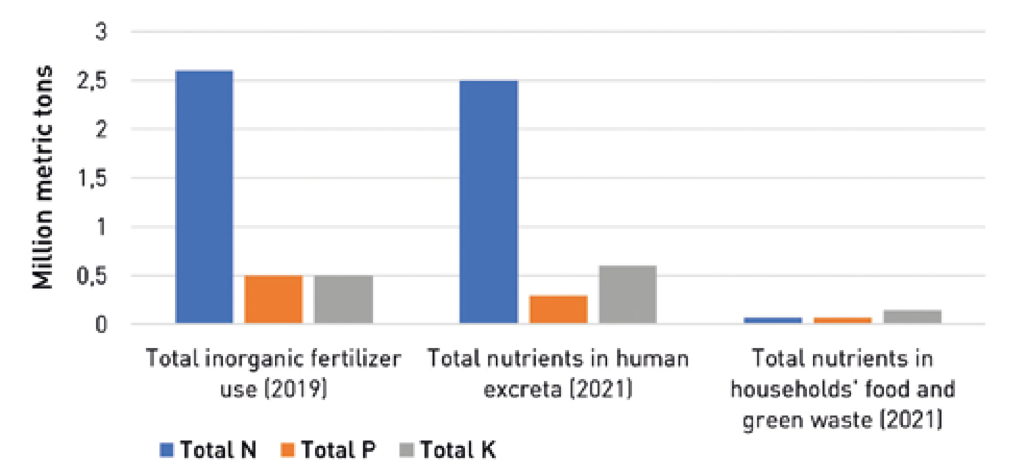
"According to our research, as well as by [research of] others, the yield of many crops increased by 16 per cent to 52 per cent when these crops received the recommended doses of biofertilisers." *(Researcher, Heliopolis University, Egypt)*

Of the global production of biofertilisers, products with N-fixing properties account for about 80 per cent, those with P-solubilising properties for 14 per cent and others for 6 per cent. The global market share of biofertilisers in Africa is estimated at about 5 per cent. The most advanced market in Africa for biofertilisers and producers can be found in South Africa. Egypt, Kenya, Malawi and Zimbabwe seem to exhibit a more advanced level of production and usage, primarily relying on rhizobia-based products. In contrast, Central and West Africa are the least developed regions in terms of production and usage. However, most of the biofertilisers marketed in sub-Saharan Africa are imported, and their product quality is often deficient.

One of the challenges regarding rhizobia production and use is the lack of access to modern technology. One exception is a company in Malawi, currently producing rhizobia for 50,000 ha. Further, consistent standards and quality control are lacking in many countries, which are crucial for consumer trust and hence increasing market shares. Most of the case study countries have introduced initial policies for organic and biofertilisers. However, these policies are often insufficiently comprehensive and are only partially implemented and enforced in practice.

"Quality standards and testing are missing. And enforcing the standard is what is more import-

Current application of NPK via inorganic fertilisers and total nutrients potentially available in human excreta and household waste across 12 African countries



Own calculation, figures are rounded; population data: World Bank (2021); total agricultural use of inorganic fertilisers (oxide forms converted to amount nutrient: N, P, K) from FAOSTAT (2019); human excreta according to Rose et al. (2015); household food and green waste data from Kaza et al. (2018); low anticipated average nutrient contents in compost N (0.5%), P (0.5%), K (1%) (e.g. Kabasiita et al., 2022).

ant because to have a standard that you don't enforce is as good as if you didn't have a standard. There are many products spilling in [from outside Africa] but you don't know if the product is tested, if it is good, if it is really working. So, they might sell it for a low price which finally affects the development of good products which might cost more but work in the end." *(Biofertiliser/rhizobia producer, Malawi)*

Challenges in biofertiliser application include limited understanding about storage, dosage and application technology, resulting in uncertainties and variable outcomes. Microbial contaminants are common problems influencing the quality of biofertilisers; hence the properties of carrier materials need to be well maintained to secure shelf life and, ultimately, product quality. Issues stem from incomplete knowledge of bacterial multifunctionality, complex interactions in soils and varying responses to biotic and abiotic factors. Technical challenges in formulation and inconsistent practical results are further important obstacles. However, as research and development continue, biofertilisers may play an increasing role in agriculture.

Key opportunities for scaling

The future potential of off-farm produced organic and biofertilisers appears promising for improving soil health and crop yields, reducing environmental pollution and human health burdens, and creating employment opportunities and additional income. To foster the potential for scaling, several key areas need to be addressed:

Policies, regulations and standards

- Institutionalise waste management through recycling policies, laws and regulations.
- Ensure policy consistency and cross-sector coordination: waste, sanitation, agriculture.
- Develop clear and unambiguous policies to permit and guide the safe application of fecal sludge (e.g. as co-compost) in agriculture.
- Create coherent standards and quality monitoring for organic and biofertilisers. Verified products with a constant quality and reliability are needed to gain consumer trust and hence foster market growth.
- Harmonise standards across countries to foster trade and create a favourable business environment.
- Collect regionalised source specific biomass data.
- Provide guidelines on the hygienic treatment of human excreta-based fertilisers and household waste.
- Support collection (reduce costs for entrepreneurs, decentralised production) and incentivise waste segregation in the context of private-public partnerships.
- Increase incentives by implementing blended finance, favourable interest rates, reduced import taxes and subsidies equivalent to those for inorganic fertilisers – among others.
- Reduce and optimise bureaucratic procedures, especially for small enterprises and start-ups.
- Municipalities can support entrepreneurs through the provision of land for processing.
- Municipalities can provide gate fees to treatment facilities for their services, just as they do for landfill management, to support waste management and ensure cost coverage for the treatment facility.

Economy and markets

- For any economic assessments, internalise external costs of lacking waste management (pollution, public health, etc.); and incorporate the value of other nutrients and the carbon.
- Foster business thinking – focus on both landfill reduction and the fertiliser market needs.
- Build on existing inorganic fertiliser market channels and also ensure affordable prices for smallholders.

Research, education and training

- Test optimal combinations of inorganic and organic fertilisers, soil amendments and biofertilisers combined with forage legumes/multipurpose legumes and alley cropping.
- Conduct systematic research on bacterial and fungal inoculants and optimal combinations.
- Intensify rhizobia research for all legume species; develop a forage legume seed market.
- Build awareness: establish advisory services, teaching and training on organic and biofertilisers.

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The full study report and a knowledge brief can be accessed at: https://www.desiralift.org/resources/

References: **www.rural21.com**