SMEP: A Circular Economy Experiment in the South

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Introduction

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 together 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. 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 based on information produced through the Sustainable Manufacturing and Environmental Pollution program (SMEP). SMEP seeks to reduce pollution in manufacturing and plastics production in the global South. After a brief discussion of the CE, we turn to the innovative features of the SMEP, its preliminary findings and lessons for the transition to circularity.

Ambiguity Around the Meaning of "Circular Economy"

Economist Kenneth Boulding's classic 1966 article was the precursor for the circular economy. In the article, the economist referred to closed and open economy systems, referring to the linear economy as "the cowboy economy" of a new frontier, while the CE was more like a "spaceship economy," recognizing finite natural resources and the importance of waste management (Boulding, 1966). The more recent popularization of the CE economy is often traced back to Pearce and Turner's 1989 work 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 not only provides useful products but also the resources for all types of living organisms (Pearce and 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 effects on the biosphere. The CE notion thus builds upon long-standing concepts around externalities in economics. Externalities are defined as benefits or costs not borne by the producer. The classic example is pollution, which creates negative air, land or water quality whose costs are spread far beyond the factory 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 externality and commons issues. In short, the CE is more of a general concept than a theory, linking resource use with the long-standing notions of "industrial ecology," the bioeconomy, "ecosystems" and more recent ideas around a "green economy" that emphasizes shifts to lower carbon emissions (D'Amato and Korhonen 2021). The CE speaks more widely to a paradigm shift, away from continual linear growth as a measure of economic success, to include values of sustainability and more egalitarian distribution, seeing the mutual dependency of human and natural systems and the economy as a dynamic system with feedback loops, rather than a production machine (Raworth 2017).

Becque et al. (2016, 5) offer perhaps 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. Such concerns gain increasing currency given the rapid growth of consumers in developing countries in the South, which further highlights the doubts about the long-term feasibility of continuing linear consumption patterns. 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 North generate 1-2 tons of solid waste per year. In 2007, total global waste was estimated to reach as much as 3.2 gigatons (1 billion metric tons or 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 and 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).

The SMEP program focuses on sub-Saharan Africa and South Asia. These two regions are of particular interest for global waste. According to the World Bank's latest World Development Indicators, just 1.5% or the world's manufacturing value added took place in sub-Saharan Africa, and another 4.5% in South Asia in 2019. However, as a percentage of GDP, the figures are 12 and 13% respectively. Therefore, these two regions are the fastest growing the world, averaging 4% and 7% annual growth from 2010-8. Moreover, in the latest year for which data are available (2014), the manufacturing and construction sectors accounted for 13% and 26% of CO_2 emissions in each region. South Asia is home to about 23% of the world's population and has some of the fastest population growth rates. A recent report by SACEP

(2019, ii, 1-2) estimates that 34% of waste in South Asia 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 express 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 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 and reuse as well as recycling, and more importantly, more consideration for 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. The demand side implies wide changes in social norms and attitudes as well as technological fixes; small groups of individuals who are ecologically conscious cannot shift markets. According to some authors, 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, such as 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 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 that the CE means 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 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 South, there is a viable secondary markets in mobiles, whereby refurbished phones are sold (Zink and 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 allows for considerably greater efficiency in use and lower 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.

Of course, this is not really sharing but a different type of business model. In theory, the sharing economy should reduce transactions costs by reducing search costs and eliminating a middleman (wholesaler/retailer) to allow for more person-to-person transactions. However, in practice the sharing economy tends to be dominated by a few platforms in many sectors, such as car sharing companies, that can evade formal regulations such as safety and driver training and can dominate their workforce, taking a large percentage of their earnings through monopoly effects (Hira and Reilly 2017; Ravenelle 2017). In this sense, the sharing economy does little to reduce consumption, and, in contrast to its name, may stoke more individualist production and consumption patterns (Cherry and Pidgeon 2018). Moreover, gig jobs cannot substitute for the formal education and specialized training required for most high paying jobs. Indeed, most large platforms seem geared towards high, not low, income consumers (Ganapati and Reddick 2018). In short, the sharing economy, for now, seems to have limited applications for moving consumption in the South towards a circular economy, though it potentially makes some services based on capital goods more accessible. As a result, the SMEP program focuses on supply side solutions in manufacturing, rather than on the consumer side.

Examples of Policy Support Mechanisms and Business Strategies for CE Goals

Given the challenges of shifting demand from a price fixation (that does not figure in externalities), it is most likely that immediate action will happen on the supply side. In other words, the vast majority of consumers are likely to prioritize price over whether the goods they buy are made through green processes. Therefore, the best way to move towards a CE is to change production processes, which is the main concept of the SMEP.

Supply side actions take place in two arenas, policy and business models. Though there is widespread acceptance of CE values, actual efforts vary considerably, including which sectors should be in focus. For example, AMCEN, the African Ministerial Conference on the Environment, suggests 4 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 (2019, 5). However, the choice of sectors is not justified. The EU and China are the main regions who have pushed forward CE initiatives, but both with remarkable limitations in practice.

Becque et al. (2016, 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 under-covered by literature. Wilts et al (2016) describe 3 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 responsibility upon individual producers, which would mean that producers would bear the costs 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, focusing in practice more on increasing recycling and waste management, without undertaking the fundamental shifts needed to develop a CE. In short, the EU provides limited guidance for countries in the South.

China embraces CE principles in its 12th Five Year Plan (2011-15), where it states its goal to improve energy and water efficiency of 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 seen as "top down," led by the Chinese state (Matthews and Tan 2011). Ghisellini et al. (2016, 11) state that China has made the circular economy a national objective. They note the importance of all actors in society being willing to change patterns in order to develop more suitable "collaboration and exchange patterns." Here again what we see is that there is limited policy transferability to the South, where few states have the ability to impose top down solutions along these lines.

Thinking of 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 byproducts. 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.

Still, 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-Freunde 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, furthermore, 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 under-developed. Finally, 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 South. For example, neither the ambitious 2018 African Continental Free Trade Agreement (AfCTA) or the Agreement on South Asia Free Trade Area (SAFTA) has any sections or provisions dedicated to improving environmental conditions (African Union 2021). It must be noted, however, that there are an increasing number of FTAs with environmental provisions between Global North and South countries, such as the EU's trade agreements with South Africa, Peru, and Vietnam (Ubaldo and McGuire 2021). Environmental governance principles are largely absent from regional trade agreements covering countries in the South (SMEP 2020).

However, through the General Agreement on Tariffs and Trade (GATT) exceptions, RTAs in the South can indirectly address environmental issues relating to trade in manufactured goods (SMEP 2020). Notably, GATT exceptions apply for SAFTA and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) in South Asia and the Economic Community of West African States (ECOWAS) and the Southern African Development Community (SADC) in sub-Saharan Africa (SMEP 2020). Additionally, "deep" regional trade agreements - agreements that deal with regional development and cooperation - are secondary mechanisms for addressing pollution related to trade in manufactured goods

(SMEP 2020). The environmental provisions established in these types of agreements establish rights and obligations for signatories to protect the environment (SMEP 2020). The Common Market for Eastern and Southern Africa (COMESA) is an example of a "deep" regional trade agreement (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 byproducts as well as integrating CE concepts from design to disposal/re-use. Prior to the UN's agenda emphasizing industrial resource efficiency, industrial parks were primarily based on the co-location of related industries operations (Sharma 2013). 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 clustered businesses (Sharma 2013). 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.

To be effective, 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 (Kornietzko et al. 2020; Ehrenfeld and Gertler 1997).

Government policies that promote the industrial zoning are important in tackling manufacturing pollution (SMEP 2020) and facilitating sustainable industrial development in eco-industrial parks (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 Diamniadio 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).

Likewise, a review of industrial policies relating to industrial park in SMEP countries reveals a lack of emphasis on the incorporation of circularity and industrial symbiosis in the development of industrial parks. The policy documents for Ghana (Ministry of Trade and Industry – Republic of Ghana 2020), Kenya (Republic of Kenya 2012), Rwanda (Ministry of Trade and Industry - Government of Rwanda 2011), Ethiopia (FDRE Ministry of Industry 2013), and Pakistan (Khyber Pakhtunkhwa Board of Investment and Trade 2020) highlight the emphasis placed on clustering or co-location of related manufacturing operations in the development of industrial parks with the overarching goal of increasing industrial development. Policy evidence seen in those countries show a tendency for promoting the clustering of industrial operations, in addition to other incentives, as ideal for attracting investment capital, thereby spurring economic growth (Walcott 2020). According to a recent study on eco-industrial parks in developing countries, the lack of support and policies for industrial symbiosis had been a critical barrier to the development of eco-industrial parks (UNIDO 2016). Nonetheless, there is an increasing appreciation of the need to transition from co-location into eco-industrial parks in the developing world. During a UNIDO workshop in 2015, State Minister of Industry for Ethiopia espoused the need for the development of eco-industrial parks across Africa (UNIDO 2015) – as well as policy guidance documents that emphasis the incorporation of circular economy principles and business models in the development of industrial parks (UNIDO 2019).

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 so far, 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. They examine three dimensions of institutionality: 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 is inadequate transparency or certification systems to spur businesses who want to brand their products as eco-friendly. Finally, customers generally prefer new products. Where they see corporate initiatives, pressures are haphazard and inconsistent. For example, Huawei felt pressure from private stakeholders and thus began an e-cycling program. 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. Lieder and Rashid (2016) conclude in their overarching view of research on the CE that while broad and multidisciplinary, the field is "fragmented" and "highly granular and rarely touching implementation."

<u>The SMEP Program: Towards Circularity in Manufacturing in the South</u>

Even with all of these obstacles, we cannot afford to ignore the importance of environmental initiatives in the South. Indeed, 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 South and Southeast Asia and sub-Saharan Africa. 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 South(east) Asia and South Africa. Much of this waste is filtering into the oceans, with serious negative repercussions for marine life (Jambeck et al. 2015; Beaumont et al. 2019).

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 South.

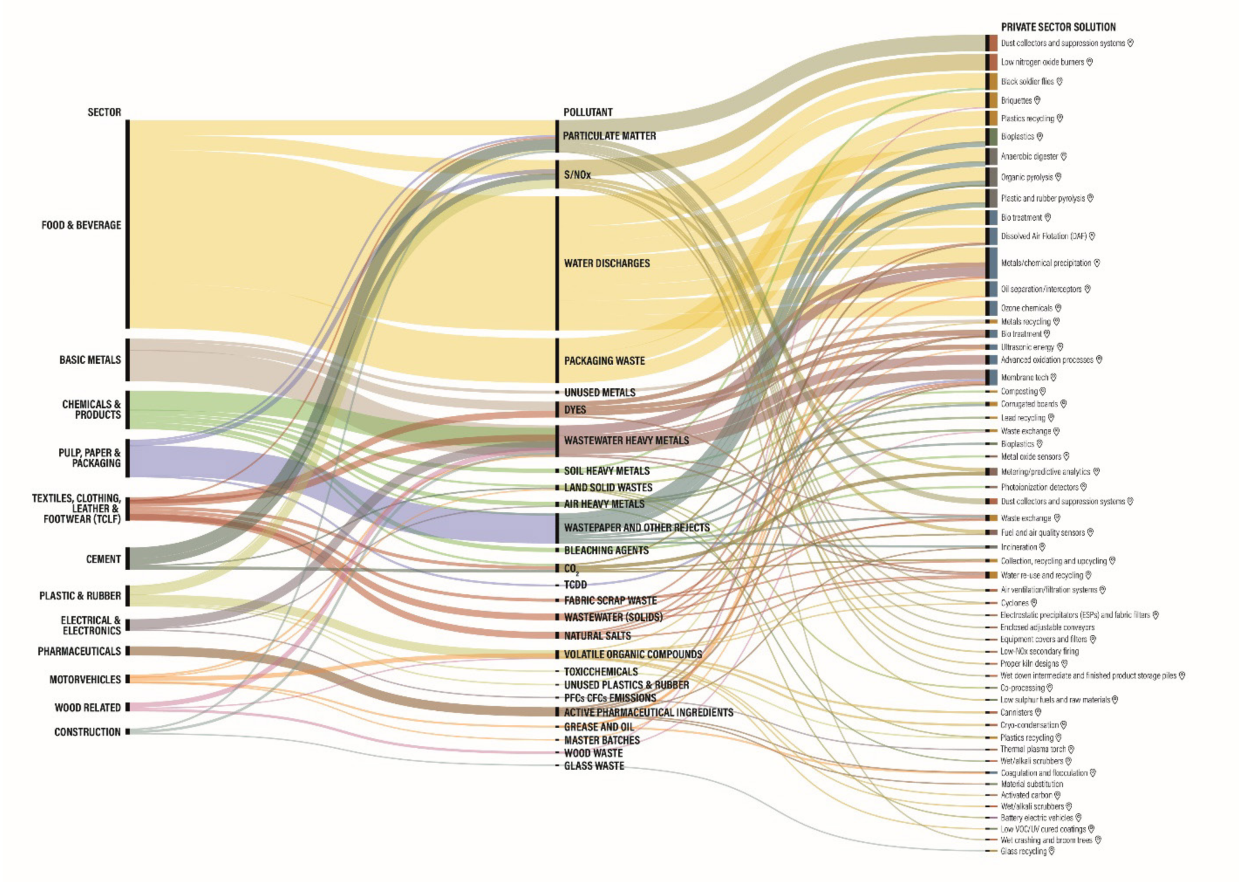
Yet, here again CE or zero waste manufacturing is more of a concept rather than a field of study so far. Manufacturing waste treatment lacks "technologies, knowledge and resources" (Singh et al. 2017, 1239). Nonetheless, the lack of collaborative reuse links among manufacturers and of a "reverse supply chain" around reuse of waste products remain significant barriers (Kumar et al. 2019). Jaeger and Upadhyay's (2020, 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 vs. 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 FCDO-UNCTAD (U.K. Foreign Commonwealth Development Office and the United Nations Conference on Trade and Development) Sustainable Manufacturing and Environmental Pollution (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 2018-23. The program is designed to address the well-documented issues around negative health outcomes in manufacturing and plastics pollution in the South. The long-term goal is to reduce the negative health effects of pollution in the South, with a co-benefit of bringing carbon emission reductions through material and process innovations.

The SMEP baseline report found that the top industries for sub-Saharan Africa in terms of value-added in 2020 were: food and beverages; chemicals; metals; and non-metallic mineral products. For South Asia, they are: apparel and textiles; food and beverages; chemicals; and basic metals (SEI and University of York 2020, 10 & 52). These industries thus became the principal targets for the SMEP projects. Activities take place across 10 countries in Sub-Saharan Africa and 3 in South Asia. The SMEP baseline study (SEI and University of York 2020) identifies a wide variety of health-related hazards in the 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, i.e. 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 a. 2019, 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 separate stream around plastics waste. The overall causal model is summarized in the following Figure:

Figure 1: SMEP as a CE strategy (to be developed)



Source: SMEP - Open Capital Advisors and UNCTAD.

SMEP funds research by subcontractors with local presence in Sub Saharan Africa and South Asia 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 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 (SMEP, Open Capital, Surfacing private pollution mitigation strategies in Kenya and Uganda, final report).

The various projects attempted different types of solutions to these issues. 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; to develop new private sector business models; to more directly improve public and worker knowledge; and to create lab-based data on lead levels (GAHP Final Report).

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, to improve 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 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 2012-3 to 2017-18 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 IQ Synthesis Report).

In regard to distilleries, the project in Kenya highlighted the sector-specific nature of CE transformations. This sector has a mix of both formal and informal enterprises. The challenges revolve around the discharge of vinasse in making alcohol. Vinasse reduced oxygen levels in water. There is also an issue around sold waste. As both residues are organic, the report recommends converting residues into fertilizer, and using better equipment to reduce the overall amount of waste (Teifa IQ Synthesis Report).

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 IQ Synthesis Report).

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, S. Africa, Algeria and Morocco produced an estimated 4.4 Mt of plastic waste in 2010 (Jambeck et al. 2018). Meanwhile, South Asia produces an estimated 11% of global plastic waste, or 26.72 Mt per year (Kapinga and Chung 2020). The most common alternative, incineration, creates toxic emissions and speeds climate change. Only about 5% of plastic is recycled in S. 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 African 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 under-regulated for consumers.

The main aspiration for the plastics projects is 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 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 enforcement. There are major obstacles s 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 manufacturing capacity of natural substitutes (Graduate Institute SMEP Plastics Substitutes, Final Report).

Needs more inputs from projects during the conference- did causality match up to what was expected? What challenges have they faced in public/national strategy and private sector strategies? What lessons for CE transformation- what else is needed?

Figure 2 Here: Summary of Lessons for CE from SMEP (to be developed)

Conclusion

The SMEP projects demonstrate the need for sector and context-specific policy interventions in order to improve circularity in the South. Poverty and the lack of public and private sector capacity create inestimable externalities on human health with repercussions around the globe. The main factors pushing such dysfunctionality 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 problematic 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 production 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, 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 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 South.

Needs expansion

Possible Journals

Journal of Cleaner Production, Sustainability, Journal of Industrial Technology, Renewable and Sustainable Energy Reviews; Resources, Conservation and Recycling; Intl. Journal of Sustainable Development and World Ecology; Waste Management; Energy, Environment and Resource Governance; Resources; Cleaner Environmental Systems; Journal of Waste Resources and Recycling; Production, Planning and Control; Procedia CIRP

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