**Seeking and Exploiting Synergies Among the UN Sustainability Development Goals:**
**Research Opportunities for Operations Management**

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**Abstract**

In 2015, the United Nations countries signed up to achieve 17 Sustainable Development Goals (SDGs) for people, planet, prosperity, peace, and partnership by 2030. However, the trend of progress toward achieving these goals indicates that none of the 17 goals may be achieved by 2030 globally. We first provide a foundation for OM researchers to help shape the interventions for countries and companies to help achieve the SDGs by (1) identifying the *synergies* among the SDGs so that interventions can impact multiple SDGs positively and (2) *linking* some of the extant OM research with the synergies among the various SDGs. This way, researchers can understand the complexity of the challenges ahead and build on the OM research to influence the interventions of governments and organizations to maximize the attainment of the SDGs.  We also provide some research opportunities to help OM researchers develop research agendas.

*We must rise higher to rescue the Sustainable Development Goals – and stay true to our promise of a world of peace, dignity, and prosperity on a healthy planet.*

- António Guterres, Secretary-General, UN

# 1. Introduction

How can the world achieve sustainable development? Management guru Peter Drucker said, "*If you can't measure it, you can't manage it*." Having adopted the United Nations Millennium Declaration in 2000, world leaders sought to commit their countries to a new global partnership by setting specific "ambitious but feasible" – and measurable – goals for 2015 to reduce extreme poverty. These were the eight Millennium Development Goals (MDGs).[1] By the time the project concluded, attaining the eight goals was "uneven" across different countries and goals. Countries in sub-Saharan Africa made the least progress. Moreover, new challenges emerged, requiring a broader approach.

Drawing on the lessons learned from the MDG project, the UN took up the challenge again with a second 15-year project, establishing a broader set of 17 Sustainable Development Goals (SDGs) for people, planet, prosperity, peace, and partnership. The motivation was a balanced approach to the economic, social, and environmental dimensions, akin to the triple bottom line concept of profit, people, and planet, coined by John Elkington (Economist, 2009). The 193 countries in the UN signed up to achieve these 17 goals – with 231 (performance) indicators to track progress – by 2030.

However, halfway through the 15-year horizon for achieving the SDGs in 2023, the attainment of these goals indicated the *same widespread unevenness* across countries and goals as the MDGs. In the 2023 UN SDG Index report card for countries, the 25 countries that led in the progress towards attaining the SDGs are all European, except for Japan, followed closely by Canada at 26. The bottom 25 countries are mostly from sub-Saharan Africa, with only a few non-African countries: Afghanistan (under economic sanctions), Haiti, and Papua New Guinea (Sachs et al., 2023).

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[1] Millennium Development Goals, accessed https://www.un.org/millenniumgoals/ on Oct. 17, 2023. The eight MDGs are: (1) To eradicate extreme poverty and hunger; (2) to achieve universal primary education; (3) to promote gender equality and empower women; (4) to reduce child mortality; (5) to improve maternal health; (6) to combat HIV/AIDS, malaria, and other diseases; (7) to ensure environmental sustainability; and (8) to develop a global partnership for development.

Two conclusions may be drawn from this 2023 report card: (1) the countries that need to attain the SDGs the most are also the least likely to attain them, and (2) the 'partnership' goals across the globe will likely be missed again as reflected in the glaring global disparities. Moreover, there is unevenness across the attainment of the SDGs globally, and even in Europe, individual goals will be missed. The overall assessment was that "at the global level, averaging across countries, not a single SDG is currently projected to be met by 2030, with the poorest countries struggling the most" (Sachs et al., 2023: p.2).

*This assessment motivates us to examine how operations management (OM) research can help accelerate attaining these goals*. It also prompted us to start by providing a basis for OM researchers to understand the complexity of the problem of improving the SDGs and what OM and other researchers have already done as interventions for companies and governments towards the different SDGs directly or indirectly. As such, we started by (1) recognizing the *synergistic interconnections* between operational interventions and multiple SDGs to have maximal impact, and (2) *establishing linkages* between the extant OM research (in various areas such as humanitarian operations, socially responsible operations, and sustainability) and the UN SDGs (and the synergies among them). By capitalizing on these opportunities, we can build on the existing research in different OM streams and, more importantly, help shape the interventions of individual governments and companies toward attaining the SDGs as much as possible without duplicating efforts or wasting resources. We also provide some research topics for OM researchers to explore or build their research agendas on achieving the SDGs.

In the rest of this paper, Section 2 summarizes the UN reports on the extent to which the SDGs were attained midway through the 2015-2030 SDG horizon. Next, Section 3 covers recent literature that shows the growing interest in the SDGs. Section 4 identifies synergies between the SDGs using different lenses from the OM literature, while Section 5 ties the pertinent OM literature to the SDGs. Sections 4 and 5 provide the basis for further research, and we provide some research topics in Section 6. Section 7 concludes.

## 2. The Extent of SDG Non-Attainment

Different regions (and countries) have made varying progress towards achieving the targets for each of the 17 SDGs. Sachs et al. (2023) created an SDG attainment index comprising various metrics based on publicly available data or, for some metrics, from think tanks or other reliable organizations. Using the index, they have rated the level of SDG achievement and the trend in such achievement for each of the 17 SDGs by country or region (**Figure 1**). For economic-geographic regions, it is easy to see that attaining

some SDGs would be a problem worldwide. SDG 2 (zero hunger), SDG 3 (good health), SDG 14 (life below water), SDG 15 (life on land), and SDG 16 (peace, justice, and institutions) had low levels of achievement. The trend also indicates stagnation and, therefore, unlikely to be met by 2030. The world average reflected the poor levels of achievement for SDGs 2–3 and 14–16 by the end of 2023. Oceania (not including Australia and New Zealand), the Small Island Developing States, and sub-Saharan Africa showed alarmingly poor levels of regional achievement of most SDGs as of 2023 (**Figure 1)**.

| SDG | 1 No poverty | 2 Zero hunger | 3 Good health & well-being | 4 Quality education | 5 Gender equality | 6 Clean water & sanitation | 7 Affordable & clean energy | 8 Decent work & economic growth | 9 Industry, innov, & infrastructure | 10 Reduced inequalities | 11 Sustainable cities & communities | 12 Resp. consumption & prodn. | 13 Climate action | 14 Life below water | 15 Life on land | 16 Peace, justice, strong institutions | 17 Partnerships for the goals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Level - Region achievement for SDG (2023)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| East and SouthAsia | 3 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 |
| Eastern Europe and Central Asia | 2 | 2 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 2 | - | 1 | 1 | 3 |
| Latin America and the Caribbean | 2 | 2 | 1 | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 1 | 1 | 1 | 3 |
| Middle East and North Africa | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 1 | 1 | 1 | 2 |
| Oceania (not incl. Aus. and NZ) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 | 2 | - | 4 | 1 | 2 | - | 1 |
| OECD members | 3 | 1 | 3 | 4 | 3 | 3 | 2 | 3 | 4 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 3 |
| Small Island Developing States | 1 | 1 | 1 | 2 | 2 | 1 | 1 | - | 2 | 2 | 2 | - | 3 | 1 | 1 | 1 | 2 |
| Sub-Saharan Africa | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 3 | 1 | 1 | 1 | 1 |
| **World average** | 2 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 1 | 1 | 1 | 2 |
| | | | | | | | | | | | | | | | | | |
| **Trend - Region progress towards SDG achievement (2023)** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| East and SouthAsia | 4 | 2 | 3 | 3 | 3 | 4 | 3 | 2 | 4 | - | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| Eastern Europe and Central Asia | 1 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | - | 2 | 2 | 3 |
| Latin America and the Caribbean | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 2 | 3 | - | 2 | 3 | 4 | 2 | 2 | 2 | 4 |
| Middle East and North Africa | 1 | 2 | 3 | 3 | 2 | 4 | 2 | 2 | 3 | - | 2 | 4 | 3 | 2 | 2 | 2 | 3 |
| Oceania (not incl. Aus. and NZ) | 2 | 1 | 2 | 3 | 2 | 2 | 2 | - | 3 | - | 2 | - | 2 | 2 | 2 | - | 2 |
| OECD members | 2 | 2 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| Small Island Developing States | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 2 | 2 | - | 3 | 2 | 2 | 2 | 2 |
| Sub-Saharan Africa | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | - | 2 | 4 | 4 | 2 | 2 | 1 | 2 |
| **World average** | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 |

| | Level | | Trend |
|---|---|---|---|
| d | SDG achievement | 4 | On track |
| 3 | Challenges remain | 3 | Moderately increasing |
| 2 | Significant challenges remain | 2 | Stagnating |
| 1 | Major challenges remain | 1 | Decreasing |
| - | Data not available | - | Data not available |

**Figure 1: The level and the trend (as of 2023) for SDG attainment for each SDG on 4-point scales, respectively.  The upper table with the *level* shows that the columns for SDG 2, 3, 13, 14, and 15 show that major challenges remain worldwide. The lower table shows that the *trend* for improvement of these SDGs is also not encouraging. The same can be said for Small Island Developing States and Sub-Saharan countries across all the 17 SDGs. *Data*: Sachs et al. (2023).**

We can learn more about humanity's challenges by considering the worldwide progress for each of the 17 SDGs in the UN Sustainable Development Goals Reports for 2022 and 2023 (UN, 2022; 2023). These reports show the reversal of progress for the SDGs, not just because of the so-called three C's: *climate, conflict*, and *Covid-19,* but also because of a lack of global partnership. Below, we provide some highlights from these UNSDG reports for each goal as discussed above (**Figure 1**):

**SDG 1.** *No poverty*: Over the past 25 years, poverty reduction has reversed, with 93 million more people falling into extreme poverty. Worse, only a third of the countries are likely even to halve their poverty levels, let alone end poverty. A working definition of extreme poverty, and thus, 'the poor' as we use the term in this article, is provided by the World Bank, based on a poverty line set at $2.15 per person per day using 2017 prices.[2] About 648 million people were in this situation globally in 2019. Although we can measure poverty along multiple dimensions and decide whether it encompasses only food, shelter, and hygiene or includes access to education, healthcare, and information (e.g., UNDP, 2020), the World Bank definition is practical for measuring progress.

**SDG 2.** *Zero hunger***:** A rising number of people were experiencing hunger and food insecurity, even before Covid-19. As many as 828 million people may have suffered from hunger in 2021, in part due to growing conflicts, climate-related shocks, and widening inequalities. In 2022, some 45 million children below age 5 suffered from wasting, while another 148 million had stunted growth, and 37 million were overweight.

**SDG 3.** *Good health and well-being***:** The pandemic disrupted essential health services, triggered an increase in the prevalence of anxiety and depression, lowered global life expectancy, derailed progress toward ending HIV, tuberculosis (TB), and malaria, and halted two decades of work towards making health coverage universal. Approximately 800 women died every day worldwide from pregnancy or childbirth in 2020. Still, three-fourths of all countries or areas have met or are likely to meet the SDG target on children under-5 mortality.

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[2] World Bank. Measuring poverty. https://www.worldbank.org/en/topic/measuringpoverty, accessed Dec. 10, 2023.

**SDG 4.** *Quality education***:** The (Covid-19) pandemic deepened the education crisis worldwide, impacting children's learning and well-being, especially girls and disadvantaged groups. Over the past two years, 147 million children missed more than half of their in-person instruction. At current trends, an estimated 84 million children will still be out of school in 2030, with about 300 million students lacking basic numeracy and literacy skills. SDG 4 targets have already been reduced compared with the original ones. More investment is needed as 79 low-income and lower-middle-income countries have an average annual financing gap of $97 billion.

**SDG 5.** *Gender equality***:** Progress in many areas, including time spent on unpaid care and domestic work, decision-making regarding sexual and reproductive health, and gender-responsive budgeting, has fallen behind targets. Only one in seven indicators (sub-goals) of this goal are "on track," while nearly a quarter of the indicators are far off track from 2030 targets.

**SDG 6.** *Clean water and sanitation***:** Billions of people will lack clean water in 2030. The demand for water is rising due to rapid population growth, urbanization, and increasing pressure from agriculture, industry, and the energy sector, which have exacerbated water stress, thereby deteriorating water-related ecosystems.

**SDG 7.** *Affordable and clean energy*: This goal will not be met by 2030 at the current pace. Hundreds of millions of people still lack access to electricity, and slow progress towards clean cooking solutions means that the health of 2.4 billion people is at risk. The most vulnerable are getting even further behind. Projections at the end of 2023 for 2030 are that 660 million people will lack access to electricity, while 2 billion people will still rely on polluting fuels for cooking.

**SDG 8.** *Decent work and economic growth***:** The least developed countries (LDCs) have struggled with weak economic growth and labor market fallout due to workplace closures. Even with the recovery in 2021, the rate of economic recovery slowed down in 2022 and 2023. A quarter of young people (23.5%, or 289 million) worldwide were not in education, employment, or training in 2022, more than the 2015 baseline of 22.2%. There were regional differences, with more than 31% of young people in Central and Southern Asia in this situation, and marked deterioration in sub-Saharan Africa, with the highest increase from 2015 to 2022. Globally, young women remained twice as likely (32.1%) than young men (15.4%) to not be in education, employment, or training in 2022.

**SDG 9.** *Industry, innovation, and infrastructure*: In the LDCs, recovery was sluggish and remains uncertain since the pandemic in 2020; the crisis negatively impacted almost one in three manufacturing jobs. Women, youth, and low- and middle-skilled workers have suffered the most losses. However, it is encouraging to note that the 4G network reached 88% of the world's

population in 2022, double from 2015, creating a potential for innovation and showing how widespread the infrastructure is across the globe.

**SDG 10.** *Reducing inequality***:** The pandemic worsened in-country and across-country inequality and intensified structural and systemic discrimination.  The World Bank estimates that 2020 was the year with the highest increase in across-country inequality in 30 years. The number of refugees worldwide reached a record in 2021, but the record was broken in 2022 with 34.6 million refugees, indicating rising inequality.  Similarly, 2021 witnessed a record number – nearly 6,000 – documented deaths along migratory routes of those attempting to migrate, but 2022 was even worse, with almost 7,000 such migration-related deaths recorded.

**SDG 11.** *Sustainable cities and communities***:** In 2019, ambient air pollution from traffic, industry, power generation, waste burning, and residential fuel combustion resulted in 4.2 million deaths. Growing urbanization worldwide has created growing problems: less than a quarter of the population in urban areas in Africa, Asia, and Latin America was served by public transportation in 2020. Additionally, air pollution is becoming a significant problem in towns and not just cities in Africa and Asia.

**SDG 12.** *Responsible consumption and production***:** The materials extracted anywhere in the supply chain to meet high-income countries' per capita domestic demand is ten times that of low-income countries, reflecting regional disparities in consumption and production. In 2021, 13.2% of the world's food was lost somewhere in the supply chain from the farm to the point of consumption. Also, an additional 17% was lost at the point of consumption, whether at household, food service, or retail levels. At the same time, 828 million people were facing hunger. In 2021, governments spent twice as much on coal, oil, and gas subsidies than in 2020.

**SDG 13.** *Climate action***:** The mean temperature for the globe and the year has increased linearly since 1975. The Intergovernmental Panel on Climate Change (IPCC) has warned that the critical 1.5 °C increase in global temperature, leading to irreversible climate change, will be breached by 2035, even with the combined pledges from all countries in the Paris Agreement. As ice on sea and land melts, sea levels worldwide have been rising at an accelerating rate, threatening relocation for 900 million people living in low-lying areas worldwide. Still, developed countries provided only $80 billion in 2020 against their annual $100 billion climate finance commitment for 2020-25; even then, the money provided to developing countries, mainly (70%), was in the form of loans.  More funding went to fossil fuels than climate financing.

**SDG 14.** *Life below water***:** Rising temperatures affect the oceans, which absorb 90% of the heat. Warming of oceans has led to acidification (more dissolved $CO_2$) and more nutrients, giving rise

to algal blooms that deplete the oxygen. The number of stations reporting ocean acidification almost doubled from 2021 to 2022, indicating widespread acidification, which is 30% more than pre-industrial times and increasing. Higher temperatures and more acidity threaten life below water, fisheries, and livelihoods. More than 17 million metric tons of plastic waste entered the ocean in 2021 and will likely double or triple by 2040 if the current trends continue. The depletion of a third of global fish stocks over 1950-2015 has resulted in further overfishing, particularly in Asia, which employs 50 million (out of the global 59 million) fishers and farmers worldwide.[3]

**SDG 15.** *Life on land***:** The threats to life on land are severe: climate change, pollution, biodiversity loss, increasing trends of forest loss, and land degradation. The area under forests had experienced a net loss of almost 10 million hectares annually in recent years as of 2023, driven almost entirely by agricultural expansion for cropland and livestock grazing, most acutely in Eastern Asia. Around 40,000 species are at risk of extinction over the coming decades, and the rate of decline in the number of species has grown with every decade since 1993, according to the Red List Index (https://www.iucnredlist.org/). As of 2022, protected area coverage had not improved since the countries committed themselves to the SDGs in 2015.

**SDG 16.** *Peace, justice, and strong institutions*: As of Dec. 2022, 108 million people have been forcibly displaced worldwide, an increase of 21% over the previous years, with worse numbers expected for 2023 with Israel's forced relocation of the people of Gaza. Civilian deaths in conflict rose 53% in 2022 over the previous year, and we expect more for 2023. Usage of heavy weapons and explosive munitions in indiscriminate and disproportionate attacks rose from 13% in 2021 to 39% in 2022, with a further increase expected in 2023. A third of the world's population, primarily women, reportedly fear walking alone in their neighborhoods at night. A quarter of the world's population lived in conflict-affected countries at the end of 2020, but this number may be growing. Unsentenced prisoners –indicating the lack of justice – have been growing steadily since 2015 and were 31% of the prison population worldwide in 2021.[4]

**SDG 17.** *Partnerships for the goals*: The level of Official Development Assistance (ODA) at 0.33% of the donors' combined Gross National Income fell short of the 0.7% target, not enough to enable

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[3] Our World in Data, 2021. Fish and overfishing, accessed Dec. 16, 2023.

[4] United Nations on Drugs and Crime Report, 2021. https://www.unodc.org/documents/data-and-analysis/statistics/DataMatters1_prison.pdf, accessed Dec 16, 2023.

developing countries to meet SDG targets. While ODA increased in 2022, the increase was because of refugees in donor countries and development support for Ukraine. The debt-to-gross-national-income ratio for sub-Saharan countries nearly doubled in a decade, from 23% in 2011 to 44% in 2020—debt service as a proportion of exports shot up in Africa and Latin America. As of Dec. 2022, 37 of the 69 poorest countries were in debt distress. One reason is that the share of exports from the least developing countries in global trade, as also noted by the UNCTAD, has stagnated around 1% from 2010 onwards and is nowhere near the goal of 2.04% targeted by the Istanbul Programme of Action.[5]

The above is only a sampling of the current status of SDG achievement from the UN (2022; 2023) reports to highlight the challenges underlying the bleak assessment in Figure 1. The SDGs are estimated to cost trillions of dollars to implement, and the countries that benefit most from the SDGs need more resources to meet these costs. Kharas and McArthur (2019) estimate a shortfall of about $1 trillion in annual SDG-related public spending across all countries in 2025. Moreover, their estimates suggest that all countries with a per capita GDP of less than $1000 in 2025 would have an SDG-related spending gap of more than 10 percent of their GDP and, therefore, a much more significant percentage shortfall in their SDG-related spending. There is a shortage of data, too, as some countries have not reported these goals for partnership and climate action, and less than 30% of countries have reported on gender equality (Kitzmuller et al., 2021). SDGs, such as climate change mitigation and adaptation, will require significant technological advances, such as solar energy, but these advances also need funding and political will for partnership.

Moreover, the level of 'partnership' between the developed and developing countries was arguably lower in 2022 and 2023 compared to when all the countries signed up in 2015 to implement the SDGs. The SDG Index Report stresses funding to realize the SDGs (Sachs et al., 2023), and we saw above that the funding – or other financial help by importing goods – is not coming through fully.

## 3. Recent Literature on SDGs

OM (and related) research that refers explicitly to SDGs is nascent as of writing but growing. There is a special issue of *POM* (Besiou et al., 2021) and one paper in *M&SOM* (Besiou and Van Wassenhove,

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[5] UNCTAD, 2021. Least developed countries remain marginalized in global exports, accessed https://unctad.org/topic/least-developed-countries/chart-december-2021 on Dec. 18, 2023.

2020), both focused on SDGs related to humanitarian operations, along with a paper in *POM* focusing on empowering women to improve SDG 5 gender equality (Tang, 2022). Still, there have been special issues on topics closely tied to the SDGs. For instance, *POM* has special issues focused on responsible operations (Sodhi, 2015), modern slavery (Faizi et al., 2021), and diversity, equity, and inclusion (Corbett and Narayanan, 2022).

Similarly, *M&SOM* has a special issue on responsible operations (Deshpande and Swaminathan, 2020) and one on value chain innovations in developing countries (Lee, 2019). *Supply Chain Management*: *An International Journal* also has a special issue on sustainability in the supply chain (Fritz et al., 2022). There are also SDG-focused special issues of journals in related fields, e.g., the *Journal of Management and Organization* (Macht et al., 2021), *Sustainability* (Setó-Pamies and Papaoikonomou, 2020), and the *Journal of Business Ethics* (Nonet et al., 2022). Springer Nature has a Sustainable Development Goals Series under the Springer and Palgrave imprints to present research on the SDGs and efforts to address society's most significant grand challenges.[6] There is also one subseries of books for each of the 17 SDGs and an eighteenth subseries, "Connecting the Goals," for volumes addressing multiple goals or studying all the SDGs together. Several volumes are already available in the series.

Additionally, there are individual articles in the OM and the broader management literature. In a structured literature review on management and the SDGs, Pizzi et al. (2020) analyzed 266 articles published before 2019 to identify four key research themes: technological innovation, firms' contribution in developing countries, non-financial reporting, and education for SDGs. They also analyzed bibliometrics. For instance, by 2019, the *Journal of Cleaner Production* had 58 SDG-related articles with 653 citations, and the *Journal of Management Education* had 17 articles with 126 citations. Their analysis also reflected the geographical context of the papers on SDGs: global (61% of the articles), Australasian (15%), European (10%), African (8%), South American (4%), and North American (1.5%). Berrone et al. (2023) review SDG-related articles published in nine leading management journals – *AMJ*, *AMR*, *MS*, *ASQ*, *Journal of Mgmt, JMS*, *Org. Science*, *Org. Studies*, and *SMJ* – to provide a research agenda for management researchers and implications for practice.

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[6] Springer Nature Sustainable Development Goals series, accessed at https://www.springer.com/series/15486 on Nov. 1, 2023.

With this broad background for the OM interest in SDGs, we delve deeper into the OM research by (1) recognizing the *synergistic interconnections* between operational interventions and multiple SDGs to have maximal impact and (2) *establishing links* between the synergistic SDGs and the extant OM research in areas such as humanitarian operations, socially responsible operations, and sustainability. We do so next in Sections 4 and 5, respectively.

# 4. Identifying Synergies among SDGs

The SDGs are interconnected; hence, an intervention that helps achieve one goal can also help achieve others. The OM literature offers different theoretical lenses to identify such synergies.

## 4.1 An Operational Performance Lens

Operational performance entails working with a hierarchy of objectives. The SDGs are no different and have a three-tier hierarchy: level 1 with the 17 SDGs, level 2 with 169 targets or sub-goals, and level 3 with 248 (performance) indicators (with 231 unique metrics) to monitor progress. These synergies are apparent at the goal level. For instance, an initiative to reduce poverty (SDG 1) will also reduce hunger (SDG 2).

Also, interventions for increasing female participation in a country's workforce can help achieve *decent work and economic growth* (SDG 8) and *gender equality* (SDG 5) simultaneously. Improving access to *quality education* (SDG 4) can lead to a more skilled and knowledgeable workforce, fostering *decent work and economic growth* (SDG 8). Transitioning to *affordable and clean energy sources* (SDG 7) and *responsible consumption* (SDG 12) can help reduce greenhouse gas emissions, thus contributing to *climate action* (SDG 13). Providing access to *clean water and sanitation* (SDG 6) is crucial for *good health and well-being* (SDG 3). *Peaceful and inclusive societies* (SDG 16) can help reduce inequalities within and among countries (SDG 10).

However, interventions sometimes entail trade-offs rather than synergies across multiple SDGs. Interventions for *decent work and economic growth* (SDG 8) and *responsible consumption and production* (SDG 12) can be contradictory, as economic growth can increase consumption and production patterns that are unsustainable and wasteful. Moreover, such consumption (and production) could damage the environment, creating a negative impact on *climate action* (SDG 13) and *life on land* (SDG 15).

Still, such conflicts can be resolved with innovation. *Zero hunger* (SDG 2) and *life on land* (SDG 15) appear to conflict if the target is to expand agricultural land, leading to deforestation and biodiversity loss. However, the conflict can be resolved if we focus on using innovative farming techniques to improve the productivity of current agricultural land rather than increasing it at the expense of forest area. Similarly, *good health and well-being* (SDG 3) and *industry, innovation, and infrastructure* (SDG 9) can conflict when industrial development increases air pollution and health risks. Worse, one country might export the most polluting parts of its industry to other countries, leaving the planet worse off. While this has been true historically, technological innovation could help improve SDGs 3 and 9.

Synergies can also be sought at the more granular level, recalling that there are 231 metrics,[7] called indicators or targets, for the 17 SDGs. As illustrated in **Table 1**, some metrics are *repeated* under multiple SDGs; for instance, the proportion of the people affected by disasters is the same metric: 1.5.1 (SDG 1), 11.5.1 (SDG 11), and 13.1.2 (SDG 13). Some metrics *drive* others; for instance, the proportion of local governments (11.b.1 in SDG 11) and the number of countries (13.1.1 in SDG 13) adopting disaster reduction could lower the proportion of people affected by disasters (1.5.1, 11.5.1, and 13.1.2). Other metrics complement each other for the same purpose. Increasing the number (5.b.1) or the proportion (9.c.1) of people owning a mobile phone and the number of people with fixed-line internet subscriptions (17.6.2) would contribute to the proportion of individuals using the Internet (17.8.1).

Other links could be more direct. The extent of bribery faced by individuals (16.5.1) and businesses (16.5.2) can increase wildlife trafficking (15.7.1 or 15.c.1); also, in some countries, people in poverty with high unemployment (8.5.2) are more likely to resort to such trafficking. Supporting marine biodiversity and ecosystems (14.4.1,14.5.1,14.6.1, 14.7.1, and 14.a.1) would also indirectly support the land species (15.5.1) that rely on marine life (**Table 1**).

**Table 1: Selected indicators (metrics) for some UN SDGs (Source: UN, 2020)**

| SDG # | SDG definition | Selected indicators (metrics) |
|---|---|---|
| 1 | No poverty | 1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population |
| 5 | Achieve gender equality | 5.b.1 Proportion of individuals who own a mobile telephone, by sex |

[7] These 231 metric indicators can be found at: https://unstats.un.org/sdgs/indicators/indicators-list/.

| 8 | Decent work and economic growth | 8.5.2 Unemployment rate, by sex, age and persons with disabilities |
|---|---|---|
| 9 | Industry, innovation and infrastructure | 9.c.1 Proportion of population covered by a mobile network, by technology |
| 11 | Sustainable cities and communities | 11.3.2    Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically<br>11.5.1    Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population<br>11.b.1    Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030 |
| 13 | Climate action | 13.1.1 Number of countries that adopt and implement national disaster risk reduction strategies (in line with the Sendai Framework for Disaster Risk Reduction 2015–2030)<br>13.1.2 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 people |
| 14 | Life below water | 14.4.1    Proportion of fish stocks within biologically sustainable levels<br>14.5.1    Coverage of protected areas in relation to marine areas<br>14.6.1    Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing<br>14.7.1    Sustainable fisheries as a proportion of GDP in small island developing states, least developed countries, and all countries<br>14.a.1    Proportion of total research budget allocated to research in the field of marine technology |
| 15 | Life on land | 15.5.1  Red list index (to take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species)<br>15.7.1  Proportion of traded wildlife that was poached or illicitly trafficked<br>15.c.1  Proportion of traded wildlife that was poached or illicitly trafficked |
| 16 | Peace justice and strong institutions | 16.5.1    Proportion of *persons* who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months<br>16.5.2    Proportion of *businesses* that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months |
| 17 | Global partnerships | 17.6.2    Fixed Internet broadband subscriptions per 100 inhabitants, by speed<br>17.8.1    Proportion of individuals using the Internet. |

## 4.2 A Stakeholder-Focused Lens

Engaging stakeholders is necessary to develop initiatives because of the comprehensive nature of the SDGs. However, business managers, governments, and the public may have different and conflicting objectives. Developing mechanisms to *align their interests* and *striking a balance* among the SDGs can be difficult with their emphasis on different stakeholders, including various sections of society and the ecosystem with wildlife, biodiversity of plants, etc. Building on stakeholder theory, Sodhi (2015) proposes a stakeholder-resource-based view (SRBV) for the decision-makers in a company to develop

their organization's and their stakeholders' dynamic capabilities, resources, and routines to maximize their utility and these stakeholders' utility. Stakeholders for a large company include those in the extended supply chain (suppliers, including smallholder farmers or contract workers) and those of the corporate entity (consumers, shareholders, and regulators).

At the corporate level, SRBV can be useful for normatively evaluating corporate interventions to improve conditions for any subset of stakeholders and exploiting synergies across multiple stakeholders. Similarly, at the national or regional level, government officials charged with SDG implementation must consider improving the respective utilities of even more diverse stakeholders, and that too against a political background with competing interests. SRBV, when used normatively and transparently, can help frame how a particular intervention could improve conditions for multiple stakeholders. For example, a better quality of *life below water* (SDG 14) would mean more business for coastal communities, helping *reduce poverty* (SDG 1). At the same time, sustainable agriculture could be good for *reducing hunger* (SDG 2) and improving *life on land* (SDG 15). Sodhi et al. (2022) provide empirical support for such synergistic thinking in corporate India: The proportions of corporate social responsibility funding in education, healthcare, skill development, and six other broad categories in the local community are statistically identical across the top 50 companies by capitalization. Finally, there is a many-to-many relationship between the SDGs and stakeholders. As such, companies and governments can focus on the interests of a narrow set of stakeholders, for instance, the "poor" with low incomes (e.g., Sodhi and Tang, 2014), to achieve multiple SDGs (**Table 2**). For practical reasons, we use the World Bank's definition of extreme poverty to refer to the "poor," as noted in Section 2, but alternative definitions could be used instead.

**Table 2: Stakeholders who would benefit directly and indirectly from implementing each SDG.**

| SDG # | SDG definition | Selected stakeholders that would benefit *directly* | Selected stakeholders that would benefit *indirectly* |
|---|---|---|---|
| 1 | No poverty | The poor | Society at large |
| 2 | Zero hunger | The poor | Society at large |
| 3 | Good health and well-being | The aged, children, and the poor; also, the broader segments of the population | Productive labor force; less burden on society as a whole |
| 4 | Quality education | The young, particularly from poor households | Industry benefitting from a productive labor force |
| 5 | Achieve gender equality | Women and girls | Society at large |
| 6 | Clean water and sanitation | The poor | Productive labor force |
| 7 | Affordable and clean energy | The poor and other segments of society | Business and industry; society at large |

| 8 | Decent work and economic growth | The poor, the young, and the unemployed; also, women | Business and industry |
|---|---|---|---|
| 9 | Industry, innovation, and infrastructure | All segments of society | Business and industry |
| 10 | Reduced inequalities within and among countries | Minorities, refugees, low-income countries | Society at large; developed countries |
| 11 | Sustainable cities and communities | All people, especially the poor | Society at large |
| 12 | Responsible consumption and production | Wildlife, all segments of society particularly the most vulnerable | Society at large |
| 13 | Climate action | Poorer countries that are more vulnerable to climate change | Richer countries and the planet as a whole |
| 14 | Life below water | Marine life | Fishing communities, research community |
| 15 | Life on land | Wildlife; particularly, threatened species | Improved agriculture benefitting farmers and consumers |
| 16 | Peace justice and strong institutions | Vulnerable populations | All of society |
| 17 | Global partnerships | Less developed and low-to-middle-income countries | Richer countries benefit from fewer refugees and less conflict. |

In their review of sustainable development-related articles in nine leading management journals, Berrone et al. (2023) use a four-stage SDG adoption framework for companies based on guidelines from consultancies – (1) prioritizing SDGs to the strategic goals of the firm, (2) contextualizing the SDGs to the firm's geographical and industrial contexts, (3) collaborating with other organizations and stakeholders to make more impactful progress (global partnerships, SDG 17, can be seen in this light), and (4) innovating via business model change.

In the first stage, an organization can prioritize SDGs in its strategic agenda based on tensions or synergies between it and society's activities. The purpose is to look for alignment (or lack thereof) between corporate and societal goals to avoid consultancy-driven "implementation simplicity" or "commercially driven, stakeholder-engaging initiatives" (Berrone et al., 2023, p. 321). From their review, Berrone et al. note that the management literature offers managers criteria to assess how much to support an SDG (**Figure 2**). The upper-right quadrant represents the 'win-win' case in which efforts towards an SDG would also be relevant to the organization's goals, so the organization should leverage that effort. In the upper-left quadrant, the organization finds advancing a given SDG is pertinent, but doing so would require trade-offs. Managers must take a paradoxical approach that recognizes the contradictions and helps them to acknowledge and embrace the contradictions among the financial, social, and environmental dimensions. For the two lower quadrants, the SDG of interest has low relevance. In the

lower-left quadrant, the SDG conflicts with the organization's goals, so managers should ignore it and direct their efforts elsewhere. In the lower-right quadrant, even with synergies with the organization's other goals, management can postpone the SDG-related initiatives (park for later) to focus on higher-priority SDGs or other goals.
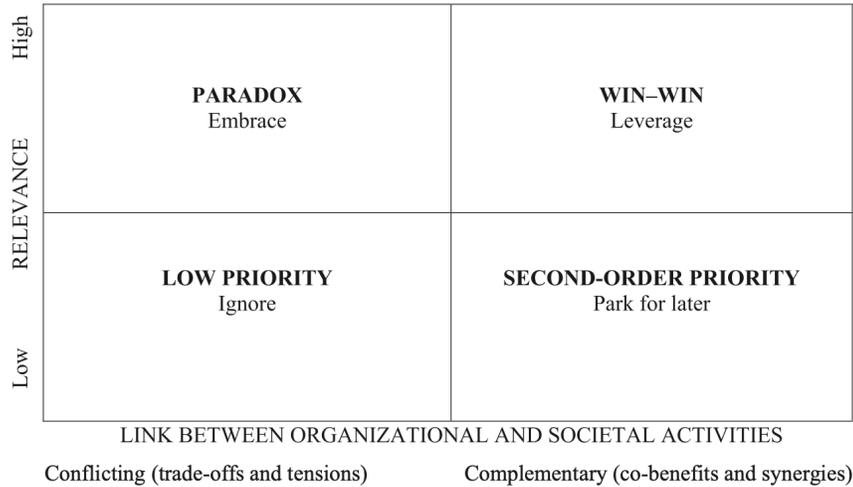


**Figure 2: Prioritization of UN SDGs in a company with tensions and synergies between the firm's organizational and societal activities and the relevance of the SDGs to the firm's values, core activities, and geography (Source: Berrone et al., 2023).**

## 4.3 A Systems Dynamics Lens

The interconnected SDGs can also be conceptualized as a "self-perpetuating" dynamic system fueled by "feedback loops." In this self-perpetuating system, progress with one subset of SDGs helps with that of another subgroup, which in turn helps with another subset, eventually helping with the first subset, without any SDG being a 'root cause' or driver (**Figure 3**) (Besiou et al., 2021).

The different subsets of SDGs and their positive links in the feedback loop are (**Figure 3**):[8]

1. *Survival* SDGs: These are related to poverty (1), hunger (2), good health (3), and clean water (6). Fulfilling these SDGs is needed for people's very survival in a society.

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[8] Due to page limitation, we omit the detailed description of the framework for modeling the feedback loops presented in Besiou et al (2021). We shall refer the readers to Besiou et al. (2021) for details.

2. *Individual* SDGs: These pertain to quality education (4), gender equality (5), affordable energy (7), and decent work (8). If people can survive, they can focus on improving their quality of life, so progress on survival SDGs helps progress on the individual SDGs.

3. *Communal* SDGs: These goals relate to industry and infrastructure (9), inequalities (10), sustainable communities (11), and responsible consumption and production (12). With individual SDGs sufficiently achieved, people can focus on community-related goals to give back to society. Another way to look at this is that with individual SDGs achieved, quality of life can improve only with the achievement of the communal SDGs – getting a nice car is not worthwhile if the roads are in bad shape – hence the positive link from the individual to the communal SDGs.

4. *Global* SDGs related to climate (13), life below water (14), life on land (15), and peace and justice (16). Beyond communal goals, if one community does better, it can help the individuals in other communities survive. At least, that is the belief underlying global development aid, providing a reinforcing link from the global SDGs to the survival SDGs above (**Figure 3**).
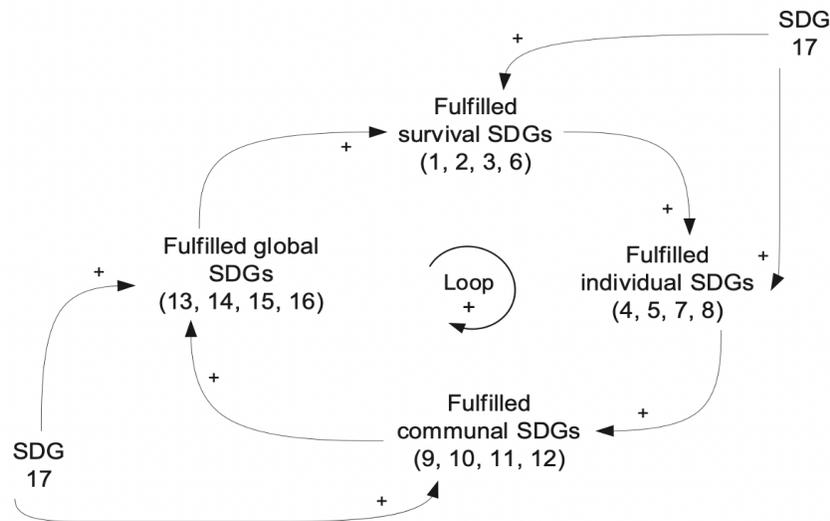


**Figure 3: A systems dynamics model with macro-interactions of SDGs: Each arrow represents an interaction in this positive feedback loop. For example, progress towards fulfillment of SDG 17 improves the attainment of SDGs 13–16, which advances SDGs 1, 2, 3, and 6, and then 9–12, which, in turn, helps with SDGs 13–16** (*Source: Besiou et al., 2021*).

The partnership SDG (17) extends the idea of global SDGs in supporting all the above subsets.

Interestingly, the model does not have anything to improve SDG 17 further. Indeed, we have seen from

the MDGs over 2000-2015 and the SDGs over 2015–2023 that the global partnerships SDG can remain unfulfilled despite its potential to improve all other SDGs.

There is another positive feedback loop. Sodhi (2016) empirically shows a vicious cycle of disasters leading to an exponentially increasing impact over time as regards the number of people affected or the value of property damaged, even after considering population or GDP growth. This vicious cycle is a positive feedback loop of natural disasters' impact leading to poverty, which leads to vulnerability, and that means when the disaster strikes, the effect is even more significant for a country. In their effort to respond as quickly as possible, humanitarian organizations tend to underestimate the power of this vicious cycle or ignore it (Besiou et al., 2021). From a systemic perspective, humanitarian operations reduce the risk of future disasters and increase community resilience, contributing to fulfilling SDGs 1–16. Strengthening the SDGs, in turn, improves the potential success of future humanitarian operations and lowers the dependency on them by ending poverty, ensuring prosperity, and protecting the planet (**Figure 4**).
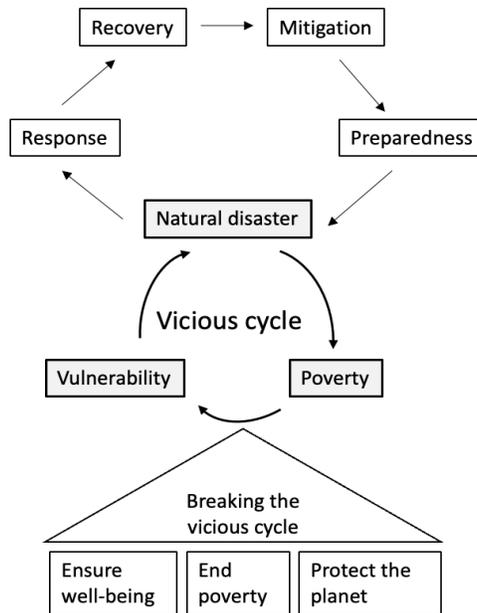


**Figure 4: Dealing with disasters effectively using response, recovery, mitigation, and preparedness (Besiou et al., 2021). Additionally, achieving SDGs can break the vicious cycle of disasters, poverty, and vulnerability (Sodhi, 2016).**

A positive feedback loop means that the output, namely the different types of impact, would exhibit exponential growth. To illustrate, consider the exponential growth of global property damage. After adjusting for inflation, the global damage appears to double every 14 years, using the data from the EM-

DAT database. Even though there are questions about the reliability of the older data, the exponential growth pattern is evident (**Figure 5**). The global GDP has also grown exponentially over this time but slower than the damage growth, so the global damage has also grown exponentially relative to global GDP, further evidence of a positive feedback loop. Notably, countries are not uniform in GDP growth or the impact of the disasters they endure. Therefore, we have disparities among countries regarding achieving basic UN SDGs regarding food or poverty, with vulnerable countries caught in a vicious cycle of disasters, poverty, and vulnerability (Sodhi, 2016).
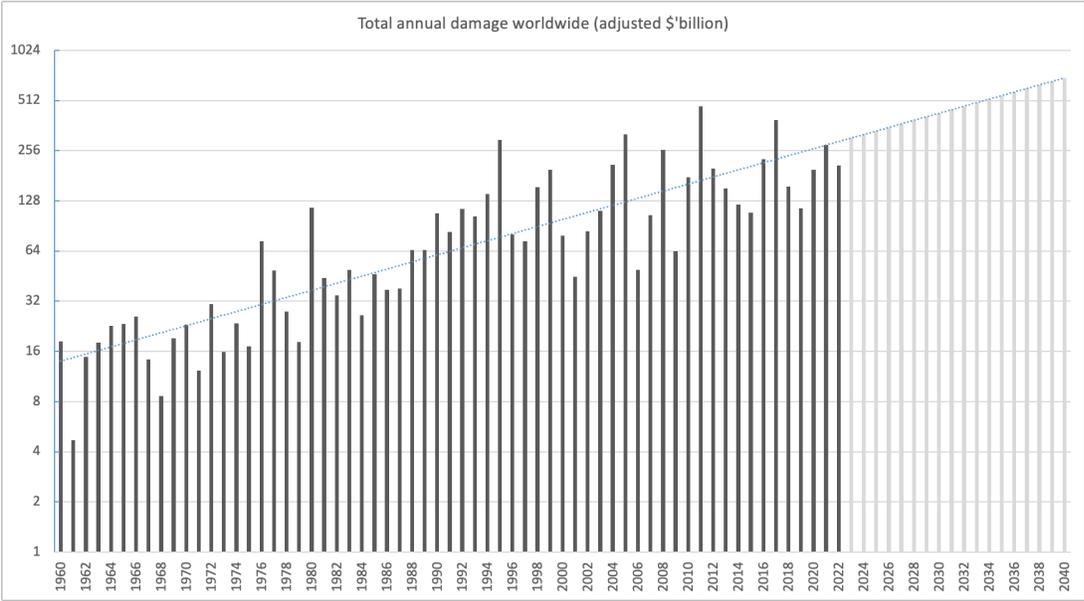


**Figure 5: Exponential growth of annual property damage from disasters worldwide, over 1960-2022, with the inflation-adjusted damage in billions of US $ on a logarithmic scale; successive ticks indicate double the damage. The projections in the lighter shade are from 2023 to 2040.** *Data: EM-DAT.*

## 4.4 A "Wedding Cake" Lens

To highlight the underlying linkages among different SGDs, the Stockholm Resilience Centre developed a "wedding cake" representation of the SDGs, with the SDGs partitioned among economy, society, and the biosphere. The cherry on the cake is the goal of *partnerships for the goals* (SDG 17), for which the countries are underperforming by a wide margin as they did with the MDGs. Within each layer, there are synergies and trade-offs. For instance, SDGs 8 and 12 are trade-offs. As we shall see in the next section (Opportunity 2), this representation helps us find synergies not only among SDGs within the same layer

with a *horizontal cut* of the cake but among SDGs across layers with a *vertical cut* to relate the economy, society, and the biosphere (**Figure 6**).

| | | | 17. Partnerships for the goals | | | | |
|---|---|---|---|---|---|---|---|
| **Economy** | | | 8. Decent work & economic growth | 9. Industry, innovation, & infrastructure | 10. Reducing inequality | 12. Responsible consumption & production | |
| **Society** | 1. No poverty | 11. Sustainable cities & communities | 16. Peace, justice, & strong institutions | 7. Affordable & clean energy | 3. Good health & well-being | 4. Quality education | 5. Gender equality | 2. Zero hunger |
| **Biosphere** | 15. Life on land | | 14. Life below water | | 6. Clean water and sanitation | | 13. Climate action | |

**Figure 6. A (three-layered) wedding cake representation of the 17 UN SDGs. Adapted from Stockholm Resilience Centre,** *https://tinyurl.com/nhcud8hv***.**

# 5. Tying Extant OM Research to SDG Synergies

Next, we link specific extant OM research with synergies among different SDGs with an illustration by "cutting" the SDG wedding cake (**Figure 6**) horizontally or vertically. These 'cuts' are examples of synergies OM researchers may seek to identify themselves.

## 5.1 A Horizontal Cut: Gender Equality and No Poverty

The horizontal layers of the cake (Figure 6) are the *economy*, *society*, and the *biosphere*. A research agenda can be established by focusing on any of these layers, for instance, around interventions to *alleviate poverty* (SDG 1) and *reduce hunger* (SDG 2) that can improve *gender equality* (SDG 5) and *education quality* (SDG 4) in the society layer. For instance, by considering several SDGs within one layer, one can examine how access to clean water and sanitation (SDG 6) in the *biosphere* layer can improve gender equality (SDG 5) and education quality (SDG 4) in the *society* layer (Figure 6).

Consider two OM papers as examples that can be viewed as taking a horizontal cut across the *society* layer of the cake (Figure 6). Tang (2022) examines how innovative operations enabled by technologies such as mobile phones, online platforms, solar technology, blockchain, AI, and the Internet of Things can improve *gender equality* (SDG 5), *alleviate poverty* (SDG 1), and *quality education* (SDG 4). Another example is the work of Plambeck and Ramdas (2020). Over 300 million women in India lack access to affordable sanitary napkins, causing many of them to drop out of school at puberty and miss work during menstruation. Hence, cheap and readily available sanitary napkins can affect *quality education* (SDG 4) for girls and women, enable *gender equality* (SDG 5), and *reduce poverty* (SDG 1).

OM research also discusses technological interventions that take similar horizontal cuts. *Gender quality* (SDG 5) begins with identity: a prerequisite for accessing services and exercising their rights. With one out of every two women in low-income economies not having a national ID or similar identity credential,[9] the World Bank has worked with over 40 countries to develop digital ID systems called ID4D for people, particularly women, to obtain authenticated identity.[10]

Another innovation is mobile apps. UNICEF and Microsoft developed a global learning platform called "Learning Passport" (https://www.learningpassport.org/) that offers free lessons via mobile phone. Khan Academy (https://www.khanacademy.org/) has a mobile app that offers free online lessons in Mathematics (along with other subjects) for Pre-K to 8th-grade students. As two-thirds of the world's illiterate adults are women (Ford, 2015), mobile learning can play an essential role in improving *quality education* (SDG 4) and *gender equality* (SDG 5). Mobile apps can help people experiencing poverty and women find jobs. In China, during Covid-related lockdowns, Alibaba created an online platform with restaurant chains for online employee-sharing plan so that over 3,000 restaurant workers could find temporary work during the pandemic (Wang, 2020) to reduce poverty and maintain gender equality.

Another technological innovation studied in the OM literature is solar and other devices, which add *affordable and clean energy* (SDG 7) to the same horizontal cut through the cake's *society* layer. Solar lanterns are safer than kerosene lamps or burning wood that generate carbon monoxide. Also, it can

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[9] Source: https://www.gatesfoundation.org/ideas/articles/mosip-digital-id-systems#:~:text=One%20in%20two%20women%20in,life%20are%20out%20of%20reach, accessed on August 23, 2023.

[10] Source: https://id4d.worldbank.org/country-action/id4d-diagnostics, accessed on August 24, 2023.

enable students to study and workers to work at night, which supports quality education and alleviates poverty. Sodhi and Knuckles (2021) present a field study across five solar-lantern 'development-aid' supply chains in Haiti to show how donor cash enables these supply chains. Motivated by such development aid supply chains, Yu et al. (2020) show analytically that donors' intervention through subsidies can be effective, and more product and retail-channel choices can increase the number of beneficiaries; this increase becomes more pronounced as demand becomes more uncertain. Considering the case of subsided pricing, recharging, and adoption of lamps, Uppari et al. (2019) find that upfront subsidized prices and subsequent recharging micropayments are insufficient to ensure higher adoption rates.

In 2016, 13% of the world's population did not have access to electricity, and over 3 billion off-the-grid households relied on women to collect fuel wood to meet their energy needs (Ritchie and Roser, 2020). Some social enterprises developed solar cookers that enabled women in rural Nicaragua to produce and sell baked goods, candies, and roast coffee (Sodhi and Tang, 2011). Solar Energy Kenya Foundation (https://solar-energy-foundation.org/en/) installs solar lighting systems for classrooms. It offers 100 portable solar lamps for each pilot school so that children come to school with the lamp to recharge during the day and return home with a fully charged lamp for evening learning. Among different initiatives that aim to improve *gender equality* and *alleviate poverty*, one initiative in India entails the development of a solar-powered eKOCool cooler to enable female micro-store owners to sell ice-cold drinks, operate at night by using and charging solar lanterns, and offer mobile phone charging service to customers by tapping into the charging ports provided by eKOCool coolers (Kumar, 2012).

## 5.2 A Vertical Cut: Reducing Hunger through Responsible Consumption and Production

We can develop different research agendas by exploring issues that affect the biosphere, society, and the economy, i.e., by taking a vertical cut across the layers of the SDG wedding cake (Figure 6). For example, there is a need to increase food supply with *responsible consumption and production* (SDG 12) to *reduce hunger* (SDG 2) without damaging the environment in line with *climate action* (SDG 13). We must consider humanity's reliance on fishing and seafood – much more than poultry, pork, and beef – and the link to *life below water* (SDG 14). A pertinent example is the collapse of the Alaskan crab population due to the rising temperature of the ocean. The collapse forced the state of Alaska to call off the crab harvest

in 2022, financially impacting the fishing communities dependent on the crabs for a $150 million annual harvest (Salam, 2023).

A vertical cut through the layers indicates the urgency of the world's challenges, the threat of growing world hunger being particularly compelling, and the attainment of the goal of zero hunger (SDG 2) is threatened. The UN reported that in 2020, roughly 161 million more persons worldwide were suffering from hunger than in 2019. In 2020, a staggering 2.4 billion people, or above 30 percent of the world's population, were moderately or severely food-insecure, lacking regular access to adequate food.[11] The average per capita arable land worldwide has declined from 0.26 hectares per person in 1980 to 0.11 hectares per person in 2020.[12] Moreover, the UN reported that five billion people, or around two-thirds of the world's population, will face at least one month of water shortages by 2050 (Cusick, 2022). Rather than increasing land under agriculture with a consequent alarming rate of deforestation, the world needs to improve farm yields or other operations, particularly those of smallholding farmers in low-income countries.

OM researchers have written about interventions whose impact cuts across all three layers of the cake, for instance, on company efforts to improve *responsible consumption and production* (SDG 12), *reduce inequalities* (SDG 10), and reduce waste to improve *life below water* (SDG 14) and *life on land* (SDG 15). For instance, Chen et al. (2022) have written about the apparel company Patagonia's program to ensure their contract manufacturers' workers are paid above the living wage for their country while encouraging customers to reduce consumption (with its "don't buy this jacket" campaign) and use the Patagonia-provide repair services to extend the life of its products.

OM scholars have researched at least three ways farmers can produce more:

**1. Sustainable agriculture.** One topic is sustainable agriculture. Sustainable agriculture is a plausible remedy for this challenging situation as it can increase crop yield by as much as 79%, according to the Food and Agricultural Organization of the United Nations (FAO).[13] The *Journal of Operations*

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[11] Source: https://www.un.org/sustainabledevelopment/hunger/, accessed on Aug 24, 2023.

[12] Source: https://data.worldbank.org/indicator/AG.LND.ARBL.HA.PC, accessed on Aug 24, 2023.

[13] Source: https://www.fao.org/newsroom/detail/oecd-fao-agricultural-outlook-2023-32-maps-key-output--consumption-and-trade-trends/en. Accessed on Aug 25, 2023.

*Management* has called for a special issue on sustainable agriculture (Durach et al., 2023). Boyabatli et al. (2021) have compiled recent OM research streams that examine ways to improve farmer productivity, including ways to facilitate learning about sustainable farming techniques and financial subsidies to entice farmers to grow crops that could be better for the environment and the farmer.

**2. Information access and sharing.** A second topic in the OM literature is the information flows to improve farmers' productivity in low-income and lower-middle-income countries. These information flows are enabled with mobile phone technology for the most part. Sodhi and Tang (2014) discussed how the e-Choupal initiative created by ITC, a leading food manufacturing company in India, facilitates information sharing among farmers about specific farming techniques to improve production yield via face-to-face meetings as early as 2000 and then moved to a mobile platform in 2018. Tang et al. (2016) have written about pasta-maker Barilla and its web-based support for farmers for sustainable farming in this regard.

There are also "peer-to-peer" (P2P) knowledge-sharing programs, such as the one by WeFarm, to assist knowledge exchange among smallholders across the globe. Similarly, Rainforest Alliance launched its Farmer Training App in 2015 for farmers to share tips, videos, and photos with others about best practices in sustainable agriculture, with a pilot study with a Guatemalan cooperative of coffee farmers to watch videos on sustainable farming, post questions, and share tips. However, Xiao et al. (2020) find that farmers with high knowledge levels are unwilling to share their knowledge with other farmers due to self-interest unless there is an appropriate reward mechanism. Indeed, Rainforest Alliance's SCN offers a small number of free phone minutes to reward farmers who share effective farming practices.

**3. Subsidies and price support.** A third strand in the OM literature is the study of subsidies and price support most governments provide, focusing on those of low-income and lower-middle-income countries. Many governments often provide "input subsidies" for farmers to purchase quality seeds and effective fertilizers to improve yield, and some governments offer "output subsidies" to defray farmers' storage and transportation costs of their harvests. Tang et al. (2023) find that while both subsidy schemes reduce income inequality among farmers, the input subsidy scheme is more effective in increasing food supply at a lower selling price than the output subsidy scheme, which helps towards *zero hunger* (SDG 2).

In India, the minimum support price (MSP) is a price support scheme offered by the Indian government to farmers to improve (a) the farmer welfare by safeguarding farmers' incomes against vagaries in crop price and (b) the consumer surplus by ensuring sufficient crop production. The government needs to reexamine

its MSPs to ensure sufficient incentives for growing crops like corn or millet that require less water than the rice and wheat currently being produced in excess in India at the detriment of groundwater. Chintapalli and Tang (2021) examine the implications of a credit-based MSP scheme, in which the government will credit farmers based on the price difference if the prevailing market price falls below the pre-specified MSP when risk-averse farmers face both price and yield uncertainties. They find that when one crop (such as sorghum) is more rewarding (higher price) but riskier (lower yield) than the other crop (such as rice), then it is sufficient to offer an appropriate MSP for one of the two crops. In a follow-up study, Chintapalli and Tang (2022a and 2022b) find that offering MSPs to complementary crops (e.g., lentils and rice) is more beneficial than providing MSPs to substitutable crops (e.g., staples such as rice and wheat).

# 6. Research Opportunities

Given the different lenses OM research affords to view the synergies across the SDGs (Section 4) and examples from the OM research and the use of such lenses (Section 5), we hope that OM researchers can build their research agenda from our work. There are plenty of compelling research topics to understand the non-achievement of the SDGs thus far and to find normative solutions for the immediate future. These OM research issues range, for instance, from empowering women's economic development, which can help achieve SDG 5 (gender equality), to enabling farmers to use information and digital technologies in agriculture to produce more using less land and water, which can help achieve hunger SDG 2 (zero hunger) and support SDG 13 (climate action). Geopolitical challenges have also created other research opportunities. Below are some examples of research topics that researchers can explore or use to build their research agendas:

1. *Action research and case studies*: As an example of normative or action research, one could propose value-adding activities by the Solar Mamas program, including repairing, reusing, and recycling solar devices to support the circular economy models to reduce waste. The Solar Mamas' knowledge about user experience could also be helpful for the manufacturers of these solar devices to improve their product design for a circular economy. Such a research opportunity corresponds to a vertical cut of the SDG wedding cake that intends to develop a mechanism to create decent work (SDG 8) to sustain affordable and clean energy (SDG 7) and to reduce electronic waste that can improve life on land (SDG 15).

2. *Use of information and digital technologies in agriculture*: Similarly, due to declining arable land and agricultural water, it is essential to help farmers produce more using less land and water. As various industry 4.0 technologies become more affordable, OM researchers could examine the costs and benefits of different precision agriculture techniques using sensors, drones, robots, etc. Indeed, pasta maker Barilla has been guiding durum wheat farmers for region-specific guidance on the sowing time, watering, fertilizing, and harvesting using the web (Tang et al., 2016). For instance, researchers can study the value of precision agriculture techniques in increasing farmers' productivity, quality, and profitability while reducing environmental impacts (e.g., minimizing water consumption via precision irrigation systems) and, at a national level, enhancing food security. Such research questions correspond to a vertical cut of the SDG wedding cake across the economy, society, and the biosphere with the adoption of precision farming technologies towards industry, innovation, and infrastructure (SDG 9) to reduce hunger (SDG 2) and water consumption, which would support climate action (SDG 13).

3. *Achieving global partnership*: At a higher level, researchers can look at the SDGs (and MDGs) to investigate whether these are the means for global sustainable development. On one hand, humanity shares this planet, which is under threat on many fronts. On the other hand, there is competition among countries for resources and dominance. In such a setting, is the only solution that rich countries provide *some* SDG-related funding to least-developed or lower-to-middle-income countries but not *all* the funding required? If so, researchers could propose better mechanisms to bring about more cooperation between countries – and between regions within a country – to achieve a higher level of partnership (SDG 17) and, thus, attain the other SDGs to the level agreed.

4. *Empowering women in developing countries*: Tang (2022) has outlined various research topics in three categories that we summarize here:

   (a) Making necessities accessible: Carrying out data-driven research for determining the optimal location for toilets and water tanks to maximize social welfare through empowering women in rural areas of developing countries.

   (b) Affordability of emerging technologies such as solar technology: Examining the impact of different pricing and operating models (including the revenue sharing model) on the adoption rate of solar technology in emerging markets for female micro-entrepreneurs.

(c) Sustainability of environmental and social issues: Conducting behavioral research on (a) the impact of social nudging on sustainable efforts and (b) the impact of mobile financial services on sustainable savings among female users.

5. *Measuring poverty specific to UN SDGs*: Researchers could also investigate the notion of 'poverty,' which is crucial to development. As noted earlier, the World Bank uses an income-based measure of US $2.15 per day per person for a low-income country, $3.65 for a lower-middle-income country, and $6.85 for an upper-middle-income country in 2017 prices as the poverty line. While the (national) poverty line is incorporated in SDG 1 (no poverty) as one of the 13 indicators, overall, the indicators for the SDG take a much broader approach in line with the global multi-dimensional poverty index (MPI) (UNDP, 2020).[14] Researchers looking for synergies could investigate how the different dimensions of poverty (indicators of SDG 1) are linked to the other SDGs and their indicators.

6. *Business recognition of stakeholders*: Besides government commitments (whether held in practice or not), there are business declarations. For instance, as per the Business Roundtable website, some 179 CEOs of US-based companies have signed a statement saying that they recognize and commit to various stakeholders by (a) delivering value to customers, (b) investing in employees, (c) dealing fairly and ethically with suppliers, (d) supporting the communities where the companies operate, and (e) generating long-term value for shareholders. OM researchers could investigate the convergence of such declarations with the UN SDGs, focusing on pertinent stakeholders, as these businesses may be only virtue-signaling with their declarations. OM researchers could investigate positive changes in these businesses' support of communities where these companies have operations or in the improvement of conditions for labor upstream in the supply chain.

7. *The impact of conflict*: In Section 2, we saw that progress on some SDGs has been held back due to various conflicts worldwide. Besides affecting individual SDGs on zero hunger (SDG 1) or peace, justice, and institutions (SDG 16), conflict reflects poor global partnership (SDG 17) and further undermines it. A poorer state of global partnership, in turn, jeopardizes the achievement of nearly all the SDGs for many of the poorer countries. Therefore, it would be helpful to examine

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[14] UNDP 2020. The 2020 Global Multi-dimensional Poverty Index, United Nations Development Programme and Oxford Poverty and Human Development Initiative, Accessed https://hdr.undp.org/content/2020-global-multidimensional-poverty-index-mpi on Nov. 3, 2023.

the short- and long-term impact of various regional conflicts – such as those between Russia and Ukraine, Israel and the Palestinian people, and internal ones in Iraq and Syria – on the progress of the SDGs in Europe, the Middle East, and even other regions. For example, progress towards SDG 2 (zero hunger) in many African countries suffered due to their reliance on grain exports from Ukraine, which plummeted after the end of the grain deal between Ukraine and Russia in July 2023, or fertilizer exports from Russia indirectly affected by Western sanctions.

8. *De-globalization and the China-US trade conflict*: Tensions between the US and China on trade and security matters have triggered many Western firms to diversify their supply chains away from their suppliers from China to countries such as Vietnam and India. However, Vietnam and India rely on China for various parts and components to produce electronic products, solar panels, etc., creating risks to supply chains overall despite increasing opportunities in these countries (Tang, 2023b). An *Economist* podcast (Economist, 2023) and a recent article in Danish Foreign Society magazine (Sodhi, 2023) delve into the risks of de-risking from China. More generally, there is the problem of a possible reversal of globalization as many countries, including the US and the EU, seek to develop domestic capacity for critical goods like electronic chips (Sodhi, 2022). For instance, the $280 billion US CHIPS and Science Act of 2022 encourages domestic production of semiconductor chips. Because of de-risking supply chains away from China and, more generally, de-globalization, global supply chains have become even more complex (Tang, 2023a). On the one hand, such efforts promise more job opportunities, improving the potential for decent work and economic development (SDG 8) within the country. Yet, on the other, such moves divert funds away from almost all other SDGs, undermine global partnerships (SDG 17), and eventually diminish the achievement of SDG 8, providing researchers an opportunity to understand the dynamics of deglobalization.

# 7. Conclusion

To summarize, we noted at the outset that in 2015, the United Nations countries signed up to achieve 17 Sustainable Development Goals (SDGs) for people, planet, prosperity, peace, and partnership by 2030. Still, the trend of progress toward achieving these goals indicates that none of the 17 goals may be achieved by 2030 globally. We sought to provide a foundation for OM research in this area by (1) identifying the synergies among the SDGs so that interventions can impact multiple SDGs positively and (2) linking the pertinent extant OM research with the synergies among the various SDGs. To do so, we *first* outlined four different lenses that OM researchers could use to find synergies among the SDGs: (1)

an operations performance lens, (2) a stakeholder-focused lens, (3) a system dynamics lens, and (4) a wedding cake lens. Researchers can use any of these lenses to view and frame synergies across SDGs for studying or normatively designing interventions. Tying extant OM research that uses different lenses to identify possible synergies between SDGs can enable OM researchers to develop research agendas around them. *Next*, to illustrate how to link the extant OM research to SDG synergies, we used the wedding cake lens to illustrate how some of the OM literature ties to SDG synergies by taking a horizontal and a vertical cut of the SDG wedding cake. We also outlined some specific research topics. Thus, we provide a springboard for further OM research on SDG attainment and interventions needed by companies and governments to make progress on the SDGs.

Given the threats facing the planet in the coming years and the gap between the achievement of the SDGs and the level necessary, OM researchers must start paying more attention to the SDGs. The attention to the SDGs till 2030 and other similarly motivated programs after 2030 can only grow in the coming years and decades. We hope our article helps OM researchers frame their research in SDG terms and find extensions and new ideas.

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