The Sustainable Development Goals as Drivers of Change

Chapter 7 in: The Routledge Handbook of Waste, Resources and the Circular Economy

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Abstract

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Making the case for improved solid waste management (SWM) as a political priority is challenging. The three historical drivers of public health, local environmental protection and resource value are sometimes enough. The case is strengthened significantly by extending the scope from SWM to waste and resource management (WaRM) and the circular economy; and by recasting improved WaRM as an entry point for tackling higher profile sustainable development goals (SDGs). The primary home for SWM is SDG11 (*sustainable cities*) and indicator 11.6.1, which is envisaged as a data hub for compilation of a global baseline on WaRM in cities. But WaRM is directly related to indicators under SDG1 (*end poverty*); SDG 6 (clean water and sanitation); and SDG12 (*responsible consumption and production*). Links to *climate action* (SDG13) and *life below water* (SDG14) are surprisingly strong: e.g. cutting by half the weight of plastics entering the oceans through extending waste collection and eliminating uncontrolled disposal. Links to six other high priority SDGs are still direct but more difficult to measure (e.g. SDG8 *decent work* through sustainable job creation, and SDG2 *zero hunger* through reducing food waste). Indirect links can be made to the remaining five SDGs, including difficult-to-tackle equality and governance issues.

1. Evolution of Drivers for Waste and Resource Management

Solid waste management (SWM) is one of the essential utility services underpinning modern society. However, unlike water supply and sewerage, electricity and gas, transport and telephone and broadband internet, it is often not recognised as a utility (Wikipedia, n.d.). Arguably, it is the victim of its own success: regular solid waste collection in Western Europe and North America dates back to a series of cholera epidemics from the 1830s and the resulting drive to protect public health, and has been ubiquitous at least in urban areas for well over a century, so now is taken for granted – that is until something goes wrong, when it makes national or international news headlines.

Public health remained the major driver for more than a century (Wilson, 2007). It was not until the environmental movement started in the 1960s that new regulations to eliminate open dumping and burning of wastes were introduced from the 1970s, with standards gradually ramped up over the next few decades.

Resource value within waste pre-dates public health as a driver. In pre-industrial times, products were routinely repaired and reused, and materials recycled. Food wastes were either fed to animals or composted as a soil improver. The industrial revolution concentrated people in cites, increasing waste quantities while disrupting natural cycles back to the soil. Many of the urban poor made their livelihoods as informal 'street buyers' of source-separated reusable products or recyclable materials, or as 'waste pickers' retrieving materials from mixed waste. Since the nineteenth century, rising living standards and cheap mass production led to a steady decline in municipal solid waste (MSW) recycling rates in developed countries. Both rising disposal costs since the 1980s and increased public opposition to new sites have led developed countries to 'rediscover' recycling for MSW, driven not so much by revenues but rather by recycling markets offering a competitive 'sink'. The resource driver has recently been supplemented by growing concerns over the depletion of virgin raw materials and resource scarcity, leading to a new focus on waste prevention and resource efficiency. Hence the focus of this Handbook on waste, resources and the circular economy, and of this chapter on waste and resource management (WaRM), not just SWM.

Despite this progress, UNEP's inaugural *Global Waste Management Outlook* (GWMO1) in 2015 estimated that at least 3 billion people, more than 40% of the World's population, still lack basic SWM services (UNEP and ISWA, 2015). Extending waste collection to unserved neighbourhoods, and eliminating open dumping and burning, is essential to protect public health, prevent flooding and clean up the local environment, with children being especially vulnerable. In terms of the resource driver, the informal recycling sector is thriving in many cities as a means of livelihood for the urban poor and often achieves moderately high recycling rates, albeit at a social and environmental cost.

One of the objectives of GWMO1 was to highlight SWM as a political priority. The three historic drivers of public health, local environment and resource value, on their own, are often not enough to spark the policy level interest and resulting budgetary allocations needed to sustain basic, controlled municipal SWM services. An early analysis of the development drivers for waste management sought to strengthen the case by linking those into the drivers for sustainable development (Wilson, 2007). GWMO1 took that several steps further (UNEP and ISWA, 2015), establishing a firm framework of linkages to the Sustainable Development Goals (SDGs), which were at that time being developed in parallel. Linkages between the wider circular economy and the SDGs have also been explored (Schroeder, et al., 2018).

2. Improved Waste and Resource Management as an Entry Point for Achieving Multiple SDGs

2.1 Linking WaRM to the SDGs

The 2030 Agenda for Sustainable Development was adopted by Heads of State at the UN General Assembly in 2015 as a '*plan of action for people, planet and prosperity*'. It sets out 17 high-level SDGs, each subdivided into targets, 169 in all. The SDGs '*are integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental*'. The primary purpose is as drivers for action '*in areas of critical importance for humanity and the planet*' (UN, 2015).

Negotiating the SDGs took many years and involved much compromise. The scope had to be comprehensive, but equally the absolute number of goals and targets had to be constrained if the whole was to be implementable. So, some strong candidates for the primary goals had to miss out. For this Handbook, the good news is that ensuring sustainable consumption and production patterns (i.e. the circular economy) was adopted as SDG12; the bad is that SWM is not a primary goal. A similar compromise is reflected in SDG13, taking urgent action to combat climate change, while controlling air pollution in general is not a primary goal.

However, there is no suggestion that either SWM or controlling air pollution are low priorities, rather they are cross-cutting issues featuring in numbers of targets across multiple goals. SWM and air quality have each found a 'base' within the SDG11 indicator set on Sustainable Cities, while aspects of both are encountered in multiple SDGs.

GWMO1 argued that this could be viewed as a strength rather than as a weakness: '*The political case for action can be significantly strengthened when waste management is viewed as an 'entry point' to address a range of (SDGs), many of which are difficult to tackle*'

(UNEP and ISWA, 2015). However, the call for attention to improve SWM, and the transition to WaRM, is diffused in practice across many SDG goals and targets, leading to potential gaps and overlaps. So, GWMO1 set out what could be termed a SWM- and WaRM-related 'virtual SDG', i.e. what such a goal might have looked like had all the relevant targets been collated under a single high-level SDG. In GWMO1, the five targets were labelled as 'Global Waste Management Goals', but to avoid confusion they have been termed here as 'global waste targets' and numbered 'target GW1', etc.

The linkages between these five global waste targets and the 17 SDGs and their targets was first set out in GWMO1, and subsequently elaborated (Rodic & Wilson, 2017) (Lenkiewicz, 2016). The discussion below has also been informed by early drafts of the second edition of the GWMO (GWMO2) (UNEP and ISWA, 2022).

Figure 1 and *Table 1* together present a simplified overview of some of these linkages. In *Figure 1*, the rows are the 17 SDGs, while the columns are primarily the five global waste targets. The linkages are sub-divided into three groups: direct links which are in principle measurable and/or explicit under an SDG target (six SDGs); direct links that are more difficult to measure (six SDGs); and indirect links (five SDGs). *Table 1* expands on the 12 direct linkages, with these categorised according to the three overarching drivers discussed in *Section 1*.

2.2 Direct Entry Points to the SDGs

Public health is the driver for the first global waste target GW1 '*ensure access for all to adequate, safe and affordable solid waste collection services*.' The wording reflects that in SDG targets 11.1 (under the goal sustainable cities) and 1.4 (end poverty), with solid waste collection included in their list of 'basic services'. There is also a clear and direct link to SDG 3 (good health and well-being), as uncollected waste causes both childhood and waterborne diseases, the latter via blocked drains and watercourses.

Local environmental protection is the driver for target GW2, '*eliminate uncontrolled disposal and open burning*'. Both targets GW1 and GW2 are directly linked to two SDG targets: 11.6 on reducing the adverse environmental impact of cities is the most explicit in referring to both air quality and solid waste management; while these two global waste targets provide a necessary first step towards SDG target 12.4, '*environmentally sound management of … all wastes … in order to minimise their adverse impacts on human health and the environment',* the wording of which is reflected in target GW3. Target GW2 also links directly to SDG target 6.3 (*improve water quality by … eliminating dumping …*') and both targets GW2 and GW3 to SDG15 (protect life on land).

SUSTAINABLE DEVELOPMENT GOALS	*Global Waste Targets* [1] [2]					
	GW1. Ensure access for all to solid waste collection	GW2. Stop uncontrolled dumping and open burning	GW3. Achieve environmentally sound management	GW4. Reduce, reuse, recycle and create jobs	GW5. Halve food waste from markets, shops and homes & reduce food losses in the supply chain	*Governance factors underpinning sustainable SWM*
Key to the shaded boxes: *Direct link – in principle, measurable* / *Number: SDG target that explicitly requires decent SWM* (1.4) / Direct link – but difficult to measure / Indirect link						
1 END POVERTY[2]	1.4					
2 ZERO HUNGER						
3 GOOD HEALTH AND WELL-BEING						
4 QUALITY EDUCATION						
5 GENDER EQUALITY						
6 CLEAN WATER AND SANITATION		6.3				
7 AFFORDABLE AND CLEAN ENERGY						
8 DECENT WORK AND ECONOMIC GROWTH						
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE						
10 REDUCED INEQUALITIES						
11 SUSTAINABLE CITIES AND COMMUNITIES	11.6 11.1	11.6				
12 RESPONSIBLE CONSUMPTION AND PRODUCTION			12.4	12.5	12.3	
13 CLIMATE ACTION						
14 LIFE BELOW WATER	14.1	14.1				
15 LIFE ON LAND						
16 PEACE, JUSTICE AND STRONG INSTITUTIONS						
17 PARTNERSHIPS FOR THE GOALS						

Figure 1: Linkages between Solid Waste Management (SWM) / Waste and Resource Management (WaRM) and the Sustainable Development Goals (SDGs)[2]

Managing waste properly and improving SWM/ WaRM / developing the circular economy can help deliver all the SDGs

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[1] The five global waste targets were termed 'Global Waste Management Goals' in GWMO1 (UNEP and ISWA, 2015). They represent what a SWM- and WaRM-related 'virtual SDG' might have looked like had it been included as a high-level SDG. [2] Some wordings have been edited for clarity and conciseness.

Table 1. Relationship between Sustainable Development Goals (SDGs) and Solid Waste Management (SWM-) / Waste and Resource Management (WaRM-) related Global Waste Targets

Adapted extensively from (Rodic & Wilson, 2017)

Drivers		Sustainable Development		SWM / WaRM
		SDG [1]	**Specific SDG Target** [1 2]	**Global Waste Targets** [3]
Protection of public health		SDG11: Sustainable cities	**11.1** Ensure access for all to adequate, safe, and affordable housing and **basic services** and upgrade slums	→ **Target GW1. Ensure access for all to adequate, safe, and affordable solid waste collection services.** *Waste collection is a basic utility service. Uncollected waste is often dumped in waterways or burned in the open air, thus directly causing pollution and contamination. Waste also clogs the drains, which exacerbates floods, keeps water stagnant and contributes to water-borne diseases and malaria. Children are among the most vulnerable, so they are affected the most.*
		SDG1: End poverty	**1.4** Ensure that all men and women, in particular the poor and vulnerable, have equal … access to **basic services** …	
		SDG3: Good health and well-being	3.2 End preventable deaths of children under 5 years 3.3 End malaria and combat water-borne diseases 3.9 Reduce illnesses from hazardous chemicals and air, water and soil pollution, and contamination	
		SDG11: Sustainable cities	**11.6** Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and **municipal and other waste management**	
		SDG12: Responsible consumption and production	**12.4 Environmentally sound management of** chemicals and **all wastes** … in order to minimise their adverse impacts on human health and the environment	→ **Target GW2. Eliminate uncontrolled dumping and open burning**, *as the first stepping-stone to achieving environmentally sound SWM practices.* → **Target GW3. Achieve the sustainable and environmentally sound management of all wastes, particularly hazardous wastes** (*both chemical and biological hazardous wastes*).
Protection of the environment	**LOCAL**	SDG6: Clean water and sanitation	**6.3** Improve water quality by reducing pollution, **eliminating dumping** and minimising release of hazardous materials	
		SDG15: Protect life on land	15.1 Ensure the conservation of terrestrial and inland freshwater ecosystems and their services	
	GLOBAL	SDG7: Affordable and clean energy	7.2 Increase the share of renewable energy in the global energy mix	→ **Target GW3.** *SWM technologies can derive renewable energy from (organic) waste.*
		SDG13: Climate action	SDG13: Take urgent action to combat climate change and its impacts	→ **Targets GW2 & GW3.** *Improved WaRM practices can mitigate large amounts of climate pollutants* [4].
		SDG14: Life below water	**14.1 Prevent marine pollution** of all kinds, **in particular from land-based activities, including marine debris**	→ **Targets GW1** & **GW2.** *Extending waste collection to all and eliminating uncontrolled dumping will prevent waste (particularly plastics) entering the oceans* [4].

Table 1. *Cont.*

Drivers	Sustainable Development		SWM / WaRM
	SDG [1]	**Specific SDG Target** [1] [2]	**Global Waste Targets** [3]
Resource value Sustainable livelihoods	SDG12: Responsible consumption and production	**12.5 Reduce waste through prevention, reduction, recycling, and reuse** 12.1 Implement the 10-Year Framework Programme on Sustainable Consumption and Production … 12.2 Achieve the sustainable management and efficient use of natural resources	**→ Target GW4. Substantially reduce waste generation through prevention and the 3Rs (reduce, reuse, recycle) and thereby create 'green' jobs** *Waste prevention is the highest-ranking option in the waste management hierarchy. It is followed by reuse of products or their parts, and then by recycling of component materials.* *Both this target and several targets under SDGs 8, 9 and 12 extend explicitly into the circular economy* *Reuse and recycling have significant potential for creating jobs.* **→ Target GW1 Extend collection, Target GW4 3Rs and Target GW5 Halve food waste** *In developing countries, SWM services (both for collection and recycling) are often provided by individuals and small and micro-enterprises. Similarly, much food is grown by small-scale producers who are particularly vulnerable to food losses prior to market. Any measures applied to support them will improve livelihoods and directly contribute to SDG1 as well as to SDGs 8, 9 and 2.*
	SDG8: Inclusive and sustainable economic growth and decent work for all	8.3 … support … decent job creation … encourage the formalisation and growth of micro … -sized enterprises, including through access to financial services 8.4 Improve … global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation …	
	SDG9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	9.1 Develop quality ... sustainable ... infrastructure ... with a focus on affordable and equitable access to all 9.3 Increase the access of small-scale ... enterprises ... to financial services, including affordable credit, and their integration into value chains and markets 9.4 ... increase resource-use efficiency and ... adopt .. clean and environmentally sound technologies and industrial processes ...	
Resource value End hunger	SDG1: End poverty	1.4 Ensure that all men and women, in particular the poor & … vulnerable, have equal rights to economic resources … land … and financial services, including microfinance	**→ Target GW5. Halve per capita global food waste at the retail and consumer levels and reduce food losses in the supply chain.** *See also comment above on small-scale producers, which relates to SDG target 2.3, which calls for the doubling of their agricultural productivity and incomes by 2030.*
	SDG12: Responsible consumption and production	**12.3 Halve per capita global food waste at the retail and consumer levels** and reduce food losses along production and supply chains, including post-harvest losses	
	SDG2: Zero hunger	SDG2: End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	

[1] Source of SDGs and SDG targets: (UN, 2015) (UNStats, n.d.). The wording has in some cases been shortened. Some of the Global Waste Targets in the last column apply to multiple SDGs and SDG Targets in the previous columns (i.e. some rows overlap). [2] Bold highlighting of SDG targets denotes more explicit referencing to SWM/ WaRM. [3] The five global waste targets were termed 'Global Waste Management Goals' in GWMO1 (UNEP and ISWA, 2015). They represent what a SWM- and WaRM-related 'virtual SDG' might have looked like had it been included as a high-level SDG. The wording has in some cases been shortened. Explanations are given in *italics*. [4] Further discussion and references are provided in Section 2.2.

Resource value is a major driver for global waste targets GW4 and GW5, but Table 1 highlights linkages to other drivers that traditionally command more political attention. Sustainable livelihoods (SDG8) is an explicit driver for target GW4: '*Substantially reduce waste generation through prevention and the 3Rs (reduce, reuse, recycle) and thereby create 'green' jobs'*, which also reflects in part the wording of SDG target 12.5. End hunger (SDG2) is a driver for target GW5: '*Halve per capita global food waste at the retail and consumer levels and reduce food losses in the supply chain*', which echoes the wording of SDG target 12.3. Indeed, the UN Food and Agriculture Organisation has calculated that one third of all the edible food the world grows goes to waste, 1.3 billion tonnes a year, which would be enough to feed all the hungry twice over (FAO, 2015).

In developing countries, SWM services, both for collection and recovery, are often provided by individuals and small- and micro-enterprises, who are often referred to as the 'informal sector' (Wilson, et al., 2006) (Scheinberg, et al., 2010) (UNEP and ISWA, 2015). Similarly, much food is grown by small-scale producers who are particularly vulnerable to food losses prior to market. Table 1 highlights several SDG targets, under SDG2, SDG8 and SDG9, aimed at supporting such groups, which will improve livelihoods and contribute directly to SDG1 (end poverty).

2.3 Linkages to Global Environmental Crises

Two of the linkages shown in *Figure 1* and *Table 1* are worthy of more detailed discussion, as improved WaRM can make a major contribution to mitigating both global heating (SDG13) and the quantity of plastics entering the oceans (SDG14, target 14.1).

2.3.1 Climate Change

Global heating has been a major driver for improvements in municipal SWM in Europe since at least the 1990s, with legislative targets set for diversion of waste from landfills explicitly to reduce emissions of methane (CH_4), a powerful short-lived climate pollutant, from anaerobic decomposition of organic wastes. For example, changes in Germany's waste sector between 1990 and 2006 reduced the country's total greenhouse gas (GHG) emissions by 5% (Dehoust, et al., 2010); this was in addition to the significant mitigation of methane emissions already achieved between the first introduction of regulatory controls on solid waste disposal in the 1970s and 1990.

But direct emissions of methane are just part of the story. Reuse and recycling can yield large indirect savings in industrial processes, reducing direct energy consumption as well as avoiding mining, processing and transporting virgin raw materials – e.g. recycling reduces

GHG emissions from a tonne of aluminium by 97%. A life cycle assessment (LCA) carried out for the German government examined four example countries – Germany, Turkey, Tunisia and Mexico – and estimated that a 10-15% reduction in global GHG emissions could be achieved through improved WaRM, including landfill mitigation and diversion, energy from waste and recycling (Dehoust, et al., 2010).

Extending the scope of WaRM to include waste prevention increases the impact further. Taking as just one example the FAO estimate of 1.3 billion tonnes a year of edible food waste, growing this food which is not eaten accounts for 8% of total GHG emissions (FAO, 2015).

Against this background, the official estimate of around 3% as the contribution of the waste sector to global GHG emissions, made by the UN's Intergovernmental Panel on Climate Change (IPCC) in its 2013 Fifth assessment report, looks like a significant underestimate. The discrepancies are however easy to explain. The IPCC estimate refers to a 2010 baseline, so the huge progress made before then by the developed world (but not yet developing countries) in mitigating methane from land disposal is not accounted for. The IPCC is the custodian of climate science and is incredibly careful to avoid any double counting – so indirect savings in other agricultural or industrial sectors from prevention, reuse and recycling are explicitly excluded.

There is one additional factor to be considered. Open burning of MSW is recognised as a potential contributor, but IPCC did not have sufficiently reliable data to include in its 2013 assessment. Open burning produces black carbon (soot), an extremely powerful short-term climate pollutant with a potency compared to carbon dioxide of around 3,000 (which compares to 30 for methane). Recent research at Imperial College London has aimed to plug the data gaps, resulting in a best estimate of the contribution of black carbon from the open burning of MSW to global heating in the range 2-10% of global CO_2e emissions (Reyna-Bensusan, et al., 2018) (Reyna-Bensusan, et al., 2019).

Finding 'low hanging fruits' which offer significant reductions in climate pollutants over a short time-frame is a major priority in the fight to mitigate global heating. Improving WaRM and moving towards a circular economy provides a compelling entry point for making significant reductions to climate pollutants across the World economy. Whether the mitigation potential is 15, 20 or 25% or even more will continue to be debated (UNEP and ISWA, 2015) (Wilson, 2018). The linkage is strong, direct and in principle measurable, although the UN has allocated responsibility for such measurement to the IPCC rather than under SDG targets and indicators - hence no specific SDG target is shown here in *Figure 1*.

2.3.2 Marine Plastics

Marine plastics has emerged relatively recently as a major cause for public concern, and largely post-dates the SDGs. Target 14.1 encompasses plastics but is not as explicit as it would likely be if being drafted today: '*Prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.*'

Most plastics entering the ocean comes from land-based activities. Modelling studies estimate that about 10 million tonnes of plastics enter the oceans from the land each year (Jambeck, et al., 2015), with 20% of that from rivers (Schmidt, et al., 2017) (Lebreton, et al., 2017); this is at least an order of magnitude greater than estimates of the visible quantities in the oceans or on beaches (ISWA, 2017) – so the first priority is to 'turn off the tap'. Land-based sources include unmanaged or mismanaged municipal solid wastes in developing countries; litter from all countries; manufacturing wastes including spillages of plastic pellets; micro- and nano-plastics in products; fibres from washing synthetic textiles; and micro-plastics from road vehicle tyre wear (ISWA, 2017). A recent review of evidence concluded that unmanaged or mismanaged MSW in developing countries likely accounts for 50-70% by weight of plastics entering the oceans (CIWM and Wasteaid UK, 2018). It follows that the quantity of plastics entering the oceans could at least be halved by extending MSW collection to all and eliminating uncontrolled disposal, which are the global waste targets GW1 and GW2.

2.4 Indirect Linkages to all the Remaining SDGs

Figure 1 and *Table 1* shows that improved WaRM provides a direct entry point into 12 of the 17 SDGs, sub-divided into two levels of impact. The less detailed *Figure 1* extends the argument to include indirect effects, which extends the linkages to include all 17 SDGs.

SWM is an issue of human dignity, and arguably of human rights and equality. Lack of access to such a basic utility service directly impacts on inequality within a country (SDG10). Women and children do most of the work within the home, including bearing the main responsibility for SWM/WaRM. Self-management by dumping and burning is both more time consuming and more hazardous, so access to collection services both promotes gender equality (SDG5) and frees up time for education (SDG4). Reuse and recycling similarly supplement household livelihoods, again impacting on both gender equality and opportunity to access education. Properly functioning SWM/WaRM in a city requires good governance and well-functioning institutions (SDG16), including control of corruption (target 16.5).

Improving WaRM requires capacity building and improved access to international finance and technology transfer (SDG17).

3. SDG Indicators

'*If you don't measure it, you can't manage it*'. Having set 17 high-level SDGs and 169 component targets, the next step for the UN was to assign indicators to monitor progress towards meeting them, and then to agree methodologies to measure each indicator.

Data relevant to sustainable development has not traditionally been collected by national statistics agencies. So, in parallel to negotiation of the SDGs, the UN Secretary General set up an Independent Expert Advisory Group on a *Data Revolution for Sustainable Development* (IEAG, 2014). Data then needs to be turned into indicators in a '*form that is designed to synthesise, simplify and communicate information and to turn that into knowledge*' (UNEP and ISWA, 2015). Negotiations again aimed to keep the number of SDG indicators manageable: having agreed on 165 targets, this meant that more than half of the targets were restricted to just one indicator. The list of indicators adopted by the UN General Assembly in July 2017, to act as a starting point of work on measurement protocols, totalled 241 entries, or allowing for those listed against more than one target, 230 indicators. 36 major changes to the framework in the form of replacements, revisions, additions and deletions were agreed as part of the 2020 Comprehensive Review (UNStats, n.d.). To give a flavour, *Table 2* shows indicators corresponding to some of the 'circular economy' SDG12 targets.

Each indicator on the agreed list was assigned to a UN custodian agency, who generally convened a multi-agency and expert working group to develop an agreed measurement methodology/ protocol; and trialled the draft indicator where necessary before rolling it out. Both the protocols and the resulting statistics database are becoming available via the regularly updated SDG website (UNStats, n.d.).

Much of the work on SWM / WaRM indicators has focused on SDG target 11.6: '*By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management*', for which UN Habitat is the custodian agency. Two indicators were defined, one relating to WaRM (11.6.1) and the other to air quality (11.6.2).

Table 2. Targets and indicators for SDG Goal 12: Ensure sustainable consumption and production patterns

Presented as an example of the definition of indicators for one group of targets. This version corresponds to the 'final' version adopted in the 2020 Comprehensive Review. To save space, only targets 12.1-12.7 have been included. Source: (UNStats, n.d.)

No.	Target	No.	Indicators
12.1	Implement the *10-Year Framework of Programmes on Sustainable Consumption and Production Patterns*, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	**12.1.1**	Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production
12.2	By 2030, achieve the sustainable management and efficient use of natural resources	**12.2.1**	Material footprint, material footprint per capita, and material footprint per GDP
		12.2.2	Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3	By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	**12.3.1**	(a) Food loss index and (b) food waste index
12.4	By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	**12.4.1**	Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement
		12.4.2	(a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment
12.5	By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	**12.5.1**	National recycling rate, tons of material recycled
12.6	Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	**12.6.1**	Number of companies publishing sustainability reports
12.7	Promote public procurement practices that are sustainable, in accordance with national policies and priorities	**12.7.1**	Number of countries implementing sustainable public procurement policies and action plans

UN-Habitat's working group has developed the concept of SDG indicator 11.6.1 as a *data hub*, aiming to provide primary source data on WaRM in cities around the world. The wording of the indicator was officially clarified in the 2020 review so that it now reads: '*Proportion of municipal solid waste collected and managed in controlled facilities, out of total municipal solid waste generated, by cities.*' This has then been disaggregated into two main sub-indicators for each city: (a) proportion of MSW collected and (b) proportion of MSW managed in controlled recovery and disposal facilities, each measured against the total MSW generated in a city. A third sub-indicator has been added: (c) potential plastics emissions to the environment from uncollected and uncontrolled MSW in a city.

The detailed methodology for indicator 11.6.1 addresses the definition of MSW; household surveys to measure waste generation; collection of primary data on household waste amounts and composition, both at the point of collection and the point of disposal; estimating commercial and institutional wastes and wastes from public spaces; interviews through the recovery value chain to estimate quantities managed by material type; and how to decide if a particular recovery or disposal facility is 'controlled'. The draft methodology was field tested in 2019 in Nairobi and Mombasa in Kenya and in Seychelles and a 'step-by-step' guide (UN-Habitat, 2020) (UNStats, n.d.) was prepared in parallel.

Linkages have also been agreed between indicator 11.6.1 on SWM/WaRM in cities and the indicators 12.5.1, national recycling rates and 12.3.1 (b), a (global) food waste index. The interface between these SDG 12 indicators and indicator 11.6.1 is complex and will require further work. One issue is how to aggregate 11.6.1 data collected at city level to the national and global levels used by the other indicators. Another is that 12.5.1 includes recycling rates from non-municipal sources, including various industry sectors, for which recycling rates have historically been higher than for MSW.

Having argued in Section 2 that NOT being assigned as a high-level SDG goal could be turned into an advantage for WaRM, in that it provides an entry point into many of the 17 SDGs, the process of assigning indicators to monitor progress could be seen to undermine that case. An average of less than 1.5 indicators per target makes it difficult to include indicators to monitor cross-cutting issues such as SWM/WaRM or air quality. Figure 1 highlighted six SDGs and eight SDG targets with a direct and potentially measurable link to SWM/ WaRM. However, just three of those targets, 11.6. 12.3 and 12.5 have been discussed so far in relation to the official UN work on indicators. For 14.1, the official indicator focusses on floating plastic debris density; indicator 11.6.1 (c) complements that with a measure of the source term, i.e. potential plastics emissions to the environment from uncollected and uncontrolled MSW in a city. Indicator 1.4.1 is the proportion of population living in households with access to basic services; as SWM is recognised as one of those basic services, a link to 11.6.1 as the WaRM data hub would seem to make sense.

For three of the SDG targets highlighted in Figure 1, the official indicators unfortunately do not include any focus on SWM/WaRM. Target 6.3 is to *'... improve water quality by reducing pollution, eliminating dumping ...*', and the two selected indicators focus on wastewater treatment and water quality. Target 11.1 includes *'...access for all to ... basic services ...*', but the corresponding indicator focuses only on transport. Target 12.4 is *'... achieve the environmentally sound management of chemicals and all wastes....*', but the two indicators focus only on chemicals and hazardous wastes. One could argue that 11.6.1 already covers, at least partially, the SWM elements of 6.3 and 11.1, but that is not the case for 12.4. Referring to Figure 1, indicator 11.6 .1 (a) corresponds to global waste target GW1 of access to waste collection for all, while (b) corresponds to target GW2 to stop uncontrolled dumping and open burning. But the third step, moving from controlled disposal to environmentally sound management (ESM), as set out in target GW3, corresponds to target 12.4, and there is currently no official indicator for the proportion of MSW handled in ESM facilities.

One requirement for an official SDG indicator is that it should use objective, measurable data which can be collected by a national statistics agency. This is particularly challenging for WaRM: measuring access to and quality of MSW collection services is inevitably more qualitative than quantitative. Similarly, assessing recovery and disposal facilities against a set of quality criteria, to decide whether or not they are 'controlled', is not wholly objective, requiring the exercise of 'expert judgment'. Some would argue that it is just not possible to reduce the overall performance of a city's WaRM system to a set of objective quantitative indicators, still less combining those into a single 'index'.

Nevertheless, the work on developing SDG indicator 11.6.1 into a data hub for the collection of primary quantitative data is potentially a major first step towards compiling a reliable global baseline on SWM/ WaRM systems at a city level. UN-Habitat have launched the *Waste Wise Cities Campaign,* and plan to publish the 11.6.1 data on that website (UN-Habitat, n.d.), to showcase the diversity of both cities and their WaRM systems.

A useful second step would be to extend the basic 11.6.1 data by undertaking a Mass Flow Analysis (MFA) to identify and quantify all of the material flows within a city's WaRM system, allowing a rapid assessment of collection, recycling, recovery and disposal, as well as leakages to the environment which are otherwise not measured. GIZ's Waste Flow Diagram (GIZ, University of Leeds, Eawag-Sandec, Wasteaware, 2020) and the ISWA Plastics Pollution Calculator (ISWA and University of Leeds, 2020) are two such tools.

A third step would be to use of the *Wasteaware Benchmark Indicators* (Wilson, et al., 2015)a, which combine quantitative measures of waste generation and of collection, recycling, recovery and disposal, with qualitative indicators to assess both the quality of those

'physical' aspects of the service, and also the important 'governance' aspects which are key to a successful SWM/WaRM system. These were used for comparing cities in GWMO1 (UNEP and ISWA, 2015). A detailed user manual is available to ensure a level of consistency in how the user's expert judgment is exercised (Wilson, et al., 2015)b. Indeed, it has been suggested that the state of a city's SWM system, as measured by the city's cleanliness, could be used as a proxy indicator for good governance (Whiteman, et al., 2001), which is extremely difficult to measure (SDG16, Figure 1).

Taken together, these three methodologies – the SDG indicator 11.6.1 data hub, the Waste Flow Diagram or ISWA Plastics Calculator and the Wasteaware Benchmark Indicators – are symbiotic; they capture what is needed in terms of data, diagnostics and direction of travel of a city's WaRM system.

4. Conclusions

Making the case for SWM as a political priority has always been challenging. The three historical drivers of public health, local environmental protection and resource value can sometimes be good enough. But the case can be strengthened significantly by extending the scope from SWM to WaRM and the circular economy, and by using the SDGs as drivers to link into higher profile development issues (*Figure 1*).

The primary home for a city's municipal SWM within the SDGs is SDG11 (sustainable cities) and indicator 11.6.1. But SWM is also directly related to targets and indicators under SDG1 (End poverty, where target 1.4 requires access to basic services); SDG6 (clean water and sanitation); and in the context of WaRM and the circular economy SDG12 (responsible consumption and production). The linkages to climate action (SDG13) and life below water (SDG14) are surprisingly strong: e.g. extending waste collection to all and eliminating uncontrolled disposal would reduce the weight of plastics entering the oceans by more than half. Linkages to other high priority SDGs are still direct but more difficult to measure (e.g. SDG8 Decent work and economic growth through sustainable job creation, and SDG2 Zero hunger through reducing food waste). Even the indirect linkages to equality and governance issues are also important, as these are difficult to tackle and improving WaRM provides a useful entry point.

On-going work on SWM- and WaRM- related SDG indicators within the UN system has focused in particular on 11.6.1, which is seen as a data hub for compilation of a global baseline at a city level. Three sub-indicators measure the proportion of the total MSW generated in a city which is (a) collected and (b) managed in controlled recovery and disposal facilities; and (c) potential plastics emissions to the environment from uncollected

and uncontrolled MSW. In addition, most of the SDG12 indicators are relevant to some aspect of the transition towards a circular economy (*Table 2*).

SWM and WaRM data are directly required for six SDGs and they provide a significant entry point for tackling at least 12, and arguably all 17 high-level goals. The SDGs thus provide an important opportunity to build a strong political case and can be harnessed as powerful drivers for change in improving waste and resource management and moving towards a circular economy.

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References

CIWM and Wasteaid UK, 2018. *From the Land to the Sea.* [Online]
Available at: https://wasteaid.org/wp-content/uploads/2018/04/From-the-Land-to-the-Sea.pdf
[Accessed 22 October 2019].

Dehoust, G., Schüler, D., Vogt, R. & Giegrich, J., 2010. *Climate Protection Potential in the Waste Management Sector - Examples: Municipal Waste and Waste Wood.* [Online]
Available at: http://www.umweltbundesamt.de/publikationen/climate-protection-potential
[Accessed 21 October 2019].

FAO, 2015. *Food Wastage Footprint & Climate Change. Author: Scialabba N.* [Online]
Available at: http://www.fao.org/save-food/resources/en/;
http://www.fao.org/documents/card/en/c/7338e109-45e8-42da-92f3-ceb8d92002b0
[Accessed 21 September 2020].

GIZ, University of Leeds, Eawag-Sandec, Wasteaware, 2020. *Waste Flow Diagram (WFD): A rapid assessment tool for mapping waste flows and quantifying plastic leakage. Version 1.0. February 2020. Authors: Velis C.A., Cottom J., Zabaleta, I.; Zurbruegg, C.; Stretz, J.; Blume, S. Leeds, UK: University of Leeds.* [Online]
Available at: https://plasticpollution.leeds.ac.uk/toolkits/wfd/
[Accessed 21 September 2020].

IEAG, 2014. *A World That Counts: Mobilising The Data Revolution for Sustainable Development. Report of the UN Secretary General's Indendent Expert Advisory Group.* [Online]
Available at: https://www.undatarevolution.org/
[Accessed 22 October 2019].

ISWA and University of Leeds, 2020. *ISWA Plastic Pollution Calculator: A baseline and benchmarking quantification tool for waste-related city and regional plastic pollution. Authors: Velis C.A., Cottom J., Lerpiniere D.. Rotterdam: ISWA Marine Litter Task Force.* [Online]
Available at: https://plasticpollution.leeds.ac.uk/toolkits/calculator
[Accessed 21 September 2020].

ISWA, 2017. *Prevent Marine Plastic Litter - Now! ISWA Marine Task Force Report 2017.* [Online]
Available at: https://marinelitter.iswa.org/reports
[Accessed 22 October 2019].

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T.R. et al., 2015. Plastic waste inputs from land into the ocean. *Science,* 347(6223), p. 768–770.

Lebreton, L. C.M., van der Zwet, J., Damsteeg, J.-W., Slat, B. et al., 2017. River plastic emissions to the world's oceans. *NATURE COMMUNICATIONS,* Volume 8:15611.
Lenkiewicz, Z., 2016. *Waste and the Sustainable Development Goals.* [Online]
Available at: https://wasteaid.org/waste-sustainable-development-goals/
[Accessed 31 October 2019].

Lenkiewicz, Z. & Webster, M., 2017. *Making Waste Work: A Toolkit. Community Waste Management in Low and Middle Income Countries. Report prepared by Wasteaid for CIWM.* [Online]
Available at: https://wasteaid.org/toolkit/summary/
[Accessed 22 October 2019].

Reyna-Bensusan, N., Wilson D.C., Davy, P.M., Fuller, G. et al., 2019. Experimental measurements of black carbon emission factors to estimate the global impact of uncontrolled burning of waste. *Atmospheric Environment,* Volume 213, pp. 629-639.

Reyna-Bensusan, N., Wilson, D. C. & Smith, S. R., 2018. Uncontrolled burning of solid waste by households in Mexico is a significant contributor to climate change in the country. *Environmental Research ,* Volume 163, p. 280–288.

Rodic, L. & Wilson, D. C., 2017. Resolving governance issues to achieve priority SDGs related to solid waste management. *Sustainability,* 9(404).

Scheinberg, A., Wilson, D. C. & Rodic, L., 2010. *Solid Waste Management in the World's Cities. Published by Earthscan for UN-Habitat.* [Online]
Available at: https://www.waste.nl/publications/
[Accessed 21 September 2020].

Schmidt, C., Krauth, T. & Wagner, S., 2017. Export of Plastic Debris by Rivers into the Sea. *Environ. Sci. Technol. ,* Volume 51, pp. 12246-12253.

Schroeder, P., Anggraeni, K. & Weber, U., 2018. The relevance of circular economy practices to the sustainable development goals. *Journal of Industrial Ecology,* 23(1), pp. 77-95.

UN, 2015. *Transforming our World: the 2030 Agenda for Sustainable Development. Sustainable Development Goals Knowledge Platform.* [Online]
Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld
[Accessed 21 October 2019].

UNEP and ISWA, 2015. *Global Waste Management Outlook (referred to here as GWMO1). Editor-in-Chief: Wilson, D.C. Osaka: UN-Environment (UNEP).* [Online]
Available at: https://www.unenvironment.org/resources/report/global-waste-management-outlook
[Accessed 17 October 2019].

UNEP and ISWA, 2022. *Global Waste Management Outlook 2nd Edition (GWMO2). In preparation.* Osaka: UN-Environment (UNEP).

UN-Habitat, 2020. *Waste Wise Cities Tool: Step-by-Step Guide to Assess a City's MSWM Performance through SDG indicator 11.6.1 Monitoring. Prepared by UN Habitat, Wasteaware, EAWAG and University of Leeds. Authors: Takeuchi, N; Zabaleta, I; Whiteman, A. and Velis, C.A.,* Nairobi: UN-Habitat.

UN-Habitat, n.d. *Waste Wise Cities Campaign.* [Online]
Available at: https://unhabitat.org/waste-wise-cities-campaign
[Accessed 17 March 2020].

UNStats, n.d. *Sustainable Development Goal indicators website.* [Online]
Available at: https://unstats.un.org/sdgs#
[Accessed 29 April 2020].

Whiteman, A., Smith, P. & Wilson, D. C., 2001. *Waste management: An indicator of urban governance. Paper prepared for the UK Department for International Development (DFID) and submitted by DFID to the UN-Habitat Global Conference on Urban Development, New York, June 2001.* [Online]
Available at: http://davidcwilson.com/project/waste-management-an-indicator-of-urban-governance/
[Accessed 22 October 2019].

Wikipedia, n.d. *Utilities.* [Online]
Available at: https://en.wikipedia.org/wiki/Public_utility
[Accessed 21 October 2019].

Wilson, D. C., 2007. Development drivers for waste management. *Waste Management & Research,* Volume 25, p. 198–207.

Wilson, D. C., 2018. *Dont waste our climate.* [Online]
Available at: http://davidcwilson.com/publication/dont-waste-our-climate/
[Accessed 21 October 2019].

Wilson, D. C., Rodic, L., Cowing, M.J., Velis, C.A. et al., 2015a. 'Wasteaware' benchmark indicators for integrated sustainable waste management in cities. *Waste Management,* 35(1), pp. 329-343.

Wilson, D. C. , Rodic, L., Cowing, M.J., Velis, C.A. et al., 2015b. *'Wasteaware' Benchmark Indicators User Manual. (On website, click under 'Tools').* [Online]
Available at: https://rwm.global/
[Accessed 21 September 2020].

Wilson, D. C., Velis, C. & Cheeseman, C., 2006. Role of informal sector recycling in waste management in developing countries. *Habitat International,* Volume 30, pp. 797-808.