Sustainable Manufacturing and Environmental Pollution Programme (SMEP): A Circular Economy Experiment in the Global South

Anil Hira
Simon Fraser University

Henrique Pacini
United Nations Conference on Trade and Development

Kweku Attafuah-Wadee
Resources Transformation Ghana

Jonathan Hassall
United Kingdom’s Foreign, Commonwealth & Development Office

ABSTRACT

The circular economy (CE) is a topic of growing interest, spurred by climate change and increasing recognition of the considerable costs of energy and materials waste, that reflect increasing stress on global environmental systems. Those costs range from physical landfill expenses to effects on human and natural world health. While there are a growing number of articles about the CE, there remains a great deal of ambiguity around pathways to implement it, and even fewer practical examples. Lieder and Rashid (2016) conclude in their overarching examination of CE research that while it is broad and multidisciplinary it is also fragmented, highly granular, and “rarely touching implementation.” In this article, we review recent efforts to identify models for scaling up circular economy practices in specific sectors of Sub-Saharan Africa and South Asia economies, based on information produced by the Sustainable Manufacturing and Environmental Pollution (SMEP) program. The SMEP program has been established by the United Kingdom’s Foreign, Commonwealth & Development Office (FCDO) and is being implemented in partnership with the United Nations Conference on Trade and Development (UNCTAD). SMEP seeks to reduce pollution in manufacturing in the Global South. After a brief discussion of the CE concept, this article
focuses on the innovative features of the SMEP program, its preliminary findings and lessons for the transition to circularity.

**Keywords:** Circular economy, pollution, manufacturing, plastic, supply chains, regulatory capacity

**Ambiguity Around the Meaning of “Circular Economy”**

As Lieder and Rashid (2016) point out, there is a great deal of contestation around the term “circular economy,” what it means and how it can be achieved. Economist Kenneth Boulding’s classic 1966 article was the precursor for the idea of circular economy. In this article, the well-known economist referred to closed and open economy systems, and referred to the linear economy as “the cowboy economy” of a new frontier, while the circular economy (CE) was more like a “spaceship economy,” concerned about finite natural resources and the importance of waste management (Boulding, 1966). The recent popularization of the CE economy idea is often traced back to Pearce and Turner’s 1989 work on natural resource and environmental economics. They helped to introduce the idea of a “bioeconomy,” whereby the natural resource endowments of the Earth are part of a system that provides not only the useful resources for humanity but also the resources for all types of living organisms (Pearce & Turner, 1989). The efficient use of finite resources has consequences well beyond their initial use, including the costs of disposition of waste materials as well as their effects on the biosphere. The CE notion thus builds upon long-standing concepts on externalities in economics. Externalities are defined as benefits or costs not borne by the producers. The classic example is pollution, which creates negative air, land or water quality whose costs are spread far beyond the factories creating them, an effect often not observed by the consumer. This relates to the “tragedy of the commons,” where publicly shared spaces—or systems—tend to deteriorate as no particular user is responsible for their maintenance. The complications around climate change and overfishing clearly fit within the concerns about externality and common issues.

In short, the CE is more of a general concept than a theory, linking resource use with long-standing notions of “industrial ecology,” the bio-economy, “ecosystems” and more recent ideas about a “green economy” that emphasize a shift to lower carbon emissions (D’Amato & Korhonen,
The ideas about CE speak more widely to a paradigm shift, away from continual linear growth as a measure of economic success, to values of sustainability and more egalitarian distribution, the mutual dependency of human and natural systems and the economy as a dynamic system with feedback loops, rather than as a production machine (Raworth, 2017).

Becque et al. (2016, p. 5) perhaps offer the most comprehensive definition of the circular economy, stating that it rests on three principles:

(a) to preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows; (b) to optimize resource yields by circulating products, components, and materials at the highest utility at all times; and (c) to foster system effectiveness by designing out negative externalities. Implicit within this is the use of renewable energy, as well as using energy in the most productive way.

Korhonen et al. (2018), by contrast, suggest the main principle for the CE should be that “the material flows released from economy to nature should be in a form in which nature can utilize them in its own functions.” They provide the examples of using biomass as fertilizers to expand forests that can act as carbon sinks, or using anaerobic digesters to create fertilizers out of biowastes. As they acknowledge, even such shifts may not be enough to manage natural resources if global consumption, spurred by population growth, continues to increase. As the Global South continues its development, such concerns are bound to increase, particularly given the rapid growth of consumers in developing countries in the Global South. In line with this, the SMEP program is designed to reduce pollution at the source, rather than remediating it after.

The fact is current linear production and consumption models generate enormous amounts of waste. While there are few good global measurements, the EU has funded a CREEA (Compiling and Refining Environmental and Economic Accounts) project including the EXIOBASE which seeks to estimate overall waste. Using these data, Tisserant et al. (2017) estimate that households in the Global North generate 1–2 tons of solid waste per year. In fact, in 2007, total global waste was estimated to reach as much as 3.2 gigatons (Gt; 1 billion metric tons or 1 Gt), of which just 1 Gt was recycled or reused, 0.7 was incinerated, gasified, composted, or used as aggregates, and 1.5 Gt was landfilled. While plastics have been gaining the most attention due to their persistence in the environment, the main sources in terms of volume are construction,
metal, inert material, and paper/wood (Pacini & Golbeck, 2020). A more recent estimate is that only 15% of solid waste is recycled, with the rest going to landfills (Pietzsch et al., 2017).

As indicated above, the SMEP program was established by the Foreign, Commonwealth & Development Office (FCDO) of the United Kingdom and it is implemented in partnership with the United Nations Conference on Trade and Development (UNCTAD). SMEP seeks to reduce pollution in manufacturing and plastics production in the Global South. The SMEP program focuses on Sub-Saharan Africa (SSA) and (SA). These two regions are of particular interest in terms of global waste. According to the World Bank’s latest World Development Indicators (World Bank, 2022), just 1.5% of the world’s manufacturing takes place in SSA, and another 4.5% in SA. As a percentage of total GDP, the figures are 12% and 13%, respectively, in these regions.

These two regions are the fastest growing in the world. They averaged 4% and 7% annual growth between 2010 and 2018. Moreover, in the latest year for which data are available (2014), the manufacturing and construction sectors accounted for 13% and 26% of the CO₂ emissions in each region. SA is home to about 23% of the world’s population and has some of the fastest population growth rates. A recent report (SACEP [South Asia Co-operative Environment Programme], 2019, pp. ii, 1–2) estimates that 34% of waste in SA is non-organic and that at least 80% of plastic waste is improperly disposed. Most solid waste at present is simply openly dumped, reflecting a lack of regulatory enforcement. In this regard, the two regions of SSA and SA have the most urgent needs for waste management and thus are a fertile proving ground for circular economy experimentation.

The Limitations of Demand Side Strategies in the Global South

The CE concept goes well beyond improving current waste management approaches. Instead, it seeks to transform the nature of production and consumption. This includes “the 3 Rs” of reduction, reuse, and recycling, and more importantly, more consideration for the waste created during the production process itself. These can be elaborated more elegantly into demand and supply side strategies.

The most logical approach on the demand side would be to reduce consumption; however, there are no clear strategies at present for adopting this, which goes against the core logic of a market-based economy, in
which consumption is the driver. It would require rethinking the priority of economic growth, something that has been discussed widely in academic and policy circles, but without gaining traction elsewhere. Another way to reduce consumption would be to extend the lifespan of many disposable products, such as electronics (phones and computers), appliances, and a range of other products that are difficult to recycle (such as plastic bags and mixed textiles). Moreover, a new right to repair law further reinforces CE principles in the EU and the UK.

On the demand side, this implies wide changes in social norms and attitudes as well as technological fixes, small groups of individuals who are ecologically conscious cannot shift markets. Yet, drivers for shifting social values towards a CE a poorly understood and under-investigated area (Merli et al., 2018). On the supply side, Elia et al. (2017) suggest that there are four main areas to consider: production design and production process; business models, such as collaborative consumption/sharing economy approaches; cascade/reverse cycles skills development, including supporting new systems that lead to high quality recycling/reuse; and cross cycle and cross-sector collaboration, particularly creating collaboration among different industrial actors.

Bakker et al. (2014) suggest that change has to occur in the product design stage in order to achieve greater sustainability in consumption. This could also include choice of materials; reparability/refurbishment; remanufacture; as well as recycling. The challenge in most products, particularly electronics, is that technological innovation continually creates new and more sophisticated products, rendering existing ones out of date, even while they continue to function well. The remanufacturing or refurbishing of many products, such as laptops, would be too labor-intensive and ignores continual changes in design and technology. Thus, the possibilities for more sustainable—and longer—use will vary by product. By contrast, one advantage of the SMEP project is that it focuses on technologically “mature” sectors with smaller barriers to entry, such as food processing, textiles, plastics, and leather (SEI [Stockholm Environment Institute] and University of York, 2020).

Under the broader guise of efficiency, using less materials for the same outcome generally depends on whether such shifts are rewarded in the marketplace. An additional challenge is posed by the “rebound effect” whereby declining use of a material, such as petrol, leads to lower prices thus spurring demand. Zink and Geyer (2017) extend the rebound concept to the circular economy. For example, they point to challenges around
the substitutability of recycled materials, including the fact that it is often cheaper to engage in linear production of new goods than recycle or reuse them (ignoring externalities). They also note that consumers often believe environmental and recycling/reuse costs are negligible, and are reluctant to reduce overall consumption.

Here, the SMEP program operates on potentially more fertile ground. While most consumers in the Global South are less likely to actively seek green products given their income constraints, the cheaper costs of labor and the higher sensitivities to price allow for more immediate scope in terms of the circular economy. For example, in some markets in the Global South, there are viable secondary markets in mobiles, whereby refurbished phones are sold (Zink & Geyer, 2017).

The supply side also includes the development of internet-based platforms around the “sharing economy” that has created new businesses and revolutionized existing ones. The heart of the approach is to rent hours on an asset, such as a car share system. This allows the user to pay for time in use, rather than purchasing a whole asset. If the person uses a car only a few hours or days a week, then it is sitting idle most of the time. Thus, the sharing economy (in theory) allows for considerably greater efficiency in use and lowers the number of assets that need to be created. The sharing economy could ease the post-carbon transition, such as emerging car battery rental systems. For now, the sharing economy has resulted in limited applications for moving consumption in the Global South towards a circular economy, though it potentially makes some services based on capital goods more accessible (Hira, 2017). As a result, the SMEP program focuses on supply side solutions in manufacturing, rather than on the consumer side.

The Limitations of Existing Policy and Business Strategies for the CE

Given the challenges of shifting demand from a price fixation (ignoring externalities), it is most likely that immediate action will happen on the supply side. Therefore, the best way to move towards a CE is to change production processes, which is the main concept of the SMEP program. Supply side actions take place in two arenas, policy and business. Becque et al. (2016, p. 5) suggest five main areas for CE policy interventions: public procurement; collaboration platforms/sharing economy; providing technical support to businesses; fiscal policy particularly around taxes; education, information and awareness; and regulation, particularly around
materials. They further note that the transition to the CE will inflict pain upon linear-dependent businesses even while growing new lines, an effect which is undercovered by the literature. We focus here on the two main regions where CE policy interventions have been most pro-active, the EU and China.

Wilts et al. (2016) describe three CE policy instruments from EU policies that can be generalized. The first is setting up waste/recycling targets. The second is creating mandatory design standards for recycling, reuse, and repairability. The third is placing extended responsibility upon individual producers, for the entire life cycle of the product. They note that while attractive, each concept is challenging to put into practice because of the lack of ready indicators and the jurisdictional complexities involved in international trade. Calisto Friant et al. (2021) assess EU policies more harshly, suggesting that they are rhetorical, with action more on increasing recycling and waste management, without undertaking the fundamental shifts needed to develop a CE. Thus, the EU provides limited guidance for the Global South.

China embraced CE principles in its 12th Five Year Plan (2011–2015), where it states it seeks to improve energy and water efficiency in its heavy industries through recycling and remanufacturing, including encouraging exchanges between companies (Preston, 2012). These feed into China’s policies to promote eco-industrial parks where different companies co-locate in order to achieve efficiency, particularly in reuse of waste materials. Such initiatives are “top down,” led by the Chinese state (Ghisellini & Ulgiati, 2016; Matthews & Tan, 2011). Here, again there is limited policy transferability to the Global South, where few states have the ability to impose top down solutions along these lines.

In regard to business strategies, one can observe the following emerging strategies. Design and pricing of products must be changed to consider the entire lifecycle. This includes consideration of the manufacturing process to minimize waste and pollution and encourage the economic reuse of residues and by-products. The supply chain of production needs to be matched by a “reverse supply chain” of reuse or disposal (Urbinati et al., 2017). Product service systems (PSSs) such as sharing economy models, allow customers to use products, such as machinery or sensors sharing, without ownership.

There are many obstacles to shifting business models towards CE goals in a transformational way. New businesses and specific industry strategies are needed for recycling, reuse, remanufacturing, and more effective
disposal. Business customers have to be educated and motivated towards favoring circularity in their purchasing practices. Lüdeke-Freund et al. (2019) suggest that different business models need to be developed for each of the following: repair and maintenance; reuse and redistribution; refurbishment and manufacturing; recycling; cascading and repurposing; and organic feedstock. By cascading, they refer to developing multiple revenue streams from the same materials, that is developing co-products from waste. One can infer that models will differ significantly across (sub-) sectors.

Emerging technologies may similarly be helpful to CE goals. For example, smart manufacturing, that is, using data to improve efficiency; just-in-time inventory and lean supply chains; energy efficiency more generally; “dematerialization” through reducing materials use, such as sharing assets through sharing economy type arrangements; and diversifying the use of materials can all help (Gaustad et al., 2018). Nonetheless, there are significant barriers to circular economy technology adoption as presented by Masi et al. (2018). Financial barriers including up front capital costs, the short-term focus of most shareholder, and higher costs for recycling and reuse are significant. Institutional costs are wide ranging including a lack of standards, uneven standards across jurisdictions, barriers to inter-company cooperation, and inadequate regulatory incentives. Infrastructure and technologies for recycling and reuse are also underdeveloped. The authors note social resistance in the form of a lack of awareness and urgency for circular economy goals.

These challenges are even greater in a developing country context, with limited state capacity. In fact, environmental sustainability understandably generally ranks as a low priority both governments and businesses in the Global South. For example, neither the ambitious 2018 African Continental Free Trade Agreement (AfCTA) nor the Agreement on South Asia Free Trade Area (SAFTA) has any sections or provisions dedicated to improving environmental conditions (African Union, 2021). While there are an increasing number of FTAs with environmental provisions between Global North and Global South countries, such as the EU’s trade agreements with South Africa, Peru, and Vietnam (Ubaldo & McGuire, 2021), environmental governance principles are largely absent from regional trade agreements covering countries in the Global South (SMEP, 2020).

Given the challenges of creating effective national-level policies or business systems, one approach could be more feasible—the creation of eco-industrial parks that link different suppliers and users of waste and
by-products. Prior to the UN’s agenda emphasizing industrial resource efficiency, industrial parks were primarily based on the co-location of related industries operations. The focus on clustering-related industrial operations was driven by the goal of improving the efficiency, as well as reducing costs, for industry by sharing infrastructure, such as land, roads, and drainage ways, between co-located businesses. Eco-industrial parks, however, differ by also prioritizing the exchange of waste resources between industrial park establishments, thereby simultaneously extracting economic value and reducing industrial pollution (Sharma, 2013). According to Sharma (2013), eco-industrial parks, by adopting the concept of “waste as a resource,” facilitate a shift from a linear model of industrial production to a closed-loop model whereby the waste from a particular industrial activity can become raw materials for other industrial activities within the park.

An eco-industrial park requires a data system around circularity. Thus, risk is distributed and shared along the entire supply chain, along with gaining commitment from customers. Evidently, creating a viable eco-industrial park also requires new governance arrangements. Success in creating such arrangements can create an exemplar effect, where a platform design for the system could be imitated and adapted for other products and locations (Ehrenfeld & Gertler, 1997; Kornietzko et al., 2020).

Government policies that promote industrial zoning are important in tackling manufacturing pollution via eco-industrial parks (SMEP, 2020; World Bank Group, 2017). The Danish eco-industrial park of Kalundborg has achieved a semi-mythical status in the emerging CE literature. The park co-locates a power plant; oil refinery; a pharmaceutical company, and a plasterboard manufacturer; other smaller companies also participate in the by-product and reuse market. The power station supplies excess heat and steam to industrial and residential neighbors. Similarly, by-products of the power and refining processes are used by other industries through a series of complex contracts and arrangements that have evolved over time. Municipal authorities play a crucial role in managing water treatment and streamlining environmental regulations for collective benefit (Valentine, 2016).

China has also been experimenting with eco-industrial parks as part of its national CE plans. Likewise, industrial zoning is not uncommon in SSA nor SA (SMEP, 2020)—industrial villages and parks and special economic zones, either operational or in development, can be found...
in countries such as Nepal (e.g., Damak Clean Industrial Park, 2021), Pakistan (e.g., Patel Industrial Park, 2021), Kenya (e.g., Nairobi Industrial and Technology Park, 2021), and Tanzania (e.g., Kamal Industrial Park [Textile Development Unit Tanzania, 2021]). A broader term of “industrial symbiosis” is used to describe connecting companies not just in the linear supply chain but with others who can use by- and waste products to improve circularity. There must be a business, not just policy, case for connecting companies in a circular chain. Neves et al. (2020) find that proximity is just one factor behind such efforts. The reuse of wastewater, and combined heat and power plants are among long-standing efforts towards symbiosis. The petro-chemical, pulp and paper, and iron and steel industries have long-standing reuse of by-products.

Such parks could also potentially reduce infrastructure costs, since companies are co-locating, major transport and power conduits can be concentrated near the parks. A 2021 study by the World Bank of eco-industrial parks, such as the Savar leather industrial park in Bangladesh (SMEP, 2020) and Senegal’s Diammadiio park (UNIDO, 2018), emphasizes energy efficiency and renewable energy, and water, material and waste heat recovery as priorities for circularity. These can be achieved in good part by creating common park infrastructure alongside firm-to-firm streams for reusing waste/by-products. The report also sees potential in developing “smart,” data-driven systems, to both monitor efficiency and match partners for sharing or re-use of resources.

However, emerging studies about eco-industrial parks cast doubts about the spontaneous re-creation of the Kalundborg experiment, which relied on both a propitious co-location of symbiotic firms, and deep relations of trust among company and government officials (Branson, 2016). Consider, furthermore, that Kalundborg’s success depends on the excess heat of a coal-fired plant, one that is likely to be shut down in the future, putting the experiment in jeopardy. In a review of eco-industrial park experiments, Bellantuono et al. (2017) conclude that government policy must play a guiding role, including in creating adequate incentives and organizational spaces for industrial symbiosis to have a chance to gel. Other challenges include the prohibitive cost of investments in innovative technological solutions (World Bank Group, 2017). This hurdle raises concerns over competitiveness for firms operating within eco-industrial parks who have local competitors who are not required to meet similar technological advancement requirements (World Bank Group, 2017). Additionally, effective management of eco-industrial
parks can be hindered by absence of clear and appropriate mandates, as well as sufficient financial support for resident enterprises (World Bank Group, 2017).

Reviewing policy documents from across SSA (see bibliography) around the increasing push towards eco-industrial parks across the region (UNIDO, 2019), we find the emphasis placed on clustering-related manufacturing operations as part of an industrial development goal. The parks are designed primarily to attract investment capital (Walcott, 2020). The bottom line, as Urbinati et al. (2017) point out, is that despite the development of interesting cases, we have yet to develop a clear set of strategies or models that businesses could adopt to implement new CE practices. Ranta et al. (2018) note that in practice, CE policy activities across the globe are more focused more on recycling than reuse. They suggest that there is a lack of institutional support for the CE across three dimensions: regulative; normative, including business certification and accreditation systems; and culture-cognitive, reflecting shared beliefs and values, and find each lacking in support.

For example, there is inadequate regulation regarding disposal of materials or incentivizing reuse. There are inadequate transparency or certification systems to spur businesses who want to brand their products as eco-friendly. Customers generally prefer new products, where they see corporate initiatives, pressures are haphazard and inconsistent. Dell’s recycling program was spurred by California’s law that requires it to arrange for recycling end of life products, and by perceived cost savings from recycling. Apple has developed a global recycling program which seems comprehensive but avoids the issue of continual product replacement.

Towards Circularity in Manufacturing in the Global South

The importance of innovative environmental approaches in the Global South is desperately needed. A special edition of The Lancet points out that pollution is the largest environmental cause of premature death, accounting for an estimated 16% of all global deaths, “three times more deaths than from AIDS, tuberculosis, and malaria combined.” Of these, 92% occur in low- and middle-income countries, and is highest in SA and Southeast Asia and SSA. The Lancet signals how little has been done to address the issue (Landrigan et al., 2018). Estimates also show that a large percentage of global plastic waste occurs in Southeast Asia and South Africa. Much of
this waste is filtering into the oceans, with serious negative repercussions for marine life (Beaumont et al., 2019; Jambeck et al., 2015).

Manufacturing offers a particularly important node for CE experimentation, as a major user of resources and energy and producer of waste. The general concentration of manufacturing potentially makes implementation of CE principles more plausible. Ideas span a wide spectrum of possibilities, from redesign of equipment and manufacturing processes to recycling and reuse of waste products. Initial and intermediate inputs also do not suffer from consumer resistance to “used” products. Thus, manufacturing offers a more ready vehicle for CE transition in the Global South.

Yet, here again CE or zero waste manufacturing is more of a concept rather than a field of study so far. Though there is widespread acceptance of the need to shift processes in the Global South, actual efforts vary considerably, including which sectors should be in focus. For example, the African Ministerial Conference on the Environment (2019, p. 5) (AMCEN) suggests four main areas of focus: integrated waste management; agriculture; building and construction; and manufacturing, positing that CE efforts can lead to new jobs and reduction of poverty. However, the choice of sectors is not justified.

Moreover, manufacturing waste treatment lacks “technologies, knowledge and resources” (Singh et al., 2017, p. 1239). Nonetheless, the lack of collaborative reuse links among manufacturers and of a “reverse supply chain” around reuse of waste products remain significant barriers (Kumar et al., 2019). Jaeger and Upadhyay’s (2020, p. 729) survey of various manufacturers involved in CE efforts provides a useful starting point of elucidating the barriers in manufacturing. These are high startup costs; complex supply chains; challenges in business-to-business cooperation; lack of information to guide product design and production; lack of technical skills; concerns about quality of used materials; and most importantly, the costs of disassembly of products or residuals to create usable inputs. Similarly, the abundant use of metals across manufacturing makes their re-use a prime target for CE efforts. However, at present, recycling of metals varies considerably by element, reflecting the market price of obtaining new materials versus the costs of recycling. For example, recycling of lithium stands at less than 1% while copper and iron are recycled at over 50% rates (Giurco et al., 2014). In sum, current manufacturing exhibits serious challenges to circularity.

The SMEP program is a bold experiment in seeking ways to overcome the obstacles discussed above. SMEP fits within the African 10 Year...
Framework Programme on Sustainable Consumption and Production covers a host of activities from energy efficiency to promoting sustainable public procurement (UNEP, 2012). SMEP is funded by the UK Government at £24.6 million, and goes from 2018 to 2023. The program is designed to address the well-documented issues around negative health outcomes in manufacturing and plastics pollution in the Global South. The long-term goal is to reduce the negative health effects of pollution in the Global South, with a co-benefit of bringing carbon emission reductions through material and process innovations.

The SMEP baseline report found that the top industries in SSA in terms of value-added in 2020 were food and beverages; chemicals; metals; and non-metallic mineral products. For SA, they are: apparel and textiles; food and beverages; chemicals; and basic metals (SEI and University of York, 2020, pp. 10, 52). These industries thus became the principal targets for the SMEP projects. Activities take place across 10 countries in SSA and three in SA. The SMEP baseline study (SEI and University of York, 2020) identifies a wide variety of health-related hazards in the Global South related to manufacturing. These include the use of toxic metals; bleaching agents; air particulates; and water contamination.

The unusual strategy of the SMEP program is to reduce pollution at its source in manufacturing as well as plastics production, rather than cleaning it up after release, thus exemplifying circularity principles. Other recent reports note that vital important of attacking pollution at the source, that is, reducing it before it is produced as opposed to trying to clean it up afterwards; this is particularly the case for plastics. However, there are few current efforts at “upstream” reduction (Akenji et al., 2019, p. 3). In line with the baseline study, the SMEP program targets a variety of sectors, including lead acid batteries, tanneries, distilleries, and textiles, as well as creating a separate stream around plastics waste.

SMEP funds research by subcontractors with a local presence in SSA and SA to find ways to ameliorate such conditions. Areas of focus are both technical and policy-oriented: Identification of areas for regulatory reform and creation of national strategies around manufacturing and plastics pollution, as well as attempts to shift private sector manufacturing processes. The latter includes examining alternative materials that are less harmful to the environment and human health; improving efficiency and reducing waste; and developing better by-product and waste capture and treatment.
Preliminary Lessons from the SMEP Program for the Circular Economy

The SMEP provides important lessons for moving towards circular manufacturing in the Global South. In Kenya and Uganda, the project leads found financial, regulatory and technological barriers. The financial barriers include the need for significant capital that was hard to access. This is because most of the mitigation technologies have to be imported. Regulatory barriers reflect a lack of harmonization of standards across the region; a lack of monitoring and enforcement; and a general lack of awareness of existing standards, particularly among small- and medium-sized enterprises. In regard to technological barriers, business managers lack knowledge and skill around cleaner production techniques, and there are few local experts to fill gap (see SMEP, Open Capital, Surfacing private pollution mitigation strategies in Kenya and Uganda, final report).

The Kenya and Uganda manufacturing project identified pollution pathways for specific toxic resources. They then attempted to map out leading institutions and existing solutions, both domestically and abroad, which could begin to address the issues. The pathways include a spectrum of strategic points along the production chain from energy use and storage and raw materials substitution to improving pollution monitoring and waste disposal. The food and beverage sectors are the largest in the two countries, and so the first focus. The most promising initial strategic interventions were determined to be wastewater treatment technologies using membranes or filters; anaerobic digesters to produce biogas from organic waste; and plastic and rubber pyrolysis to replace diesel fuels. Interventions are needed in terms of providing capital and expertise (SMEP, Open Capital, Surfacing private pollution mitigation strategies in Kenya and Uganda, final report).

A second project was carried out to examine mitigation strategies for used lead acid batteries in Bangladesh. As noted in the project report (GAHP Final Report), such batteries are the lowest cost rechargeable batteries available and have been used to power low-cost e-mobility. Lead batteries have been identified as creating serious health hazard, with costs estimated at $15.9 billion, as residues affect human health, ecosystems, and agriculture. There is a vigorous secondary market for such batteries in autos, e-rickshaws, solar energy systems, and throughout the informal sector. The SMEP project in this case found major gaps in
consumer awareness and knowledge; a lack of clear standards and practices around worker safety; and general business sector disregards of existing environmental, health and safety standards. The recommendations are for interventions to improve government capacity; develop new private sector business models; to more directly improve public and worker knowledge; and create lab-based data on lead levels (GAHP [Global Alliance on Health and Pollution], 2022).

A third set of projects focuses on tanneries in Bangladesh and Ethiopia; distilleries in Kenya; and textiles in Tanzania. Tanneries use chemicals and heavy metals particularly chromium that are hazardous and carcinogenic. Serious issues were found in the Bangladesh project in regard to the effluent treatment of wastewater and the disposal of solid wastes, lending focus to the central effluent treatment plant. The project recommends improving training and certification for tannery owners; developing a public-private dialogue, improving regulation; and developing new techniques for treating wastewater and solid wastes, including reusing some solid wastes. Lack of access to finance for small and medium enterprises is cited as another major challenge. At the same time, there are relatively affordable solutions such as using vegetable powder to reduce the creation of toxic chrome as a by-product (Pure Earth, 2022; Teifa, 2022) Tannery Industry Pollution Mitigation Interventions for Bang., Final Report).

In Ethiopia, an industrial policy is in place to promote the local finishing of leather projects in order to create more employment. In fact, employment in the sector doubled from 2012–2013 to 2017–2018 to an estimated 21,094, mostly in footwear production. Similar problems to Bangladesh appeared, in regard to high levels of chromium appearing in adjacent agricultural areas, and copious amounts of solid waste with no secondary use. Solutions proposed here were distinct from Bangladesh. The proposal is for the development of an integrated management policy for tanneries. On the technical side, the suggestion was for the development of anaerobic digestion to reduce chromium; the development of by-products to make glue and biogas; and new solid waste treatment protocols (Teifa, 2022).

The third set of projects examined the textile industry in Tanzania, where there are an estimated 42 formal and 14,284 informal establishments as of 2016. These include a significant gender dimension, as women constitute an estimated 44% of all workers. The country exported an estimated $236 million in textiles in 2016. The main environmental challenges are
copious use of water; air pollution including particulate matter, solid waste; and noise pollution. The toxic chemicals from wastewater and solid wastes pose serious health hazards. The project recommends a new sectoral policy approach to improve efficiency and treat wastewater and solid waste. It also requires new equipment and technologies to reduce pollution. The report also recognizes the potential role for clean renewable energy to reduce air pollution (Teifa, 2022).

The final set of projects sought to examine potential substitutes for single use plastics in Bangladesh, Kenya, and Nigeria. Plastics are accumulating in soil and oceans at a rapid pace, thus damaging the biosphere. Most plastic is placed into landfills where it degrades into small particles that infect soil and water. These projects sought substitutes for single use plastics that would be less environmentally damaging. Plastic pollution is estimated to be accumulating in oceans at an annual rate of 12 million metric tons (Mt) per year (Geyer et al., 2017). The largest African economies of Egypt, Nigeria, South Africa, Algeria and Morocco produced an estimated 4.4 Mt of plastic waste in 2010 (Jambeck et al., 2018).

Meanwhile, SA produces an estimated 11% of global plastic waste, or 26.72 Mt per year (Kapinga & Chung, 2020). The most common alternative, incineration, creates toxic emissions and speeds climate change. Only about 5% of plastic is recycled in South Asia, and 10% in Africa. The damages to agriculture and human health are estimated in the tens of billions. There is considerable variation across the countries in regard to recycling efforts. South Africa and Kenya have formal efforts, while in Nigeria and Bangladesh, the informal sector is left to handle the issue. While there are new ideas about extended producer responsibility (EPR), to make producers liable, so far they remain at the concept stage. Indeed, most plastics labeling is confusing and underregulated for consumers.

The main aspiration for the plastics projects was to develop biodegradable plastics or alternative materials. Biodegradable plastics are not currently competitive, and the technology is likely beyond the capacity of most manufacturing in the Global South. There are abundant locally available substitute natural materials, such as cloth bags, wooden cutlery, paper packaging, and glass or aluminum bottles, all of which have lower environmental footprints and most of which can be price competitive with plastics. The project finds agricultural waste to be a particularly promising feedstock. However, the project report notes
that none provide the same user experience as plastics. Moreover, there
is a lack of consumer awareness around the issues of plastics disposal.
Thus, while there are regulations in most countries in the two regions
to reduce single use plastics, there is a lack of monitoring and enforce-
ment. There are major obstacles well in terms of recycling, with a lack
of capacity and an inability to handle the diverse polymer streams of
different plastic waste. Thus, several of the countries, including Kenya
are moving towards banning some plastic products, particularly single
use bags. Beyond these issues lies the challenge of ramping up manu-
factoring capacity of natural substitutes (Graduate Institute SMEP
Plastics Substitutes, final report).

Conclusion

The SMEP projects demonstrate the need for sector and context-specific
policy interventions in order to improve circularity in the Global South.
Poverty and the lack of public and private sector capacity create ines-
timable externalities on human health with repercussions around the
globe. The main factors pushing such dysfunctions to persist are
lower costs of existing materials and technologies; a lack of knowledge
and technical know-how around mitigation; and a lack of data and will
for monitoring and enforcement of basic standards. Particularly prob-
lematic is the existence of parallel informal sectors that generally evade
regulation. Alongside this is a lack of risk awareness by the government,
consumers, and workers that slows change. Thus, the experience from
the SMEP projects reinforces the serious challenges on both the supply
and the demand side.

While capital and policy capacity are serious obstacles for new produc-
tion and waste treatment technologies, SMEP also found major gaps in
knowledge. There are some relatively cheap improvements that could be
made via new business and policy models, such as converting residues to
organic waste. Further research and the development of guidebooks are
needed to usher in such processes. AMCEN, an African initiative (2019,
p. 6) points to National Cleaner Production Centres (NPCS), which have
been established in 14 countries there to promote training and related
CE initiatives; however, it signals the importance of green financing for
small and medium enterprises as the most important key to success. It is
possible to envision similar institutional vehicles that could go beyond
regulatory advances towards a type of manufacturing extension (similar
to agricultural extension) that would extend the capabilities in both the public and private sectors.

Since supply chains for particular products tend to be similar across countries, a global strategy and network are required to develop mitigation and circularity strategies by sector. This would allow for sharing CE models and also could lead to a form of signaling by consuming countries. For example, the EU now has sustainability regulations around imported leather. Such demand pushes, if matched with supply chain efforts, could significantly improve circularity in the Global South, but only if there is adequate capital, technology and knowledge transfer.

The lessons from the overall SMEP strategy can be summarized as follows:

1. Each country and sector in the Global South needs context-specific solutions, although comparison can be helpful for learning across cases.
2. Need to target specific sectors for interventions on the basis of their importance and feasibility, including alignment of government-private sector-public support.
3. Interventions are needed to develop recycling, reuse and secondary markets; they will not spontaneously arise.
4. There is a strong desire to retain more value added in the Global South; remanufacturing could be a vehicle.
5. Regulatory capacity and collaboration with the private sector needs to be improved.
6. External actors can play a significant role in providing finance and technology. While pressure on requirements for exports or on MNCs can play a role, this alone has limited effect.
7. Technological fixes need to be vetted for their attractiveness as business cases. Energy and material efficiency offer private-sector friendly pathways. Waste cannot be a free commodity.
8. Workers, industrial customers, and the public in domestic and foreign markets need more knowledge to understand the costs of environmental pollution, and vehicles to act upon that knowledge.

DECLARATION OF CONFLICTING INTERESTS

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
FUNDING

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: The development of this article was made possible with partial funding from UK-Aid as part of the SMEP programme.

REFERENCES

African Ministerial Conference on the Environment (AMCEN). (2019). *Enhancing the circular economy in Africa* (AMCEN/17/4, October 7). AMCEN, AU, and UNEP.

African Union. (2021). *Agreement establishing the African continental free trade area*. https://au.int/sites/default/files/treaties/36437-treaty-consolidated_text_on_cfta_-_en.pdf

Akenji, L., Bengtsson, M., Kato, M., Hengesbaugh, M., Hotta, Y., Aoki-Suzuki, C., Gamaralalage, P. J. D., & Liu, C. (2019). *Circular economy and plastics: A gap-analysis in ASEAN member states*. European Commission Directorate General for Environment and Directorate General for International Cooperation and Development. Association of Southeast Asian Nations (ASEAN).

Bakker, C., Wang, F., Huisman, J., & den Hollander, M. (2014). Products that go round: Exploring product life extension through design. *Journal of Cleaner Production*, 69, 10–16.

Beaumont, N. J., Aanesen, M., Austen, M. C., Börger, T., Clark, J. R., Cole, M., Hooper, T., Lindeque, P. K., Pascoe, C., & Wyles, K. J. (2019). Global ecological, social and economic impacts of marine plastic. *Marine Pollution Bulletin*, 142, 189–195.

Becque, R., Roy, N., & Hamza-Goodacre, D. (2016). *The political economy of the circular economy: Lessons to date and questions for research*. Climate Works Foundation.

Bellantuono, N., Carbonara, N., & Pontrandolfo, P. (2017). The organization of eco-industrial parks and their sustainable practices. *Journal of Cleaner Production*, 161, 362–375.

Boulding, K. (1966). The economics of the coming spaceship earth. In H. Jarret (Ed.), *Environmental quality in a growing economy* (pp. 3–14). Resources for the Future/John Hopkins University Press.

Branson, R. (2016). Re-constructing Kalundborg: The reality of bilateral symbiosis and other insights. *Journal of Cleaner Production*, 112(5), 4344–4352.

Calisto Friant, M., Vermeulen, W., & Salomone, R. (2021). Analysing European Union circular economy policies: Words versus actions. *Sustainable Production and Consumption*, 27(21), 337–353.

Damak Clean Industrial Park. (2021). About us. https://www.damakcleanindustrialpark.com/about.php
D’Amato, D., & Korhonen, J. (2021). Integrating the green economy, circular economy and bioeconomy in a strategic sustainability framework. *Ecological Economics, 188*, 107143.

Ehrenfeld, J., & Gertler, N. (1997). Industrial ecology in practice: The evolution of interdependence at Kalundborg. *Journal of Industrial Ecology, 1*, 67–79.

Elia, V., Gnoni, M. G., & Tornese, F. (2017). Measuring circular economy strategies through index methods: A critical analysis. *Journal of Cleaner Production, 142*(Part 4), 2741–2751.

GAHP (Global Alliance on Health and Pollution). (2022). Bangladesh used lead-acid batteries and tanneries. [https://smepprogramme.org/resources/manufacturing-pollution-synopsis-series-1-country-and-sector-priorities-2/](https://smepprogramme.org/resources/manufacturing-pollution-synopsis-series-1-country-and-sector-priorities-2/)

Gaustad, G., Krystofik, M., Bustamante, M., & Badami, K. (2018). Circular economy strategies for mitigating critical material supply issues. *Resources, Conservation and Recycling, 135*, 24–33.

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances, 3*(7), e1700782.

Ghisellini, P. C. C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114*, 11–32.

Giurco, D., Littleboy, A., Boyle, T., Fyfe, J., & White, S. (2014). Circular economy: Questions for responsible minerals, additive manufacturing and recycling of metals. *Resources, 3*(2), 432–453.

Hira, A. (2017). Profile of the sharing economy in the developing world: Examples of companies trying to change the world. *Journal of Developing Societies, 33*(2), 244–271.

Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: Cases from the manufacturing industry. *Journal of Enterprise Information Management, 33*(4), 729–745.

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science, 347*(6223), 768–771.

Jambeck, J., Hardesty, B. D., Brooksa, A. L., Friend, T., Telekic, K., Fabres, J., Beaudoin, Y., Bamba, A., Francis, J., Ribbink, A. J., Baleta, T., Bouwman, H., Knox, J., & Wilcox, C. (2018). Challenges and emerging solutions to the land-based plastic waste issue in Africa. *Marine Policy, 96*, 256–263.

Kapinga, C. P., & Chung, S. H. (2020). *Marine plastic pollution in South Asia*. United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP).

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. *Ecological Economics, 143*, 37–46.

Kornietzko, J., Bocken, N., & Hultink, E. J. (2020). Circular ecosystem innovation: An initial set of principles. *Journal of Cleaner Production, 253*, 119942.
Kumar, V., Sezersan, I., Garza-Reyes, J. A., Gonzalez, E. D. R. S., & AL-Shboul, M. A. (2019). Circular economy in the manufacturing sector: Benefits, opportunities and barriers. *Management Decision, 57*(4), 1067–1086.

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N., Baldé, A. B., Bertolini, R., Bose-O’Reilly, S., Boufford, J. I., Breyssse, P. N., Chiles, T., Mahidol, C., Coll-Seck, A. M., Cropper, M. L., Fobil, J., Fuster, V., Greenstone, M., Haines, A., …, Zhong, M. (2018). The lancet commission on pollution and health. *Lancet, 391*, 462–512.

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production, 115*, 36–51.

Lüdeke-Freund, F., Gold, S., & Nancy, M. P. (2019). A review and typology of circular economy business model patterns. *Journal of Industrial Ecology, 23*(1), 36–61.

Masi, D., Kumar, V., Garza-Reyes, J. A., & Godsell, J. (2018). Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective, *Production Planning & Control, 29*(6), 539–550.

Matthews, J. A., & Tan, H. (2011). Progress toward a circular economy in China: The drivers (and inhibitors) or eco-industrial initiative. *Journal of Industrial Ecology, 15*(3), 435–457.

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production, 178*, 703–722.

Nairobi Industrial and Technology Park. (2021). About us—NITP. http://nitp.ac.ke/about-us/nitp/

Neves, A., Radu Godina, S. G., & Matias, J. C. O. (2020). A comprehensive review of industrial symbiosis. *Journal of Cleaner Production, 247*, 119113.

Pacini, H., & Golbeck, J. (2020). Trade in scrap materials: Looking beyond plastics. *Preprints, 2020, 2020100044."

Patel Industrial Park. (2021). About group. http://www.patelindustrialpark.com/

Pearce, D. W., & Turner, R. K. (1989). *Economics of natural resources and the environment*. Hemel Hempstead, Harvester Wheatsheaf

Pietzsch, N., Ribeiro, J. L. D., de Medeiros, J. F. (2017). Benefits, challenges and critical factors of success for zero waste: A systematic literature review. *Waste Management, 67*, 324–352.

Preston, F. (2012). A global redesign? Shaping the circular economy. *Energy, Environment and Resource Governance. EERG BP 2012/02: 1–1. https://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/bp0312_preston.pdf"

Pure Earth. (2022). *High priority interventions to reduce environmental impacts from tanneries in Bangladesh*. https://smepprogramme.org/wp-content/uploads/2022/04/Pure-Earth-Cover-Note.pdf
Ranta, V., Aarikka-Stenroos, L., Ritala, P., & Mäkinen, S. J. (2018). Exploring institutional drivers and barriers of the circular economy: A cross-regional comparison of China, the US, and Europe. Resources, Conservation and Recycling, 135, 70–82.

Raworth, K. (2017). Doughnut economics: Seven ways to think like a 21st century economist. Chelsea Green Publishing.

SACEP (South Asia Co-operative Environment Programme). (2019). A roadmap for sustainable waste management and resource circulation in South Asia, 2019–2030. SACEP.

SEI (Stockholm Environment Institute) and University of York. (2020). Manufacturing pollution in sub-Saharan Africa and South Asia: Implications for the environment, health and future work: Main report. UNCTAD.

Sharma, A. (2013). The landscape of industry: The transformation of (Eco) industrial parks through history. https://doi.org/10.18533/journal.v2i9.216

Singh, S., Ramakrishna, S., & Gupta, M. K. (2017). Towards zero waste manufacturing: A multidisciplinary review. Journal of Cleaner Production, 168, 1230–1243.

SMEP. (2020). Manufacturing pollution in sub-Saharan Africa and South Asia: Implications for the environment, health and future work. https://www.sei.org/publications/manufacturing-pollution-in-sub-saharan-africa-and-south-asia-implications-for-the-environment-health-and-future-work/

Teifa, I. Q. (2022). Manufacturing pollution synopsis series 1: Kenya distilleries, Ethiopia leather and Tanzania textiles. https://smepprogramme.org/wp-content/uploads/2022/04/Teifa-IQ-Cover-Note.pdf

Textile Development Unit Tanzania. (2021). Kamal industrial park—Factsheet. https://tdu.or.tz/available-land/kamal-industrial-park/

Tisserant, A., Pauliuk, S., Merciai, S., Schmidt, J., Fry, J., Wood, R., & Tukker, A. (2017). Solid waste and the circular economy: A global analysis of waste treatment and waste footprints: Global analysis of solid waste and waste footprint. Journal of Industrial Ecology, 21(2), 628–640.

Ubaldo, M. D., & McGuire, S. (2021). The joint effect of private and public environmental regulation on emissions. https://voxeu.org/article/joint-effect-private-and-public-environmental-regulation-emissions(()=>text=The%20joint%20effect%20of%20private%20and%20public%20environmental%20regulation%20on%20emissions,-Mattia%20Di%20Ubaldo&text=The%20adoption%20of%20environmentally%20friendly,of%20greenhouse%20gases%20and%20pollutants.

UNEP. (2012). Sustainable consumption and production in Africa: 2002-12. UNEP.

UNIDO. (2018). Senegal’s new industrial park open for business. https://www.unido.org/stories/senegals-new-industrial-park-open-business
UNIDO. (2019). *International guidelines for industrial parks*. https://www.unido.org/sites/default/files/files/2019-11/International_Guidelines_for_Industrial_Parks.pdf

Urbinati, A., Chiaroni, D., & Chiesa, V. (2017). Towards a new taxonomy of circular economy business models. *Journal of Cleaner Production, 168*, 487–498.

Valentine, S. V. (2016). Kalundborg symbiosis: Fostering progressive innovation in environmental networks. *Journal of Cleaner Production, 118*, 65–77.

Walcott, S. M. (2020). *Industrial parks—An overview*. https://www.sciencedirect.com/topics/social-sciences/industrial-park#:~:text=An%20industrial%20park%2C%20also%20known,%2C%20%26%20Fujita%2C%202013).

Wilts, H., Gries, N. V., & Bahn-Walkowiak, B. (2016). From waste management to resource efficiency—The need for policy mixes. *Sustainability, 8*(7), 622.

World Bank. (2022). *World development indicators—DataBank*. https://databank.worldbank.org/source/world-development-indicators

World Bank Group. (2017). *An international framework for eco-industrial parks*. https://openknowledge.worldbank.org/handle/10986/35110

Zink, T., & Geyer, R. (2017). Circular economy rebound. *Journal of Industrial Ecology, 21*(3), 593–602.

**Anil (Andy) Hira** is a Professor of Political Science and specialist in Global Political Economy. His main focus areas are industrial policy and competitiveness and sustainable development. [Email: anil_hira@sfu.ca]

**Henrique Pacini** is an Economist at UNCTAD, where he works on trade and environment issues. His themes of interest are circular economy and plastic pollution, in special their transnational dimensions. [Email: Henrique.Pacini@unctad.org]

**Kweku Attafuah-Wadee** is an Environmental Science PhD student at SUNY ESF and an Environmental Consultant. His main interests are circular economy, resource management, and waste management. [Email: kweku.attafuah-wadee@unctad.org]

**Jonathan Hassall** is Environment Research Lead at the UK Foreign, Commonwealth and Development Office, where he leads on environment, nature and pollution research issues. His themes of interest are ecosystem restoration and pollution reduction. [Email: jonathan.hassall@fcdo.gov.uk]