Impact

► Impacts on Environment and on Human Health

Impacts on Environment and on Human Health

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Synonyms

Environment: Ambient; Atmosphere; Climate; Clime; Context; Environs; Medium; Milieu; Setting; Surroundings; Terrain; Impact: Affect; Impress; Influence; Move; Reach; Strike; Sway; Health: Fitness; Healthiness; Heartiness; Robustness; Sap; Soundness; Wellness; Wholeness; Wholesomeness

Definition

"Environmental health refers to aspects of human health (including quality of life) that are determined by physical, chemical, biological, social and psychosocial factors in the environment. Environment broadly includes everything external to ourselves, including the physical, natural, social and behavioral environments. Health is a state of complete physical, mental and social wellbeing, and is not merely the absence of disease or illness" (Source: Environmental Health Indicators New Zealand-Massey University 2018) http://www.ehinz.ac.nz/indicators/overview/what-is-environmental-health/#References.

Introduction

Environment has direct relationships with all living being including humans. Any change in environment can have positive or negative impacts in every stage of life system. To some extent, most of the living being has coping mechanism; however, there is threshold. When changes occur in the environment beyond the edge, the impact begins to appear in the life system diversity and their (in human or other living being's) health condition (well-being). We have no detail account of how much changes have been occurring on life system of the planet; however, we have ample examples of the impact of environmental change on human health. As it is established notion that, anthropogenic influence in our atmospheric environment is one of the major causes of environmental change (frequently used as climate change). The evidence of climate change can be listed as rise in the atmospheric temperature, flooding, change in snow and rainfall patterns, frequent heat waves, drought, wildfires, and hurricanes (Bhandari 2018b, c). These problems have direct impact on human health. The increase in deaths and new

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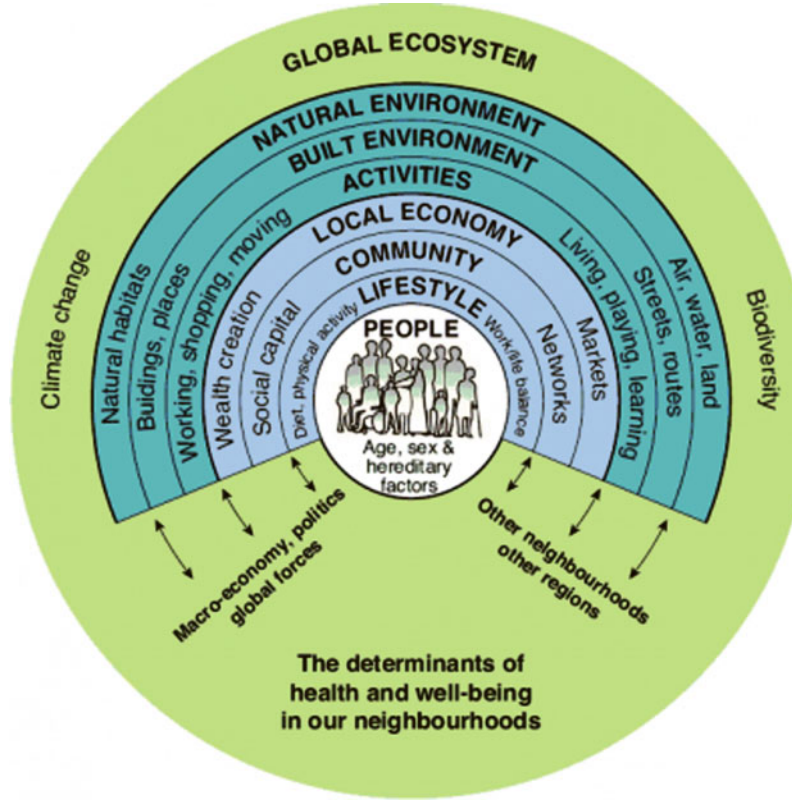
Encyclopedia of the UN Sustainable Development Goals, https://doi.org/10.1007/978-3-319-95726-5



Impacts on Environment and on Human Health, Diagram 1
Interrelationship and health determinates in global ecosystem (Source: Barton and Grant (2006). A health map for the local human habitat)

diseases can be seen as the evidence. Remoundou and Koundouri (2009) nicely illustrate this issue as "The environment affects our health in a variety of ways. The interaction between human health and the environment has been extensively studied and environmental risks have been proven to significantly impact human health, either directly by exposing people to harmful agents, or indirectly, by disrupting life-sustaining ecosystems." Similarly, there are more severe indirect impacts of climate change on human health, for example, rise of atmospheric temperature and increase in air pollution, noise pollution, water pollution that contaminates major sources of life (air, water, and food). Air and water pollution and contaminated food have both short-term and long-term impacts on human health. As FAO states, "all the physical, chemical, and biological factors external to a person, and all the related behaviors" are health related to human being. Therefore, most of the physical and mental illness can have direct or indirect impacts of environmental change (climate change). "Environmental health consists of preventing or controlling disease, injury, and disability related to the interactions between people and their environment" (US Department of Health and Human Services 2018).

The Diagram 1 from Barton and Grant (2006) summarizes the interrelationship and health determinates in global ecosystem.

Health Problems

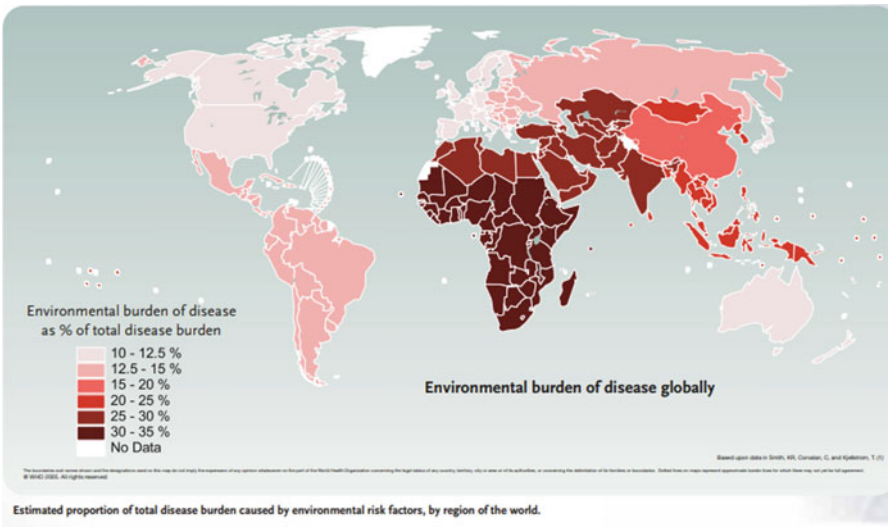
It is a fact and truth that if health condition is not good, then, nothing is good. According to US Department of Health and Human Services-USDHHS (2018), elements of environmental health include outdoor air quality, surface and ground water quality, toxic substances and hazardous wastes, homes and communities, infrastructure and surveillance, and global environmental health. Health problems occur due to exposure to hazardous substances in the air, water, soil, and food,

natural and technological disasters, climate change, occupational hazards, and the built environment (USDHHS 2018). Environmental health hazards can be biological, chemical, physical, biomechanical, or psychosocial, and causes could be due to poor sanitation and shelter, as well as agricultural and industrial contamination of air, water, food, and land (Yassi and Kjellström-in ILO Encyclopedia 2015).

The environmental health hazards could bring or cause radiation illness (follow-up of in utero exposures continuing); gastrointestinal, skeletal, muscle, autonomic, and central nervous system effects; acute lung disease; neurological disease; skin disease; general weakness; anemia; behavioral and mental effects; porphyria; kidney and bone disease; increase in heart and lung disease manifestations; cholera; etc. (ILO Encyclopedia 2015), which could increase the environmental problems and burden to all level of stakeholders including a person, family, communities, nations regions, and globe (Map 1).

"An estimated 12.6 million deaths each year are attributable to unhealthy environments - nearly one in four of total global deaths. Environmental risk factors, such as air, water and soil pollution, chemical exposures, climate change and ultraviolet radiation, contribute to more than 100 diseases and injuries". "The Global Burden of Disease (GBD) provides a tool to quantify health loss from various diseases, injuries and significant health risk factors so that health system can be improved and eliminated disparities. In order to align health systems within the populations they serve, policymakers need to understand the true nature of their countries health challenges and how those challenges are shifting over time. Disease burden is the impact of a health problem caused by a disease as measured by financial cost, mortality, morbidity or significant other indicators. The overall disease burden can be thought as a measure of the gap between current health status and the ideal health status (where the individual lives to oldage free from disease and disability" (Olanipekun and Babatunde 2016: 58).

Primarily, most dominant and visible health impacts are due to major outdoor pollutants: sulfur oxides (source – coal and oil combustion, smelters); suspended particulate matter (source – combustion products (fuel, biomass), tobacco smoke); nitrogen oxides (source – fuel and gas combustion); carbon monoxide (source – incomplete petrol and gas combustion); ozone (source – photochemical reaction); lead (source – petrol combustion, coal combustion, producing batteries, cables, solder, paint); and organic substances



Impacts on Environment and on Human Health, Map 1 Environmental burden of diseases (ILO-Encyclopedia 2015)

(source – petrochemical solvents, vaporization of unburnt fuels) (ILO-Encyclopedia 2015). These pollutions mostly come from the use of fossil fuels (transportation, industrialization, and other developmental activities, which directly impact the biophysical environment). The commonly known and increasing diseases directly due to environmental exposures include asthma, autism, autoimmune diseases (lupus), breast cancer, cancer, lung disease, obesity, obesogens, Parkinson's disease, and reproductive health disorders (USA.Gov 2018). Primarily, every one of us can be victims of the environmental health hazards; however, major sufferers are those who have no excess to health facilities and resources to cope with the situation.

Sustainable Development and Human Health Problem

Basically, the health issues interconnection with development agendas came into major discussion in the 1980s; however, major focus began from the Rio, Declaration on Environment and Development-1992. Rio-1992 clearly stated that "Human beings are at the center of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (Principle I of the Rio, Declaration on Environment and Development-1992). The International Covenant on Economic, Social and Cultural Rights clearly states that access to healthcare is part of basic human right. Likewise, the WHO's one of the major principles states, "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition" (WHO Constitution, 2nd Paragraph 1946).

The objectives of sustainable development cannot be met if large populations of people are dealing with devastating illnesses and diseases. For any ecological development, safe access to healthcare is essential for the inhabitants of its area. In this regard, the agenda 21 of Rio Declaration tries to bring all concern stakeholders through:

1. Identification and assessment of health hazards associated with environment and development.
2. Development of environmental health policy incorporating principles and strategies for all sectors responsible for development.
3. Communication and advocacy of this policy to all levels of society.
4. A participatory approach to implementing health-and-environment programs (WHO 2002: 4). Until or unless health problems are properly understood and incorporated in the development agendas, the goal of sustainable development cannot be attended/met.

Paths Forward

There have been many research and reports available about the impacts on environment and on human health and its trend and paths forward particularly due to air pollution (Hill et al. 2019; Brook et al. 2010; Brunekreef and Holgate 2002; Chay and Greenstone 2003; Clancy et al. 2002; Currie and Neidell 2005; Franklin et al. 2007; Bhandari 2018a). For example, "Air pollution is devastating for population health. Over the past two decades, studies have shown that various forms of air pollution (e.g., particulate matter, carbon monoxide, and ozone) increase the risk of heart disease, cerebrovascular disease, all-cause mortality across the life course, cause-specific adult mortality linked to respiratory diseases, cardiovascular diseases, malignant neoplasms, and unintentional injuries" (Hill et al. 2019: 1). There may be rarely any areas of non-impact of air pollution on human health, whether it is developing or developed world; however, the degree may be unequal. There is also global awareness of impacts of degrading environment on human health. The major examples are the development of Millennium Development Goals (MDGs) 2001–2015 and the Sustainable Development Goals (SDGs) 2016–2030. MDGs prime focus was to eradicate extreme poverty and hunger and to improve literacy, gender equality, and health and development (WHO 2015a). Similarly, SDGs have similar focuses with targeted goals. In this regard, paragraph 26 of the 2030 agenda for sustainable development addresses health as follows "To

Impacts on Environment and on Human Health, Table 1 Relationship between MDGs and SDGs at the goal level

Millennium development goals (2000–2015)	Sustainable development goals (2016–2030)
MDG 1. Eradicate extreme poverty and hunger	SDG 1. End poverty in all its forms everywhere SDG 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture SDG 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all SDG 10. Reduce inequality within and among countries
MDG 2. Achieve universal primary education	SDG 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
MDG 3. Promote gender equality and empower women	SDG 5. Achieve gender equality and empower all women and girls
MDG 4. Reduce child mortality MDG 5. Improve maternal health MDG 6. Combat HIV/AIDS, malaria, and other diseases	SDG 3. Ensure healthy lives and promote well-being for all at all ages
MDG 7. Ensure environmental sustainability	SDG 6. Ensure availability and sustainable management of water and sanitation for all SDG 7. Ensure access to affordable, reliable, sustainable, and modern energy for all SDG 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation SDG 11. Make cities and human settlements inclusive, safe, resilient, and sustainable SDG 12. Ensure sustainable consumption and production patterns SDG 13. Take urgent action to combat climate change and its impacts SDG 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development SDG 15. Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
MDG 8. Develop a global partnership for development	SDG 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development
	SDG 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels

Source: SESRIC 2016: 39. http://www.sesric.org/files/article/568.pdf

promote physical and mental health and wellbeing, and to extend life expectancy for all, we must achieve universal health coverage and access to quality health care. No one must be left behind. We commit to accelerating the progress made to date in reducing newborn, child and maternal mortality by ending all such preventable deaths before 2030" (UN 2015, as cited in WHO 2015a: 8).

SDGs tackle all sectors which were over sought in the MDGs, based on more facts and tangible aspects. MDGs' main focus was developing countries; however, SDGs look national variation and apply the universal and comprehensive approach to minimize the environmental impact on health and achieve the developmental goals. Table 1 below gives a general outline of MDGs and SDGs.

According to press release of WHO 2015

> Health in 2015: from MDGs to SDGs" identifies the key drivers of progress in health under the United Nations Millennium Development Goals (MDGs). It lays out actions that countries and the international community should prioritize to achieve the new Sustainable Development Goals (SDGs), which come into effect on 1 January 2016. The 17 SDGs are broader and more ambitious than the MDGs, presenting an agenda that is relevant to all people in all countries to ensure that "no one is left behind." The new agenda requires that all 3 dimensions of sustainable development – economic,

> social and environmental – are addressed in an integrated manner. Almost all the SDGs are directly related to health or will contribute to health indirectly. One goal (SDG3) specifically sets out to "Ensure healthy lives and promote well-being for all at all ages." Its 13 targets build on progress made on the MDGs and reflect a new focus on noncommunicable diseases and the achievement of universal health coverage. (Source: WHO 2015a: http://apps.who.int/iris/bitstream/handle/10665/200009/9789241565110_eng.pdf;jsessionid=3E0D50B7C26313492CF6015492D42DC3?sequence=1)

This statement clearly indicates that SDGS are developed on the established principles of MDGs, which only partially obtained within the targeted time frame 2001–2015. More importantly, SDGs are based on the past experience with broader participants from both north and south. According to WHO 2015a; SDGs covers "reproductive, maternal, newborn, child and adolescent health; infectious diseases including HIV, tuberculosis, malaria, hepatitis and neglected tropical diseases; noncommunicable diseases (NCDs) including heart disease, cancer and diabetes; mental health and substance use including narcotics and harmful use of alcohol; injuries and violence; and universal health coverage. Additionally, SDGs 'Snapshots' on 34 different health topics outline trends, achievements made, reasons for success, challenges and strategic priorities for improving health in the different areas. These 'snapshots' range from air pollution to hepatitis to road traffic injuries and also explores how health contributes to and benefits from the other 16 SDGs and examines the implications of emerging issues such as technological and environmental change on global health" (WHO 2015a) (Source: https://www.who.int/en/news-room/detail/08-12-2015-from-mdgs-to-sdgs-who-launches-new-report excessed on 1-16-19).

The Diagram 2 provides the interrelationships between environment and health.

"All countries achieve universal health coverage at every stage of life, with particular emphasis on primary health services, including mental and reproductive health, to ensure that all people receive quality health services without suffering financial hardship. Countries implement policies to create enabling social and environmental conditions that promote the health of populations and help individuals make healthy and sustainable decisions related to their daily living" (2014: 6). Above quote from SDSN provides the pathway or future direction; each county needs to make sure that its citizens should have the health access and among with the basic need for their survival. There is still need of universalism in the healthcare system within the countries as well as beyond the borders. As environmental problem has no boundary, if any incident occurs in one location, its impacts can spread quickly to another location; health-related issues could also have the same spreading natures.

In terms of path forward, SDGs' goals seem practical than MDGs, for example, MDGs have 8 goals and 18 targets, and SDGs have 17 goals and 169 targets. In SDGs each goal has agendas and pathway to achieve them. SDGs goals and agendas are more comprehensive, more stakeholder engagement-oriented and public-private partnership in development. SDGs use the integrative approach for the development of the universal principles with clear outlines of how developed countries can help developing world and how developed world will also benefit (Boucher 2015).

Conclusions

In sum, it is already accepted notion that environment has direct impact on human health. Remoundou and Koundouri (2009) succinctly summarized general scenarios of environmental impacts on health, which still are the same (in reality it increased). According to them, the exact contribution of environmental factors to the development of death and disease cannot be precisely determined; the World Health Organization (WHO) has estimated that 13 million deaths annually are attributable to preventable environmental causes [1]. The report also estimates that 24% of the global disease burden (healthy life years lost) and 23% of all deaths (premature mortality) are attributable to environmental factors, with the environmental burden of diseases being 15 times higher in developing countries than in developed countries, due to differences in exposure to

Impacts on Environment and on Human Health, Diagram 2 Interrelationships of environment and health. (Source: WHO 2009. Above diagram of WHO demonstrate the interrelationships of environment and health, as well provides a general way to achieve the goal of sustainability)

environmental risks and access to healthcare (Remoundou and Koundouri 2009: 2161).

"Health is wealth," the basic which we heard and learned from the childhood, is the main mantra of healthy life. The environment is the surroundings, the habitat we live in and maintain our well-being; and the impact is the externalities, unwanted interferences in our habitat on which our health system relies. Physically, mentally, and socially healthy society is key for development. At personal level, physical and mental fitness with stamina, strength, energy, and vitality, ability to maintain physical and mental efforts, and activeness as well as good commonsense are vital for good health. To maintain good health and active life, we need to have developed muscles, fair amount of endurance, physical and mental health for longer time, and ability, including good character and common sense (USA.Gov 2018; ILO 2015; WHO 2006; USDHHS 2018). There is a direct relationship between environment

and human health. I mean without healthy people society can not function properly or can not sustain and sustainable development is not possible without healthy society.

Cross-References

- Environmental and Social Impacts of Food Waste
- Global Food Waste
- Improving the Quality of Life of Urban Communities in Developing Countries
- Slavery and Sustainable Development
- Sustainable Consumer Lifestyles/Sustainable Consumption

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Importance

► Materiality: From Accounting to Sustainability and the SDGs

Impress

► Impacts on Environment and on Human Health

Improving the Quality of Life of Urban Communities in Developing Countries

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Definition

Quality of life refers to the extent to which an individual enjoys the important life possibilities, including improved standard of living and general welfare, as well as the feeling of being safe and satisfied with life.

Introduction

For the past half of the century, the world has been undergoing serious transformations that fundamentally impact our everyday lives. Notable among them include urbanization, industrialization, and globalization, which have dramatically altered the ecosystem, human settlements, national and local economies, and public policies with attendant implications on the environment, public health, and socioeconomic development of communities (Abubakar 2017; Hamdan et al. 2014; Muhammad 2016a). The world is facing challenges capable of limiting the available options towards providing essential human needs such as food, shelter, water supply, sanitation, education, and healthcare (Abubakar and Dano 2018; Mohit 2013a). Other challenges include climate change, environmental degradation, growing unemployment, poverty and social exclusion, energy shortage, insecurity, as well as natural and man-made disasters (Abdel-hadi 2012; Abubakar 2018a). This situation has triggered a quest for policy interventions, programs, and enhanced institutional governance to effectively address and

manage the observed challenges towards a more sustainable world (Abubakar and Aina 2016; Hanifah and Hashim 2012).

Accordingly, there is a growing need for collective efforts to promote sustainable development (SD), defined as the "development that meets the needs of current generations without compromising the ability of future generations to meet their own needs" (Brundtland 1987). During the Earth Summit of 1992, 178 nations have adopted the Agenda 21, "a comprehensive plan of action to build a global partnership for sustainable development to improve human lives and protect the environment" (Abubakar and Aina 2016). Later in 2015, the United Nations General Assembly endorsed the "2030 Agenda for Sustainable Development" towards simultaneously achieving all the three dimensions of SD: environmental protection, economic growth, and social equity (UN 2018). The principal rationale for developing the Agenda's Sustainable Development Goals (SDGs) is to reaffirm the past international commitments to ensure that tangible actions are taken to achieve SD objectives and accomplish what has not been achieved in the Millennium Development Goals (UN 2018). The modalities of achieving SD is through international cooperation and collective action involving all stakeholders from the developed to developing countries (Abubakar 2018b; Muhammad and Abubakar 2019).

Although SD has become a major area of focus in the literature and practice, greater attention has been given to its environmental and economic dimensions with little focus on the social dimension. Even within the social dimension of SD, the literature concentrates on equity in access to livelihood opportunities and basic public services with less attention on the general well-being of individuals and societies (Abubakar 2018c; Gazzeh and Abubakar 2018). As such, there is a growing call for SD efforts to focus more on the overall quality of life (QoL) of human beings (Ismail et al. 2015; McCrea et al. 2006; Mohit 2013b; Veenhoven 2000). For this reason, this entry contributes in underscoring the importance of a comprehensive review of the concept of QoL, its measurement, the relationship between QoL and SD, key approaches of improving the QoL of urban and rural dwellers, and case studies of exemplary projects for improving the QoL of populations in developing countries.

Concept of and Perspectives on QoL

The concept of QoL is fluid, so commonplace that it is found in almost all disciplines, and subject to several interpretations and hence lacking a single commonly agreed definition. It is broadly utilized in a wide range of fields including healthcare, politics, public administration, urban planning, international development, and other social sciences and humanities (Abubakar 2013; Muhammad 2016a; Raphael et al. 1996; Zayyanu et al. 2018). Given that each discipline has different perspectives on QoL, various authors have, therefore, given diverse definitions of the concept. While Szalai (1980) refers to QoL as "the degree of excellence or satisfactory character of life," Raphael et al. (1996) consider QoL as "the degree to which a person enjoys the important possibilities of his/her life." While Diener and Suh (1997) define QoL as life satisfaction, Abdel-hadi (2012) associates the concept with improving living standards based on income.

The concept also involves other perspectives such as "needs satisfaction" (Keles 2012), well-being and "material wealth" (Constantinescu 2013), and the general welfare of individuals and societies (Aklanoglu and Erdogan 2012; Hanifah and Hashim 2012). Other perceptions of QoL include the "state of feeling safe" (Sham et al. 2013), and "overall evaluation of life" (Ana-Maria 2015). Similarly, QoL concerns physical and psychological health (Eusuf 2014), as well as "level of independence, social relationships, personal beliefs and relationships to salient features of the environment" (WHOQOL 1998). According to Gregory et al. (2009), the standard indicators of QoL consist of physical and mental health, the built environment, leisure and recreation, education, as well as social well-being, in addition to income and employment. Mitchell et al. (1995) concluded that although there is no consensus yet on its definition or constituents,

QoL has six basic components: health, security, personal development, community development, physical environment, and natural resources, goods, and services (Fig. 1).

Measuring Quality of Life

Because of its diverse nature, there is no single method of measuring QoL. As such, different objective and subjective approaches are used in measuring QoL (Ana-Maria 2015; Rybakovas 2014). The objective approach empirically measures what people consider being essential to their well-being, while the subjective measures are more concerned with feelings, experiences, and behavior patterns of individuals (Mohit 2013b). The objective measures focus on the actual situations in which people live, while the subjective approach measures an individual's satisfaction with and feelings about life situations (Muslim et al. 2013). While Mohit (2013a) argues that measuring QoL depends more on the objective approach, several other scholars emphasized the subjective perceptions (Ross and van Willigen 1997; Veenhoven 2000).

The concept can be measured either at an aggregate or discrete level. The objective

Improving the Quality of Life of Urban Communities in Developing Countries, Fig. 1 Components of QoL. (Adapted from Mitchell et al. (1995), p. 111)

approach usually measures QoL at the aggregate level by assessing the physical elements of the built environment that contribute to human well-being such as number or proportion of habitable buildings (homes, schools, hospitals, offices, etc.), infrastructure (e.g., roads, railways, airports, electricity, sewer, and water networks), economic status (GDP, income, employment, or assets), environmental condition (pollution and climate change), and social services (health, recreation, education) (Leitmann 1999; Mohit 2013a). Conversely, the subjective approach considers QoL as comprising of discrete domains usually disaggregated at the individual level and more concerned with cognitive experience, feelings, and behavior dimensions according to individuals' evaluations and perceptions of life.

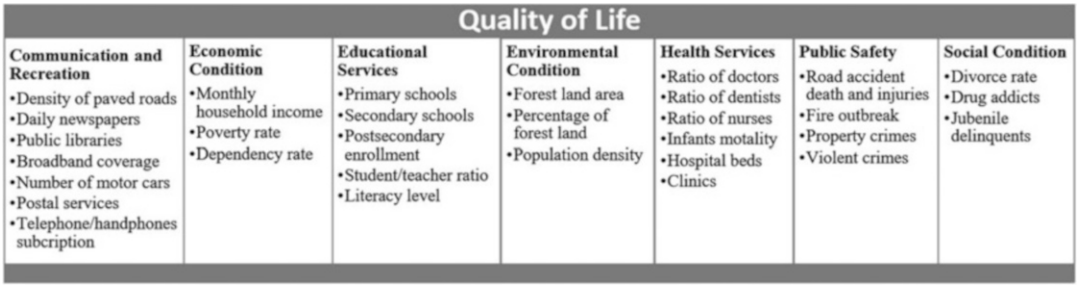
Several studies have employed the subjective or the objective or a mixed approach to QoL assessment. For example, Noor and Abdullah (2012) investigated QoL of workers in an international corporation in Malaysia using the subjective parameters, Latif et al. (2012) assessed the influence of situational factors and recycling behavior of individuals on their QoL in Malaysia, Circenis et al. (2013) measured the QoL among nurses in Latvia, Ana-Maria (2015) measured respondents' satisfaction with physical exercises for improving their QoL in Bucharest, and Romania and Zayyanu et al. (2018) measured the extent to which community-based poverty reduction projects improve the QoL of communities in Kebbi State, Nigeria. On the other hand, the objective approach has been used by Mohit (2013a) in studying regional variations in QoL in Malaysia, and Hamdan et al. (2014) assessed the relationship between the pattern of social capital and QoL among urban households in Klang Valley, Malaysia. However, Michalos (2017) and McCrea et al. (2006) argue that a more appropriate and balanced evaluation of the QoL must combine both subjective and objective measures.

Many scholars posited that the subjective indicators indeed reflect the objective variables, which may not be open to people's perception and experience (Maggino and Zumbo 2012; Michalos 2017). Similarly, Rybakovas (2014) indicates that the overall perceived QoL of individuals (subjective QoL) consists of a set of parameters that are dependent on the measurable variables (objective QoL). Certainly, a mixed approach of combining the objective and subjective indicators provides more insight about QoL and allows the strength of one approach to complement the weakness of the other (Marans 2003). For example, Ismail et al. (2015) used the mixed approach to measure the satisfaction level of residents of a low-cost residential neighborhood in Malaysia.

Being a multidimensional concept, QoL has many measurement indicators. For instance, the Australian Centre for QoL identified over one thousand indicators for measuring QoL (Ana-Maria 2015). Similarly, Juhásová (2015) adopted four domains, which contribute to overall QoL: social, physical, environmental, and psychological. Conversely, Mohit (2013a) adopted a more comprehensive QoL framework that consists of seven domains with their associated indicators that they used in investigating regional variation in QoL in Malaysia (Fig. 2). These domains are somewhat related to the QoL components proposed by Mitchell et al. (1995).

Importance and Challenges of QoL Assessment

QoL assessment is an important tool for advancing human development. It is useful in evaluating the circumstances in which people live including their needs and requirements, degree of satisfaction, happiness, and well-being. It helps to explore residents' satisfaction level with different components of the built environments such as housing, infrastructure, educational, health and recreation facilities, public safety and social status, especially in identifying problems, developing intervention policies and projects, as well as in their implementation, monitoring, and evaluation (Leitmann 1999; Marans 2003). It also enables comparison among different countries, regions, cities, and neighborhoods, especially in assessing variations and equity in access to basic socioeconomic services, livelihoods, and environmental conditions (Abubakar 2011; Mohit 2013a). For development policy formulation, QoL studies serve as important sources of information



Improving the Quality of Life of Urban Communities in Developing Countries, Fig. 2 Domains and indicators for measuring QoL. (Adapted from Mohit (2013a), p. 457)

concerning residents' sociodemographic factors, priorities in life, and causes of dissatisfaction (Abubakar 2018b).

Since the turn of the twenty-first century, QOL assessment is increasingly becoming an important tool for urban and human development planning and management. For example, Omar (2005) used a QoL survey to compare and rank the quality of living among European cities in which Zurich ranked the best, followed jointly by Vienna and Geneva, while Dublin ranked the 8th. The Liverpool City Council also employed QoL indicators in assessing residents' awareness, usage, and satisfaction with a range of council services, including leisure and transportation (Liverpool City Council 2008). Since QoL of citizens is essential for planning and policy decisions, findings from QOL studies can also be used to inform and educate citizens regarding trends in their QoL to make improvements on their welfare. It helps in identifying persons at risk for poor health outcomes and can inform illness prevention and intervention measures (Raphael et al. 1996).

However, the QoL assessment has some inherent challenges. Being a complex construct with numerous indicators, the measurement of QoL tends to be complex especially where subjective parameters are involved. For instance, measuring objective QoL that is not influenced by subjective opinions may prove difficult since the concept relies more on individual's satisfaction and feelings about life situations. Another challenge is measurement standardization. For instance, unlike QoL, gross domestic product (GDP) is an internationally adopted framework by governments and policymakers for measuring economic output. However, QoL due to its diverse and subjective nature is yet to have commonly defined measurement domains and indicators. For QOL to be adopted as an international framework, some of the common measurement issues including its diverse measurement methods and indicators should be resolved. Therefore, there is the need to evolve mutually agreed objective and subjective indicators of QoL from socioeconomic, environmental, and human capital domains.

Relationship Between QoL and SD

The definition of sustainable development (SD) has over the years varied both in concept and scope. Its diverse definitions and interpretations in the normative literature are often the sources of the misconception of the term. As opined by Ostrom (2010), SD is one of the most over used and battered words in international development literature. The concept has a myriad of definitions in different contexts including the popular and widely accepted definition by the Brundtland Report (Brundtland 1987) mentioned before. The International Union for Conservation of Nature (IUCN) defines SD as the "development that improves the quality of human life while living within the carrying capacity of supporting ecosystems" (IUCN 1980). Although the concept covers physical, sociocultural, and economic spheres of life, the academic literature has a bias towards environmental sustainability (Abubakar 2018b).

The 1992 Rio Declaration formulates a commitment for redefining SD and championed a

completely new paradigm that integrates social equity, economic growth, and environmental sustainability. A decade later, the World Summit in Johannesburg reaffirmed and further refined the SD declaration to be all-embracing of issues that include poverty eradication, sustainable consumption and production, ecological footprint, and environmental protection, human impact on the planet, which are vital for improving QoL. The terms sustainable cities, sustainable communities/neighborhoods, sustainable projects, and sustainable housing indicate some examples of the areas where the concept has been applied (Abubakar 2013). In the area of housing development, for instance, sustainable housing relates to the ability of a housing delivery system to provide safe, functional, and affordable shelter while reflecting the socioeconomic, cultural aspirations, and preferences of individuals and families for the overall societal well-being (Zainal et al. 2012).

QoL Project Sustainability

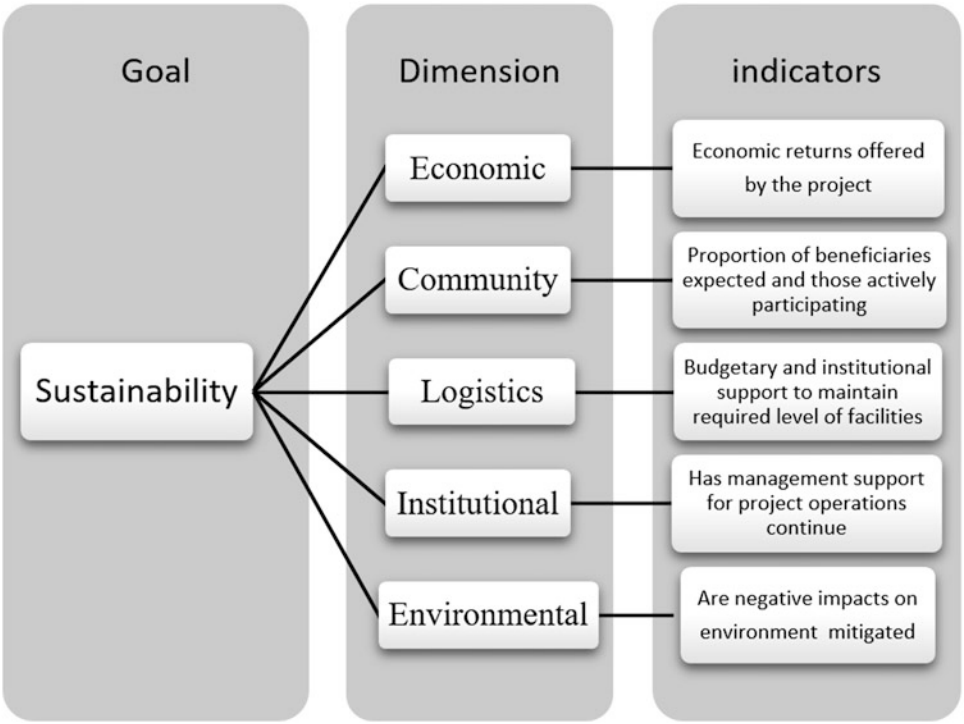
A QoL project can be defined as that which proffers lasting solutions to societal problems. The sustainability of QoL project refers to "the ability of a project to maintain its operations, services and benefits during its projected life time," which involves furthering the project's goals, values, and efforts for achieving intended results (US Department of Labor 2016). As observed by the European Commission (2006), a QoL project is sustainable when its benefits flow for a prolonged period even after project inputs have ceased. The sustainability of a QoL project also involves ensuring that its objectives are achieved via activities that are consistent with the prevailing conditions and development needs of a community. It is measured as the proportion of goods and services initiated by a project that is still being provided and maintained at the end of the project implementation (Muhammad et al. 2016). It is, therefore, a measure of the level of a continued provision of goods and services, the new initiatives that resulted from and the transformations stirred by the project.

However, a QoL project that is currently sustainable might not be so in the long run. For instance, Khan (2000) observed that while rice paddy production was previously the mainstay of Sri Lanka's agricultural sector, it is currently unprofitable and unsustainable under the prevailing economic conditions. For this reason, the sustainability of a QoL project should be seen in a wider scope of time, social, economic, and political dynamics. The sustainability of a QoL project at any stage or time of a project life cycle is usually measured using sustainability indicators. Sustainability indicators are signs that reveal the sustainability status of a project, program, or development. Figure 3 outlines the six multidimensional factors and their respective indicators of project sustainability.

- Economic sustainability: It refers to the continued flow of a project's net benefits, ensuring a reasonable level of economic returns and proper balancing of all the costs and benefits under different conditions.
- Community sustainability: It involves active and continued community involvement in development activities. It ensures that local participation in a project's activity continues over time and with the desirable and active level of participation.
- Equity: It entails equitable allocation and delivery of project benefits including goods and services among the community members. It focuses on whether the project incorporates mechanisms for guaranteeing continuous and equitable delivery and access to project benefits.
- Logistics: This relates to whether the project has received necessary fiscal and institutional support to sustain the required level of operation and maintenance of project facilities.
- Institutional sustainability: This relates to whether the project adequately considered the organizational requirements and provides for continued management support to project operations.
- Environmental sustainability: It involves maintaining environmental stability while planning and executing the project to avoid or mitigate undesirable or negative impacts of the project on the environment.

QoL and the Sustainable Development Goals (SDGs)

The concept of QoL is a subset of the social dimension of SD which involves employing mechanisms that improve the livelihoods, capabilities and overall societal well-being. Given that SD aims to protect



Improving the Quality of Life of Urban Communities in Developing Countries, Fig. 3 Framework of QoL project sustainability (Zayyanu et al. 2017)

the ecosystems and engenders a quality life for humanity, implementing SD principles in space brings about improvement in QoL. The symbiotic relationship between the manmade and the natural environment influences the QoL of the citizens who are living around it in many ways including access to air, water, land, as well as plants and animals (Perloff 1969). Accordingly, both the natural and built environments are important considerations in formulating policies to improve the QoL of citizens. Also, the equity pillar of SD strives to achieve QoL by reducing social exclusion in access to employment and basic social services, including education, healthcare, potable water, and sanitation (Abubakar 2018a; Gazzeh and Abubakar 2018). Due to its importance and direct relationship with SD, QoL is increasingly gaining attention by many governments as a measurable index for achieving SD.

There is also strong synergy between QoL and the SDGs. As Table 1 indicates, fostering the QoL of communities by improving their living standards could greatly help end extreme poverty (SDG 1) and hunger (SDG 2). Improving QoL addresses not only a lack of income and resources but also social exclusion and the lack of access to basic social services such as security, education, healthcare, drinking water, and sanitation (SDG 6). Similarly, QoL projects could also "ensure healthy lives and promote well-being for all at all ages" including minimizing infant and maternal mortality and achieving universal health coverage (SDG 3). The SDG 4 that aims to promote "inclusive and equitable quality education" can also be achieved through QoL projects that focus on providing free, quality, and equitable primary and secondary education to all boys and girls.

Approaches and Case Studies of Projects for Improving People's QoL

The first part of this section highlights the role of healthcare, housing, education, water and sanitation, and livelihood opportunities in improving the QoL of people. The second part discusses two case studies of exemplary QoL projects in West Africa.

Improving the Quality of Life of Urban Communities in Developing Countries, Table 1 Relationship between QoL Domains and SDGs

SDG	SDG target	QoL domain (Mitchell et al. 1995; Mohit 2013a)
1: End poverty in all its forms universally	Eradicate extreme poverty, implement social protection systems, and ensure equal rights to economic resources	Economic condition, personal development
2: End hunger, achieve food security, and improved nutrition	Ensure access to safe, nutritious, and enough food always and increase agricultural productivity	Socioeconomic condition, physical environment, security
3: Healthy lives	Reduce maternal and child mortality, end epidemics and reduce deaths from diseases, reduce deaths and injuries from substance abuse, road traffic accidents, and pollution, and provide universal access to healthcare and health coverage	Healthcare, personal development, security
4: Inclusive and equitable quality education	Provide free, equitable, and quality education, skills, and literacy for everyone and eliminate disparities in education	Education, personal and community development
5: Gender equality	End all forms of discrimination against females, grant them equal rights, opportunities, and participation, and eliminate all form of violence and harmful practices against them	Education, personal and community development, security, health
6: Adequate and safe drinking water and sanitation	Provide adequate and equitable access to safe and affordable drinking water and improved sanitation, improve the quality and efficient use of water resources	Health, personal and community development
10: Reduce inequality within and among countries	Achieve and sustain income growth of the poor, empower and promote the socioeconomic and political inclusion of all, guarantee equal opportunity and reduce inequalities	Socioeconomic, personal and community development
12: Sustainable consumption and production patterns	Sustainable production, management, and consumption of natural resources and materials, sound management of chemicals and all wastes throughout their life cycles	Socioeconomic, personal, environmental, and community development
16: Peaceful and inclusive societies	Improve human safety and reduce all forms of violence (such as physical, sexual, psychological, and trafficking), drug abuse, arms flow, and crimes and their related death	Security, personal and community development

Key Approaches for Improving the QoL of Populations

Access to adequate and quality healthcare, housing, education, water and sanitation, livelihood opportunities, public spaces, as well as promoting social equity and liberty, peace and happiness, security of lives and properties, and ecological protection are vital to improving the QoL of populations (Abubakar and Doan 2017; Aklanoglu and Erdogan 2012; Veenhoven 2000; Zayyanu et al. 2017). This subsection dwells on key five of the approaches.

Healthcare Delivery

Health is wealth with immense benefits to life, which include the absence of diseases, improved health status, and the pursuit of happiness and liberty (Raphael et al. 1996). Apart from the relief from pain and mental dysfunction, quality healthcare improves the overall physical, psychological, and emotional well-being of populations, especially in reducing morbidity, disability, and mortality and increased fertility, life expectancy, and socioeconomic productivity (Bunker 2001). Thus, healthcare is a prerequisite for improving QoL (Abubakar 2018c).

Housing Provision

Good housing is among the most treasured aspects of human lives and one of the key components of household wealth. It is vital for

meeting human basic needs, such as resting, sleeping, and protection from hazards and harsh weather thus vital for childhood development and people's overall well-being (Streimikiene 2015). It also provides a sense of personal security, privacy, and personal space, which are essential for starting a family. Housing and tenure types, its physical conditions and that of its immediate environment, and accessibility of amenities are important determinants of good housing required for enhancing people's QoL (Zainal et al. 2012).

Education and Literacy

Education is a universal and resourceful tool for training and enlightenment about values, behavior, and humanity, which imparts knowledge, problem-solving skills, and capability for self-development and creating livelihood opportunities (Michalos 2017). It is one of the greatest human capitals that transform individuals and societies to lead healthier and happier lives and become more technologically and economically productive (Abubakar 2013; Ross and Van Willigen 1997). It plays a central role in human social development and environmental protection. Certainly, education is a noteworthy contributor to attaining QoL.

Water and Sanitation Services

Supplying adequate and improved water and sanitation is a leading mechanism for QoL improvement. Access to safe and adequate water for individual and household use such as drinking, food preparation, sanitation, and hygiene is a human right and indispensable for life and in safeguarding public health and raising people's QoL (Abubakar 2011). Using improved sanitation has immense health benefits including reduction of risks in contracting excreta-related sicknesses such as hepatitis, diarrhea, and schistosomiasis (Gazzeh and Abubakar 2018). These essential public services significantly influence QoL of individuals as they are associated with good health, reduction of poverty and inequality, and are among the key indicators of SD.

Livelihood Opportunities

The amount of socioeconomic activities, innovations, and entrepreneurship in human settlements greatly influences the availability of livelihood opportunities thereby impacting the QoL of residents (Abubakar and Dano 2018). Employment in the primary sector of the economy (e.g., agriculture and mining), manufacturing and trade, and service industries (e.g., insurance and finance, IT and telecommunication, transportation, media, entertainment and advertisement, education, health) provide income, reduce poverty and crime rates, and improve the general living standards of individuals, especially in improving their access to shelter, basic services, education, and healthcare (Abubakar and Doan 2017; Muhammad and Abubakar 2019).

Case Studies of QoL Projects

Improving QoL usually involves planning, executing, and sustaining projects and programs for community socioeconomic development in collaboration among stakeholders: governments, private sectors, local and international organizations, and the target populations. In developing countries, the community-based development approach is an important mechanism for improving the QoL of citizens that attracts international development assistance. This section highlights two case studies of community-based QoL projects in Nigeria and Burkina Faso.

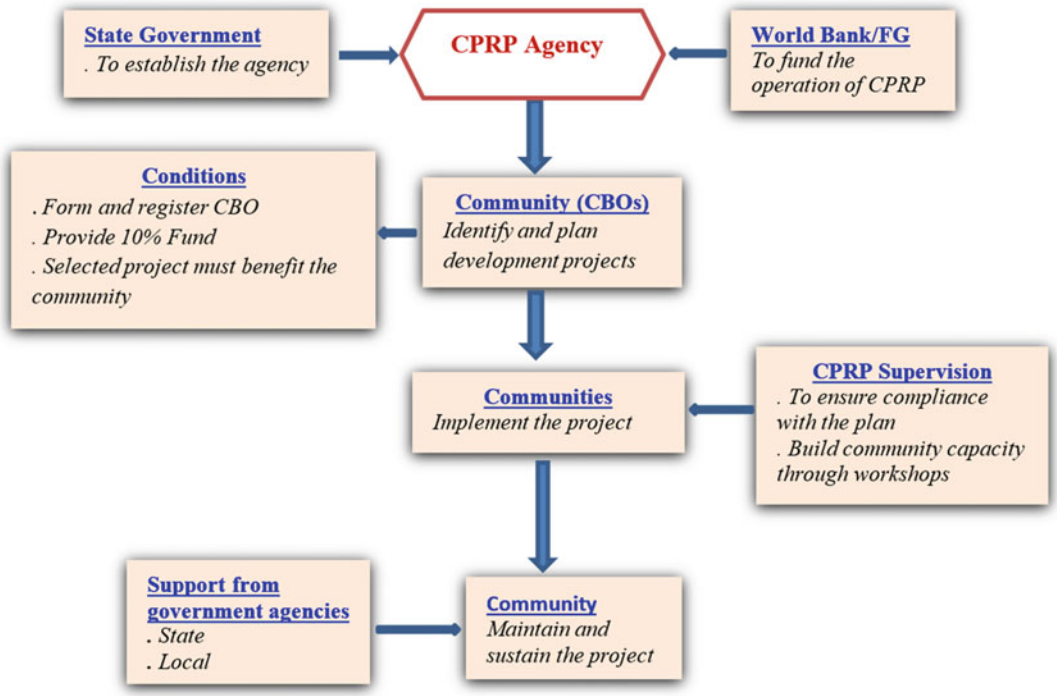
Case I: Community-Based Poverty Alleviation Project in Kebbi State, Nigeria

In Nigeria, the ineptitude of the public sector to independently address the lingering problem of poverty has prompted the application of this model towards improving the welfare of poor citizens (Muhammad 2016b). Based on collaboration between the World Bank and Nigeria's government, community-based national intervention for enhancing social service delivery towards poverty reduction was adopted. One of the initiatives was the Kebbi State Community-Based Poverty Reduction Project (CBPRP), established in 2001 to improve the QoL of poor people in the State through the provision of drinking water (53 projects), education (145), healthcare (22), and 42 infrastructure and environmental projects (World Bank 2005, p. 6).

The project was modeled based on the active participation of communities and civil societies in

the planning, execution, and management of the CBPRP to ensure the sustainability of such projects. Intervention funds are channeled directly to the target communities through community-based organizations for more effective execution of the projects. In return, the communities are expected to identify, plan, execute, and maintain the microprojects in collaboration with the other stakeholders. The financing arrangement was to sustain the project for five years, after which the participating communities are expected to have developed enough skills and capacity to sustain the microprojects. Figure 4 shows the design and operational features of the CBPRP.

In many developing countries, the adoption of a community-based development strategy to improve human QoL has been successful, according to several evaluation studies (Chado et al. 2016; Kapopo 1993; Mansuri and Rao 2004; Streimikiene 2015). In the case of the CBPRP in Kebbi State, an in-house project appraisal has reported impressive results with regards to building the targeted project outputs (schools, boreholes, and health clinics), which suggest good performance regarding the project's outcomes (Muhammad 2016a). An appraisal of the CBPRP revealed that impressive project's outputs have been recorded during the project life span. Indeed, the CBPRP model has engendered significant improvements in the QoL of the project's beneficiaries in terms of the growing number of healthcare facilities, school-going children, and improved access to drinking water. However, the post-project period recorded poor results in terms of the maintenance of the schools and health facilities built under the project (Muhammad 2016b). In another related study, Muhammad et al. (2016) assessed the sustainability of the CBPRP using a framework of indicators. The findings of the study revealed that while the project's outputs are impressive during the intervention period, the project's outcomes could not be sustained after the international funding ceased. The authors concluded that the problems



Improving the Quality of Life of Urban Communities in Developing Countries, Fig. 4 Design and operational features of CPRP (Muhammad 2016b, p. 155)

concerning the sustainability of CPRP in Kebbi State is due to the "invited" nature of the participation, which lacks genuine community organization and involvement of the target communities.

Case II: Community-Based Rural Development Project in Burkina Faso

In 2002, the World Bank in collaboration with the International Fund for Agricultural Development, UNDP, and the Government of Denmark established community-based rural development projects in Burkina Faso. The 15-year projects for agricultural and rural development consisted of 18,250 microprojects designed and implemented in 3,013 villages covering the following sectors: farming, fishing, and forestry (15%); transportation (15%); water, sanitation, and flood control (15%); and other social services (23%) (World Bank 2008).

The agricultural projects included improving land tenure, farming practices, and livestock production that contributed to increased productivity, and natural resource management activities such as soil and water conservation that reduced land degradation. There are also improved water supply projects, health and hygiene infrastructure, and family planning programs that contributed to improving the condition of women. Other social services included improving living conditions of rural dwellers by establishing a borrower program for poverty and a local investment fund for financing subprojects and a national forum for consultation among development partners to monitor socioeconomic, environmental, and institutional impacts of rural development projects.

Similarly, capacity building program strengthened the technical, managerial, and organizational skills of the rural populations, civic society, and decentralized institutions at all levels. The program raised awareness about and provided training on participatory rural development strategies and planning process, partnership for rural development, and encouraging village regrouping. A total of 2,961 village and intervillage management committees were trained on project coordination, administration, and monitoring/evaluation and were able to elaborate and implement their local development plans. The program facilitates civic engagement and better consultation between communities, public agencies, and development partners, which were essential to progress on the government's decentralized rural development agenda. Most of the village committee members trained by the project were elected in the newly decentralized government agencies (World Bank 2008).

The review of these case studies of QoL projects indicates that designing and executing community-based programs requires a good knowledge of local conditions and the adoption of simple and flexibility implementation and management procedures. Although the engagement of international development agencies is vital for community-based development projects, achieving sustainability of such projects is a major challenge. According to Tango International (2009), 50% and 33% of projects sponsored by International Fund for Agricultural Development were rated in 2007 as moderately and unsatisfactory respectively in terms of project sustainability. Therefore, strong commitment of all stakeholders and effective harmonization of donor activities is critical to maximize local development impacts. Also, operational efficiency, explicit and systematic project monitoring and evaluation, economic returns and community participation is essential for their sustainability.

Conclusion

The processes of urbanization, industrialization, and globalization are associated with transformations that bring about numerous socioeconomic and environmental challenges such as climate change, depletion of natural resources, poverty and inequality, and deteriorating health and living conditions. To address these challenges, countries throughout the world implement QoL projects toward reducing extreme poverty hunger and inequalities, providing decent housing, good healthcare, quality education, improved drinking water and sanitation, livelihood opportunities, quality public spaces, and improving social equity and liberty, peace and happiness, and security of lives and properties. Considering the importance

of QoL in addressing these issues, the present entry provided a comprehensive review of the concept of QoL, its domains and measurement, the importance and challenges of QoL assessment, as well as its connection to SD and SDGs. Similarly, key strategies for improving the QoL of urban and rural dwellers and two case studies of exemplary community-based projects for improving the QoL of populations in Nigeria and Burkina Faso were discussed. In developing countries, many QoL programs and projects are executed under the community-based model with sponsorship and intervention funding from international donor organizations for a specific project period, after which the benefiting communities are expected to sustain the projects.

Given that urbanization is an inevitable process and as cities continue to urbanize into the twenty-first century, a better understanding of QoL concepts and strategies and their applications and challenges is invaluable. Accordingly, future research should focus more on the challenges faced by QoL projects and programs towards meeting the sustained aspirations of urban and rural residents. In line with the current globalization and urbanization trends, researchers from different professional spheres should actively pursue empirically based studies on a wide range of QoL issues including basic urban services, housing, infrastructure, transportation, resource utilization, and climate change. The findings of such studies would contribute significantly to addressing the numerous socioeconomic and environmental challenges the world is currently facing towards a more sustainable world for the present and future generations.

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Industrial Ecology in Support of Sustainable Development Goals

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Definitions

Industrial ecology is a subdiscipline of the natural ecosystem which aims to restructure the industrial ecosystem in ways of managing and designing linear to closed-loop industrial production and consumption system. Industrial ecology seeks to form a harmonized relations between ecological and human system to provide sustainable benefits of all aspects of sustainability including social, environmental, and economic.

Introduction

In this era of immense ecological change and environmental uncertainty, bring to fore by the wide-ranging effects on energy use, depletion of resources, waste of water resources, global warming and sustainable consumption and production of materials. The concept of industrial ecology (IE) has gained a significant attractive feature of the broader implementation of Sustainable Development Goals(SDGs). IE tools and practices can be used to address global sustainability challenges for sustainable consumption and production through SDGs 2030. The benefits of SDGs12 lie in the pursuit of industrial ecology initiatives within the fields of strategic management, supply chain, marketing, industrial economics, and consumer behavior. However, research on industrial ecology is unexpectedly limited in the strategic innovation management and marketing literature and has mainly focused on the industrial ecosystem, political ecology, and industrial symbiosis. While major of the literature on IE focuses on efficient use of material and energy between networks of firms, it provides a limited perspective on the forms of IE in advancing the United Nations Sustainable Development Goals. The proposed study could shed light on developing a better understanding of the process of advancing and supporting IE in business firms and mechanism through which firms in networks to achieve triple bottom-line benefits.

The year 1970 is generally thought of as the industrial ecology revolution in the word (Stern 1973). The idea of industrial ecology (IE) is about waste as by-products reused by other products. Frosch and Gallopoulos first used the word industrial ecology as a field of manufacturing strategies in 1989, and it came into broader application in the last two decades. Industrial ecology (IE) was not acknowledged mainly as a system approach until the last half of the nineteenth century. When Frosch and Gallopoulos expressed concern about both manufacturer and consumers from developing and developed countries must change their habits to proceed to a more harmonious industrial ecosystem (Frosch and Gallopoulos 1989). Industrial ecology (IE) is defined as the design of industrial process and products and implementation of sustainable manufacturing strategies to seek to optimize the total materials cycles from virgin material to the component, to product to waste and disposal (Jelinski et al. 1992).

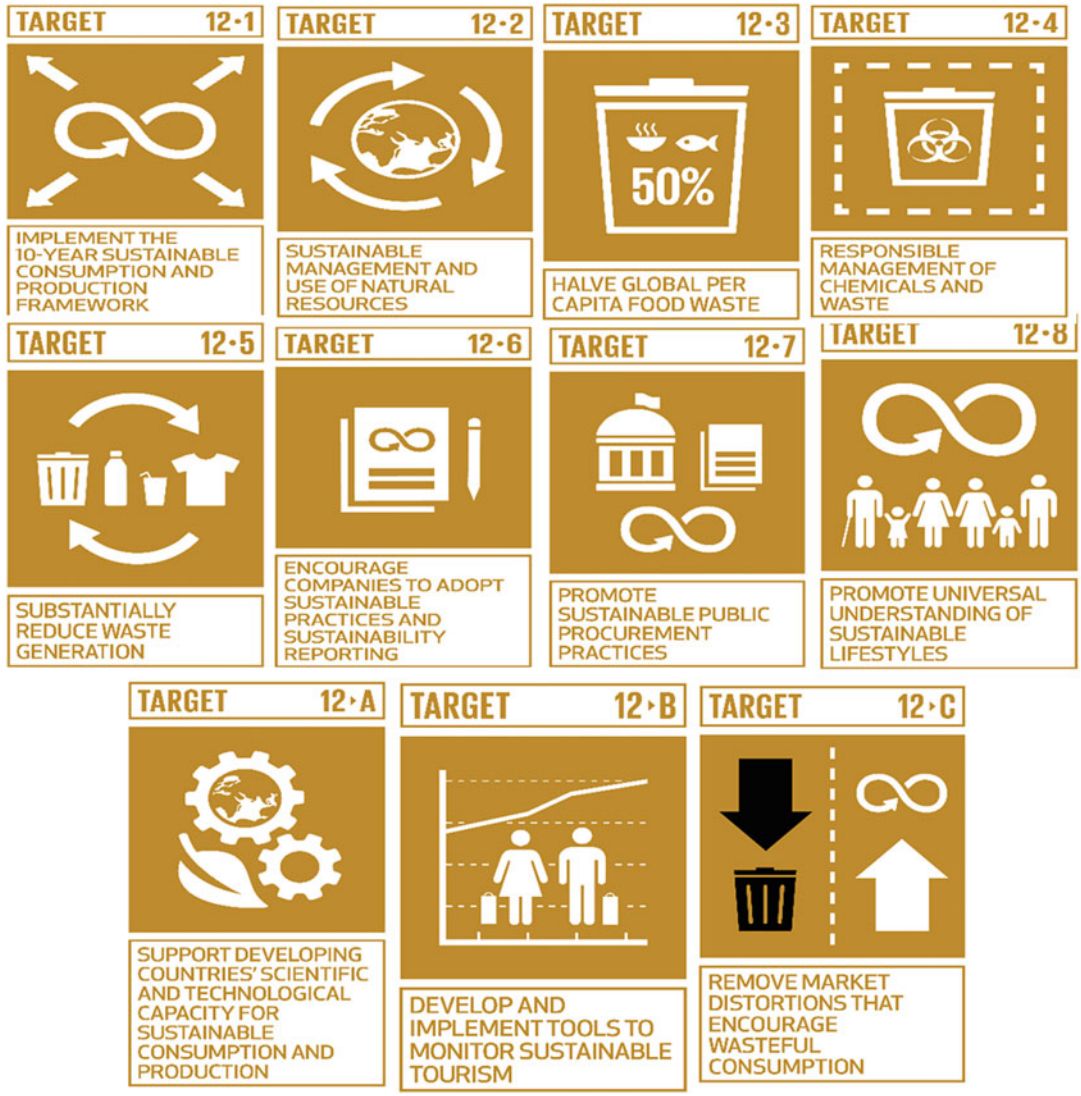
Frosch and Gallopoulos first presented the concept of the industrial ecosystem in 1989 in their

article "Strategies for Manufacturing." This term is later termed as industrial ecology (Garner and Keoleian 1995). Industry ecology aimed to provide a better understanding of the impact of the industrial system on the environmental and involving interrelationship among product and process as well as among the firms. Industry ecology is a high level of system approach to reduce industrial ecological impacts on the environmental system (Garner and Keoleian 1995). Industrial ecology (IE) is a scientific study about the effects of the industrial system have on human and natural capital. IE represents an essential aspect that the earth is a closed system with limited resources and reduced waste capacity (Chertow and Ehrenfeld 2012). Understanding how business activities promote sustainable development requires the integration of IE thinking into management literature (Hoffman et al. 2014).

Sustainable Development Goal 12 (SDGs) of the 2030 agenda are about promoting resource and energy efficiency and sustainable infrastructure and providing a better quality of life for all (United Nations 2015). It contains the righteous slot to reinvigorate sustainable development, which is not only crucial for human well-being but also essential from a policy perspective (Filho et al. 2017). The philosophy behind the SDGs12 is to enhance the material efficiency with better life cycle planning and assessment of an industrial ecosystem that relies on an increased product service system among actors. It gives support for the use of green environmental criteria in product development plans, use of biomimicry, regenerative design, and cradle-to-cradle approach that directly and indirectly helps to achieve overall sustainable development plans. It improves future benefits of social, economic, and environmental development and provides opportunities for well-being of society. Scholars in industrial policy research have shown interest in social sustainability performance (Awan et al. 2018). Industrial ecology practices offer an initial understanding of the firms' sustainability strategies, which is increasingly considered important for sustainable development goals in improving overall sustainability. The management perspective opens a wealth of research opportunities that could draw upon implementation of a closed-loop system that can be functioned efficiently and effectively, or it can be combined to these ways for the design of the regenerative system, product service system, resource efficiency, and sustainable production and consumption. Much recent research focuses on the ability of the firm to promote collaboration and participation with different network participants' firms. The industrial ecology came to mean everything about the environmental needs, notably materials, impact on the natural and human capital. Therefore, there is a pressing need remnant to develop tools, modes, and frameworks on the industrial ecosystem to help the natural and human capital. There is a need to develop a conceptual framework to evaluate the opportunities for the manufacturers within the industrial ecosystem to the continuous development of industrial ecology.

Historical View of Sustainable Development Goals

The United Nation Sustainable Development Goals (UNSDGs) was introduced in September 2015 to describe a distinctive management approach of managing global challenges in multiple spheres of human and natural capital for sustainable development globally. The past decades have witnessed a quest for achieving Millennium Development Goals (MDGs) ranged from eradicating poverty and hunger to ensuring environmental sustainability. SDGs is an alternative goal that involves broader perspective and other global challenges to achieve the sustainable development, such as equality education, clean water and sanitation, affordable and clean energy, industry innovation and infrastructure, sustainable cities and communities, responsible consumption and production, climate action, and life on land. The difference lies in the MDGs that is taking the system boundary approach, whereas SDGs is taking a system approach. There has recently been a resuscitation of interest in the 17 SDGs and its 169 targets within the business sector. The UNSDGs 12 for sustainable development framework (Fig. 1) is made up of a set of 11 targets and 13 key indicators: implementing the 10-Year Framework of Programmes on Sustainable



Industrial Ecology in Support of Sustainable Development Goals, Fig. 1 United Nations Sustainable Development Goals 12 targets. (Adapted by The Global Goals)

Consumption and Production Pattern (12.1); sustainable management and use of natural resources (12.2); halve per capita global food waste at the retail and consumer levels and reducing food losses along production and supply chains (12.3); responsible management of chemicals and waste management in all wastes throughout their life cycle (12.4); substantially reducing waste generation through prevention, reduction, recycling, and reuse (12.5); encouraging companies to adopt sustainable practices and sustainability reporting (12.6); promoting public procurement practices that are sustainable, in accordance with national policies and priorities (12.7); promoting universal understanding of sustainable lifestyles (12.5); supporting developing countries' scientific and technological capacity for sustainable consumption and production (12.A); developing and implementing tools to monitor sustainable development impacts for sustainable tourism (12.B); and removing market distortions that encourage wasteful consumption (12.C). SDGs12 is one of the most leading and widespread accepted

frameworks in current global sustainability setting, providing bases to achieve a sustainable development agenda.

Research shows that there is increasing interest in discussion on sustainable development from the last 30 years. Beyond the increased interest in sustainability, it tends to form a global common agenda to overcome sustainability challenges and assist countries (Lange et al. 2019). However, despite renewed interest in these goals, progress in the area is still at precursory. The economic and financial benefits of current business activities have witnessed in the different industrial sector across the globe.

However, due to the recent ecological and climate issues, there has been a major shift in doing business. It calls for new business strategies and approaches for the transformation of existing global challenges into the engine of sustainable development by using industrial ecology tools to pursue sustainable development goals (Sullivan et al. 2018). Industrial ecology has a critical role to play in clinching the SDGs. United Nations Global Compact Environment Program 2000 mainly deals with commitment standards, whereas SA8000 (SAI 2014) is only concerned with the social dimension and hardly applicable to firms. Environment Management System (EMS) (European Commission 2007) is only an assessment tool for environmental measurement, whereas ISO 26000 (ISO 2010) is an environment assessment and social performance measurement framework and standard GRI (GRI 2007) articulated for firms to integrate three dimensions of sustainable performance in their operations. These both ISO2600 and GRI standards are not broadly applicable in sustainable development and not exhaustive (Chardine-Baumann and Botta-Genoulaz 2014). Environmental impact defined as a "Modification of the environment due to human intervention, which may be actual or supposed potential harmful impact on the natural or ecosystem and human health." Increasing concessional United Nations Conference on Trade and Development (UNCTAD) to support developing countries to undertaken sustainable production capacity was a central feature of United Nation Sustainable Development Goals envisaged in SDGs 12. Despite the prominence of the SDGs12 provided by industrial ecology for capacity building in developing countries has been limited discussion of the relationship between industrial ecology (IE) and sustainable production and consumption. Both IE and sustainable production and consumption engross with conceptions of achieving triple bottom-line goals to support UNSDGs, and it is essential to understand where the capacity of the sustainable output assists with the enactment of IE and where they support.

Industrial ecology, however, specifically could contribute in reducing waste, integrated chain management, life cycle costing and benefits, encouraging closed-loop production and consumption of material to networks, and relying on small- and large-scale networks of institutions and firms, which take special advantage of local and international cooperation. The development of close-loop product production and consumption in IE activities requires downstream and upstream participation throughout an integration and opportunity identification approach. As a consequence of potential sustainable development benefits of IE, industrial actors are increasingly interested in understanding their longer-term environmental challenges. Awan (2011) has shown the usefulness of environmentally friendly segment in energy markets. An industrial ecologist by no means uses effectively market segmentation strategies as support to sustainability initiatives. For example, particularly developing countries require law by their national governments on the creation of industrial ecology (IE) infrastructure. It is also argued that the successful implementation of IE requires governments to examine existing environmental policies and legislation to eliminate unnecessary barriers in developing an industrial policy for manufacturers, international marketing, operations, and circular economy practices. The United Nations Industrial Development Organization (UNIDO) and business and industry associations see the urgency to act upon the reformulation of this industrial policy area for sustainability. However, equally important as the first step, such as the launch of support funds for developing countries to support IE programs, is a bigger perspective to achieve a sustainable future.

Industrial Ecosystem Versus Industrial Ecology

The earliest work on industrial ecology (IE) was sparked (Frosch and Gallopoulos 1989). Further IE concepts used as a weapon for gaining competitive advantage and later debate opened whether incorporating environmental practices into the organizations can lead to reaping the economic benefits as well as a competitive advantage (Frosch and Gallopoulos 1989). Research into the positioning of business as part of industrial ecology has continued since (Frosch and Gallopoulos 1989) concept of the industrial ecosystem. Industrial ecology differs from the industrial ecosystem because industrial ecology deals with the interrelations among different factors in which one seeks to optimize material, resources, and capital (Graedel et al. 1995). For example, Kalundborg, Denmark, is the evolution of the industrial ecosystem, where Asanes, Denmark, has the largest power stations that discharge products of gypsum which go to Gyproc, a plasterboard factor used in wallboards. The industrial ecology tends to take a system perspective when to implement desired change that supports sustainability initiatives.

A traditional industrial ecological system is characterized at the micro-level (deals with problems of individual firms) and macro-level (deals with a total system). In a previous investigation of industrial ecology, a literature (Karn 2004) identified nine dominant themes, such as material and energy flow studies, dematerialization and decarbonization, technological change and the environment, life cycle planning, design and assessment design for the environment ("eco-design"), extended producer responsibility ("product stewardship"), eco-industrial parks ("industrial symbiosis"), product-oriented environmental policy, and eco-efficiency. The industrial ecology is a system to ecological and human needs by imitating the natural flow of the system to converge from a traditional linear system of material flow to a closed-loop system. There are two popular approaches in the industrial ecology, (1) regional approach and (2) product chain approach (Boons and Howard-Grenville 2009). The first approach emphasizes on the eco-industrial parks, where similar and different firms are located with both economic and environmental benefits, whereas product chain involves all resources to develop products. Korhonen et al. suggest that IE is a kingpin on the manufacturing process as a model of sustainable industrial activity and views business as agent for sustainable products that provide routes to alter unsustainable industrial and business system (Korhonen 2004). With increasing environmental issues, the green consumption trend of using and conversing resources is prodigious, thereby exerting pressure on companies to position themselves as a socially responsible and environmentally friendly (Awan and Raza 2012).

Industrial ecology is of great importance to determining well-built and sustainable opportunities for growth of ecology and human. IE, however, specifically could contribute to reducing waste, encouraging closed-loop production, and consumption of material to networks relies on small- and large-scale systems of institutions and firms, which takes particular advantage of local and international cooperation. Industrial ecology contemporaneously constitutes a viable option for industries to transform energy and material efficiency into closed-loop flows and achieve sustainable development benefits. In addition to this approach, the term circular economy is vital for increasing the performance of industrial ecology.

Industrial Ecology and Capacity for the Sustainable Production

As industrial ecology becomes omnipresent than ever, sustainable development is becoming an essential theme in the ecological literature. The concept of industrial ecology and sustainable production offer a vantage point from which to understand the inter-firm environmental management system. Moreover, it assists in explaining what the system is and how it generates through the interaction of different actors in industrial ecological settings. Sustainable production linkages often between industrial networks of different sectors and thus requires communication and collaborations. Collaboration is defined as "the ability to

collaborate among public and private organisations to bring about technological change" (Hart and Hart 1995). Internal and external actors cannot deliver sustainable production but can participate in the creation and offering of energy-efficient and zero waste solutions. In the sustainable production of products and process, capacity is an important contributor to the development of sustainable solutions. In turn, capacity building is expected to increase the benefits of sustainable development (Shiel et al. 2016). Additionally, Avila et al. (2017) suggest the management competencies can also affect the deployment of sustainability initiatives. The green design of a firm's products is considered to be an important sustainable strategy (Awan 2011) to support the SDGs 12.

Conversely, in capacity development, internal firms' actors act as facilitators in the creation of sustainable process and products development. Emphasizing the active role of internal actors in shaping the network participants, collaboration is best to support networks commitments in terms of institutional networks. In an industrial ecological context, subjective actors' experience in identification of opportunity plays a central role in the formulation of collaboration. Thus, the capacity for sustainable production relates specifically to a realm of opportunity identification and assessment with internal actors and consciousness cooperation with the external actor. Thus, the development of capacities also encompasses elements of the adaptive style of management. Institution's support to the firms is concerned with the competencies and firm relations to its external competitive environment. The quest for the collaboration of internal actors should understand in terms of its possession of capacities for opportunity identification and assessment. Capacity development, however, is intrinsically a matter of specific and details of opportunity identification and assessment.

Circular Economy and Sustainable Consumption and Production Issue

Due to climate change challenges and awareness about greenhouse gas emission, different interest groups engaged with manufacturing firms to build to focus on an industrial system that designed products for the cycle of disassembly and reuse. Stakeholder's engagement is a key vehicle for the implementation of new ideas for the development of circular economy practices. Taken together, buyer-supplier relationship and sustainability literature suggest that firms must apply different approaches to exchange interaction to the development of innovative solutions for sustainable performance. Even though this point of view emphasizes the multi-actor network management of sustainability, it is not thus far explained how precisely these stakeholders extend across interlinked stages of a circular economy.

Industry ecology is a high level of system approach to reduce harmful industrial systems' environmental impacts on the ecological system (Garner and Keoleian 1995). Business practices related to "sustainability are an approach which firms adopt by altering or modifying their current established practices and rules" (Engardio et al. 2007). As an example, Kumpi, Finland, is helping to make cluster decisions that disregard the national infrastructure strategies. Furthermore, the infrastructure planning processes created by the local and national government somewhat are not aligned with each other, developing a planning maze for recycling initiatives. This problem is not limited to this region; the firm has closed operations less than a year, undermining future recycling investment, laying off 40 staff. Finland is a pioneer in the circular economy initiatives, and business enterprises in Finland have functional expertise to generate a circular economy benefit of other stakeholders for both present and future. However, the transition towards a circular economy requires to fully understand what infrastructure process is essential that supports recycling and remanufacturing. Even though numbers have already been published on waste generations, for all the intents and purpose, circular economy (CE) signifies providing the products' demands to society through recycling, remanufacturing, and reusing where possible. In addition to this approach, the term circular economy is vital for increasing the performance of industrial ecology.

The ongoing industrialization has led to enormous environmental challenges and issues from manufacturing industries. Kirchherr et al. (2017) discussed opportunities for the firms for sustainable development. Lieder and Rashid (2016) found in their research that CE leads to decrease environmental degradation, save natural resources, and improve the reproductive capacity. The well-known visualization strategies (reuse, repair, remanufacture, recycle, and refurbish) of the circular economy are provided by the EllenMacArthur Foundation (EMF) (Bocken et al. 2017). There have been some discussions in the literature about the role of reuse and remanufacture in establishing and supporting the CE principles, developing prolong use of and reuse of goods over time, aimed at narrowing loops associated with the use and reuse of products and process (Bocken et al. 2017). In CE, "the concept of waste is eliminated by carefully designing products and industrial processes in such a way that materials are perpetual." The most important reason for not recycling many products is the lack of customized practices and lack of focus on collection and consumption patterns. The 3R concept of circular economy, reduce, reuse, and recycle, has become central to the global economy (Murray et al. 2017). The design of product involves in manufacturing by-products, producing by-products, and product extension and end-of-life and recovery process in addition to the other aspects of the supply chain (Linton et al. 2007). According to Golroudbary and Zahraee (2015), companies should encourage to develop the capacity that can incorporate both reverse and forward flow of goods simultaneously. The Ellen MacArthur Foundations depict the concerns of the circular economy for an industrial system that is restorative by design are to take full advantage of reusability of the products through reducing and recycling process (EllenMacArthur Foundation 2013). In practice, broad variations of implementation of CE practices with some firms pursuing more of this through governmental collaborations and nongovernmental organizations. The concept of circular economy practices evolved differently in different parts of the world (Winans et al. 2017) and is still evolving in green supply chain management, industrial symbiosis, and biomimicry field.

Circular economy (CE) initiatives include the idea of reusing and recycling (Kirchherr et al. 2017; Stewart and Niero 2018). Recycling is another key dimension of circular economy in circularity ecosystem, which, in practice, is a shift from the end-of-life products to continuous use of materials within operations (Haas et al. 2015). The inner loops of reusing and remanufacturing are preferred (Mihelcic et al. 2003). Materials should "first recovered for reuse, refurbishment and repair than for remanufacturing and only later for raw material utilisation" (Korhonen et al. 2018). Industrial ecology and circular economy go hand in hand. IE represents important tools that may support the process in transition to the circular economy (CE), where CE does not just assume looking forward to transforming the linear to closed-loop materials and energy flows but also provides resources to be used for a better ecology and human future. The role of IE in the ecological building process is increasingly emphasized. Many industrial actors have incorporated IE and CE as part of their policy agenda, including in their reporting initiatives. Industrial ecology is a vital element of sustainable development.

Industrial Ecology and Capacity for Sustainable Production: The Intersection

The multi-actor cooperation can influence the identification of opportunities through identifying the use of energy-efficient resource to transform a by-product into a valuable, reusable resource. Although opportunity identification through close interaction between actors is sometimes successful, stumbling to envisage often halts these opportunities from realization, and barely the capacity building approaches are considered as a core of the more comprehensive strategy. Capacity assessment appraises the outcomes equate with a new sustainable production process. Typically, this is done with an evaluation of a product's impact on climate change from the raw material extracted. Despite the importance of sustainable production and industrial ecology (IE), to date, there has been limited academic attention on the relationship between industrial ecology and capacity

development. Building on IE and capacity literature, this section outlines a theoretical framework for understanding how opportunity identification and assessment might act as a facilitator to sustainable production. The possible 5 Cs of opportunity identification approaches have been synthesized by Anthony Scott (2012): (1) circumstance, (2) context, (3) constraints, (4) compensating behaviors, and (5) criteria. Within any firm, the capacity of opportunity identification is aimed to solve problems of sustainable development through system boundaries, social embeddedness, and institutional supports. The idea of 5 Cs of opportunity identification is a convenient way to identify whether a firm has adequate resources and acts very divergently in the process of sustainable development to visualize opportunities for sustainable production and consumption.

According to Awan et al. (2017), the development of cleaner production technologies and internal capability is a key strategy to meet the demands of external stakeholders. The climate responsiveness of customers and the increase green business image in the market steadily have poked industries to think about sustainable consumption and production using implementing industrial ecology initiatives. Context, in opportunity identification, is a key player and a driver for sustainable development. By applying this perspective, a firm may find a way to be with the customer as to find ways to use their industrial by-product waste to be used either in a process or as a product. Nevertheless, managers could discover the process of decarbonization, life cycle planning of products, eco-design initiatives, and product-oriented eco-efficiency and stewardship issues. There is an increasing body of knowledge on the importance of networks advancing the environmental performance and can contribute to the various sustainability indicators. Networks of firms enable them to acquire, develop, and transform the knowledge and information that advances to the more responsible management of waste, encouraging sustainable consumption and production and encouraging closed-loop consumption of materials. Constraints analysis may help firms to find better ideas for redesigning the process and products, and it often results in the discovery of new ideas, for example (Awan et al. 2019).

Compensating behavior (CB) has been regarded as an important determinant whether modification of existing process has a value for the firm profitability. CB is a treadmill, and it is vital to keep running to stay on the top of competitive advantage. It is suggested that CB affects worker's ability to improve productivity and its ability to anticipate opportunities and problems that are in the interest of the management. Criteria are not just a push button to select without behavioral repertoire, but it implies they think things through and debated within system boundaries. Boundary theory emphasizes how organizational members should maintain a collaborative relationship with their suppliers. Boundary theory grew from a stream of research about how to bridge the boundary between suppliers and their customers (Aldrich and Herker 1977). Lau et al. (2010) point out the importance of the acquisition of knowledge resources as input from customers, such as "idea, information about their needs for new product and process development" influence on innovation and performance. There have been some studies that used boundary theory on aspects of bridging the boundary between suppliers and customers, sharing of knowledge for innovation (Maria Stock et al. 2017). Gemünden et al. (2007) have applied boundary for investigating radical innovations in times of open innovation. The finding suggests that individual role in particular creates inter-organizational links with outside the organizational members. Boundary theory identified various organizational factors and "thus relies upon the expertise and discretion of its boundary role personnel" (Aldrich and Herker 1977).

The criteria are a set of standard procedures for IE through which a decision made, what is optimally suitable for a particular situation. Thus, the formal procedure is not merely used but instead to apply for restructuring resources. Based on the components of industrial ecology discussed in the previous section, it offers a means for understanding the future trends in sustainable production and consumptions. Internal actors for capacity development intended to provide institutional arrangements to help change the use of the existing consumption patterns, to use of one particular set of opportunity identification. While sustainable production has

probable to make consequential contributions to SDGs12, there left some substantial uncertainty about the appropriate institutional role and policy program aimed at the development commitment to industrial ecology. In this regard, opportunity identification approach could be something of a two-edged sword. If it is used and applied passably and in line with energy and resource efficiency, it could be an effective tool to support SDGs12 and a companion to industrial ecology, and if it is not exercised and applied by energy and resource limits, it could have an inauspicious effect and be sidelined by industrial ecology. Energy and resource management are considered to be important growth strategies for firms. Recently, Awan et al. (2014) suggest that energy management approaches are also important in describing differences in sustainable development goals, although they suggest that energy management is the fourth pillar of sustainable development.

Conclusion

The growing research interest in industrial ecological (IE) provides tools for leveraging the opportunity identification to facilitate SDGs12. This study demonstrates that industrial ecology emphasizes the need for an opportunity identification perspective in decision making, contemplating the use of resources in ways it represents system boundaries. The aim of the boundaries is to forepart critical sources for energy and waste inefficiencies that hinder to achieve SDGs12. Opportunity identification process enables firms to continue with current practices with only incremental change in interfirm relationships for responsible production and consumption patterns, material and energy flow reduction, product utilization of resources (biomass, fossil fuels, metal ores, and non-metal ores), minimization of food waste, responsible business management for waste reduction, generation through recycle and reuse throughout their life cycle, sustainability reporting, green and clean public procurement practices, and civic and responsible management education. The conclusion is that established marketing and management practices are not designed to assist managers in decision making for specific implementation industrial ecology strategy for achieving a decent number of SDG12 targets.

The responsible future for the upcoming generation, UNSDGs 2030 offers an attempt to interpret the future in a holistic, systematic way, to inspire practitioners and academicians to apply system thinking approach about the manufacturing industries to redesign marketing, operations, digital and environmental practices, and policies that are expected to be required to support climate challenges. Hence, industrial ecology must be recognized as offering sustainable solution; rather, they serve as riding on two horses, which should be helpful in strategic planning and economic benefits. Since the manufacturing industry is small meteoric changing and the environmental and economic balance is shifting, the cost of saving the planet from brinkmanship will be exceptionally high and might jeopardize its forbearance future of responsible firm which relies on implementation and promotion of industrial ecological practices driven by leading firms. Reanalyzing priorities and searching new industrial policies areas in operations and marketing departments is of an urgent need to face the future generation better.

Industrial ecology adaptations aim to maximize the utilization of natural resources and minimize risk from climate change. The future model of manufacturing firms goes beyond institutional compliance and beyond zero pollution. I suggest that industrial ecology transformation entails not only redesigning of the company industrial marketing practices, business innovation models, and intrapreneurship principles but also of the resource sharing relationship between firms, governments, and societies at the local, regional, national, and global level. The incentive and promotion programs represent a tool for developing an action plan on IE. The marketing promotion programs may act as a bridge between the industrial organization and decision makers, supporting the best ecological actions guiding future collaborative management choices. Such collaborative management arrangements on a collection of reuse and end-of-life products between the industrial actors can also generate a positive competition between other clusters of firms. A prevalent theme in

strategic innovation management and marketing is that firm should increasingly need to rely on life cycle management capability, material flow analysis capability, environmental design capability, waste management capabilities, the orientation of extended producer responsibility, and low-carbon management capability. Export manufacturing industries need to find the right balance between standardization of industrial ecology practices and adaptations to the foreign markets which will be a key to international market growth, export growth, and expansion to new markets. Current debates on international business and marketing strategy indicate that a lack of key industrial ecological capabilities is a hurdle to expand into new international markets. There has been little research focusing on industrial ecology capabilities' impact on internationalization, export performance and entry into new markets. The evidence suggests that SDG may be an appropriate tool for the establishment of global industrial ecology initiatives, notably in all industries. Managers can take advantage strongly from opportunity identification approach. IE provides possible research avenues in many fields, such as management, marketing, industrial engineering, geographical information system, food chemical, and electronic industries. Overall, industrial ecology tools and concepts can be used to improve the efficiency of raw materials.

Cross-References

- ▶ Business Environment: Emerging External and Internal Pressures for Sustainable Production
- ▶ Circular Economy
- ▶ Eco-industrial Parks

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Industrial Ecosystem

► Eco-industrial Parks

Industrial Park

► Eco-industrial Parks

Industrial Symbiosis

► Eco-industrial Parks

Industrial Symbiosis: Context and Relevance to the Sustainable Development Goals (SDGs)

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Synonyms

By-product exchange; By-product synergy; Eco-industrial parks; Resource synergy

Definitions

Industrial symbiosis refers to a process of connecting flows among industrial actors through (1) use of secondary material, water, and energy resources and/or (2) utility and service sharing across a network toward net sustainability outcomes (Boons et al. 2017). Industrial symbiosis is one of the founding notions within the field of industrial ecology. It builds upon the notion of biological symbiotic relationships in nature, where species exchange resources in a mutually beneficial manner. For industries, collaboration and synergistic opportunities offered by geographic proximity are key to successful symbiotic relationships (Chertow 2000). Concrete realizations of industrial symbiosis include the development of eco-industrial parks and self-organized sustainable industrial ecosystems (Chertow 2007).

Introduction

In this entry, the development, evolution, typology, and application of industrial symbiosis are discussed. The concept of industrial symbiosis is developed as part of the emerging field of industrial ecology, where researchers and industry practitioners have collectively sought solutions and frameworks to counter environmental degradation and pollution generated as a result of rapid industrial development. Industrial ecology operates at three levels – firm, interfirm, and regional/global. Industrial symbiosis addresses interfirm relationships within a production system (Chertow 2000). Specifically, industrial symbiosis focuses on the flows and networks among industrial organizations, aiming to build synergistic solutions among resource users and contribute to responsible production and consumption. It is an integral part of the Sustainable Development Goal 12 under the heading of "Responsible Production and Consumption," which promotes resource efficiency and sustainable industrial infrastructure (United Nations 2016).

The initial model of industrial symbiosis was inspired by eco-industrial parks, most notably the Kalundborg industrial symbiosis complex in Denmark. Early applications of industrial symbiosis were explored primarily in North America and Europe (Chertow 2000). Over the past three decades, researchers have uncovered diverse types and applications of industrial symbiosis models around the world. Theories were built. It has also been connected with frameworks and tools in engineering, natural, and social sciences (Boons et al. 2017). In addition, reviews of literature and industry reports indicate that industrial symbiosis has been adopted and explored globally, including rapidly developing countries/regions, including China, Turkey, Colombia, and Southern Africa (Chertow and Park 2016; Park et al. 2018).

Evolution of Industrial Symbiosis

Scholarship and practice in industrial symbiosis have evolved considerably from the 1990s to today. Geographer Pierre Desrochers dates the practice of industrial symbiosis at least as far back as the mid-nineteenth century, citing animal by-product recovery operations in that time period that fit the definition (Desrochers 2000). Most commonly, scholars consider economic benefits a strong driver of industrial symbiosis (Chertow 2007). Early academic explorations of industrial

symbiosis have focused on creating bounded systems to facilitate resource sharing among industries, such as eco-industrial parks where there are specific guidelines in resource use and planning toward sharing and reuse (Jacobsen 2006). The field has gradually shifted to focus on specific regions and case studies. In particular, China has attracted a great amount of research interest driven by the establishment and implementation of eco-industrial parks (Geng et al. 2009; Shi et al. 2010). Most recently, the availability of diverse case studies from around the world has allowed scholars to identify commonalities and divergence of industrial symbiosis patterns, outlining their dynamics over time (Boons et al. 2017).

Industrial Symbiosis Inspiration: Kalundborg

The eco-industrial park at Kalundborg, Denmark is a seminal example of industrial symbiosis, where the evolutionary process of several by-product exchanges can be clearly traced over time. The primary industries located in the park include an oil refinery, a power station, a gypsum board facility, a pharmaceutical plant, and a soil remediation company. These companies formed an interconnected resource reuse and sharing scheme for water, steam, and solid waste. Features include reuse of wastewater and cooling water from the refinery to the power plant, reuse of the steam from the power plant to the gypsum board facility, and reuse of solid by-products such as fly ash, sludge, and biomass. The Kalundborg park has illustrated substantial efficiency improvement through environmental and economic gains as well as the importance of a collective approach in industrial design and operation (Chertow 2000; Jacobsen 2006).

Industrial Symbiosis and Eco-Industrial Parks

The notion of industrial symbiosis is also tied to ongoing policy events. In the 1990s, more efforts were made around the world to implement eco-industrial parks, zero-waste projects, and integrated biosystems. In these early days, there were diverse visions of what industrial symbiosis meant. Environmental engineer Nelson Nemerow published the book *Zero Pollution for Industry: Waste Minimization Through Industrial Complexes*, wherein he envisioned a system of "industrial complexes" where companies use each other's by-products as a means of increasing production efficiency and reducing waste (Nemerow 1995). Other scholars envisioned clusters of unrelated firms located in close proximity where they share the same facilities (Lowe and Evans 1995).

The role of eco-industrial parks is closely examined in industrial symbiosis literature. The foundational idea of eco-industrial parks is that companies within these parks engage in interfirm resource sharing. While industrial symbiosis and eco-industrial parks are used interchangeably sometimes, they have different scopes. Eco-industrial parks include specific standards or guidelines in areas such as green building, waste recycling, waste reuse, and landscaping, whereas industrial symbiosis is a less bounded spatial concept. Government-led policies are critical in the development of eco-industrial parks as many of them are facilitated by public entities (Chertow and Park 2016).

Early case studies of eco-industrial parks can be found in North America, Europe, Australia, and Singapore. Gradually, more countries have considered building eco-industrial parks, including emerging economies such as Cambodia, China, Colombia, Costa Rica, Egypt, El Salvador, India, Morocco, Peru, South Africa, Tunisia, and Vietnam, and most of these countries have fully operational eco-industrial parks (Erkman and Van Hezik 2016). The diffusion of eco-industrial parks has been particularly rapid in China, where there has been an acceleration of industrial development. Furthermore, eco-industrial park development has been incorporated as part of the national-level policy agenda such as the National Pilot Eco-industrial Park Program and the National Pilot Circular Economy Zone Program in order to create a circular economy. The development involves the establishment of industrial parks across the country driven by policies incentivizing economic-technological development areas and high-tech parks (Zhang et al. 2010; Shi et al. 2010). By 2000, China was estimated to have more than 6000 industrial parks (Chertow and Park 2016). With environmental problems

becoming more prominent, the eco-industrial park model has been increasingly adopted by the national and local governments in China. One of the most notable eco-industrial parks in China is the Tianjin Economic-Technological Development Area (TEDA), which includes over 80 interfirm symbiotic relationships developed over more than a decade between utility, automobile, electronics, biotechnology, food and beverage, and resource recovery facilities. The other well-known industrial symbiosis case in China is the Guigang eco-industrial park, which started as one of the first group of state-owned enterprises in China. The best known occupant in the park is the Guitang Group, a conglomerate that facilitated by-product exchanges between sugar, pulp and paper, chemicals, and utilities facilities through multiple organizational restructurings starting from the 1950s (Shi et al. 2010; Zhu and Cote 2004; Zhu et al. 2007; Shi and Chertow 2017).

Industrial Symbiosis in Practice

Chertow and Park (2016) summarize the learnings from industrial symbiosis practices through literature review, case examination, and expert consultation. They point out the importance of the needs and concerns of private business to successful symbiosis. In addition, industrial organization/facilitator companies and supportive laws and policies play an important role in incentivizing industrial symbiosis development. There are also positive interactions between practitioners and academics (Chertow and Park 2016). A global assessment of eco-industrial parks in emerging economies by the United Nations Industrial Development Organization (UNIDO) suggests that education and clear guidance from established practitioners and/or academics is key to their development. Certification from organizations such as the International Standard Organization (ISO) is helpful but is financially inaccessible to emerging economies. In addition, eco-industrial park strategies should consider infrastructure development in areas that lack basic infrastructure. Lastly, training courses for stakeholders in the field of industrial ecology as well as support for wastewater treatment and waste management are needed in many of the regions where there is active development of eco-industrial parks (Erkman and Van Hezik 2016).

Critical Topics in Industrial Symbiosis

A critical quest in the industrial symbiosis community is to identify significant drivers of and barriers to its implementation. Industrial symbiosis has been studied from a wide range of disciplinary perspectives. Researchers have examined the spatial, social, and physical dimensions of the fundamentals of industrial symbiosis to understand what factors lead to success locally and globally. To streamline crucial factors in industrial symbiosis, Walls and Paquin (2015) have developed a framework that identifies four main aspects of industrial symbiosis based on content analysis of 121 research articles (Walls and Paquin 2015). This framework is helpful to compartmentalize critical aspects in industrial symbiosis based on their roles.

The four aspects as well as top six examples for each aspect include:

1. Antecedents: factors that facilitate industrial symbiosis. Examples include "colocation/proximity, government regulation, anchors/scavengers/other roles, diversity of actors involved, common strategic vision/beliefs/alignment, and economic reason".
2. Lubricants: factors that help industrial symbiosis to grow over time. Examples include "intermediaries/coordinators/champions, trust/openness, knowledge creation/sharing, embeddedness, culture/mind-set, and social and network ties".
3. Limiters: factors that inhibit industrial symbiosis. Examples include "power/status/asymmetries, too much diversity, exit of player/personnel/change in flows, cost/risk, environmental regulation too restrictive, and lack of trust".
4. Consequences: outcomes of industrial symbiosis. Examples include "innovation, environmental and economic co-benefits, learning, resilience, lock-in/domino effect, and social capital" (Walls and Paquin 2015).

Geographic Proximity and Colocation

A key factor discussed in industrial symbiosis literature is the role of geographic proximity and colocation. Some scholars argue that certain regional scales are favorable for industrial symbiosis based on case studies in Germany's Rhine-Neckar region (Sterr and Ott 2004). Others argue that there is no definite preferable scale for industrial symbiosis through case studies in the United States, United Kingdom, and Japan (Lyons 2007; Jensen et al. 2011; Chen et al. 2012).

Self-Organization

Another key concept in industrial symbiosis is the notion of self-organization. One branch of industrial symbiosis research closely examines deliberate planning of industrial symbiosis through prominent case studies such as Kalundborg. Others have studied the organic nature of industrial symbiosis development. Chertow (2007) compare 27 industrial symbiosis projects and proposed an "uncovering" approach to studying industrial symbiosis. This approach prioritizes developing industrial symbiosis based on existing resource exchange patterns. It offers ways to identify early-stage precursors of potentially larger industrial symbiosis development for policy-makers and practitioners that can help harness the full potential of larger-scale industrial symbiosis (Chertow 2007). Furthermore, Chertow and Ehrenfeld (2012) propose a three-stage model of industrial symbiosis development. The three stages are (1) sprouting, firms start to exchange resources; (2) uncovering, the realization of positive environmental externalities of the exchange networks; and (3) embeddedness and institutionalization, further expansion of the network that intentionally drives resource exchange (Chertow and Ehrenfeld 2012).

Complex Adaptive Systems

Scholars have also used tools in complex adaptive systems to understand industrial symbiosis formation, evolution, and resilience. A complex system approach considers a system as "large populations of interacting agents that form a dynamic network" and focuses on the collective behavior emerging from the action of the parts rather than a central controller (Romero and Ruiz 2013). Different tools are used to model these behaviors. Cao et al. (2009) apply agent-based modeling to describe how eco-industrial systems behave. Romero and Ruiz (2014) further apply agent-based model to examine the conversion of regular industrial area to industrial ecosystems. Chopra and Khanna (2014) apply network analysis to describe industrial symbiosis network structure over time. Zhu and Ruth (2013, 2014) use network models to conceptualize supply chain resilience and examine the role of coordination and government engagement. Zheng et al. (2013) use game theory to simulate the role of government's intervention in the context of industrial development.

Social Networks, Learning, and Innovation

The importance of social factors for the development of industrial symbiosis is established and widely studied using concepts and theories from social networks, economic geography, ethnography, organizational analysis, and neo-institutional theory (Ashton 2008; Gibbs 2003; Hewes and Lyons 2008; Howard-Grenville 2008; Jacobsen 2007). Industrial symbiosis is a learning process that can be linked to innovation for sustainability based on observations of industrial symbiosis networks in specific regions such as industrial clusters in Sweden, Australia and Germany, and Finland (Mirata and Emtairah 2005; Posch 2010) (Ristola and Mirata 2007). Industrial innovation networks are also studied through comparative analysis of network properties among various municipalities (Walter and Scholz 2006). Through articulating the relationships among industries and the processes of institutionalization, this strand of work has further bridged industrial symbiosis to existing theories in organizational behavior, institutional economics, and social networks.

More recent research has highlighted the importance of time in the social formation of industrial symbiosis. The emergence, evolution, and dissolution of symbiotic relationships are studied through process-tracking in specific institutional background (Boons et al. 2011; 2014; Spekkink 2014; Shi and Chertow 2017).

Metrics and Evaluation

Industrial symbiosis can also be viewed through the lens of resource optimization among colocated

companies (Jacobsen 2006). An important part of this approach is identifying and quantifying metrics that can effectively measure performance in industrial symbiosis systems. Cost saving is a core metric in many of these evaluations, but researchers have also quantified changes in resource production as well as efficiency factors. There is also qualitative analysis demonstrating that industrial symbiosis helps companies establish competitive advantage in the market (Park and Park 2014).

Environmental savings is another important family of metrics used for evaluating the effectiveness of industrial symbiosis. The most frequently used metrics in this category include energy and material savings. Specifically, material savings include savings during the manufacturing processes as well as the avoided landfill or waste material at the end of production. A more theoretical understanding of environmental savings can be achieved using energy-related metrics such as exergy (energy available to be used) or emergy (energy consumed to make a product or service). Due to the importance of climate change, some research also focuses on greenhouse gas emissions using metrics such as carbon dioxide equivalent. Due to the application of life cycle assessment (LCA) as a tool in evaluating industrial symbiosis effectiveness, a wide range of metrics in LCA were considered (Eckelman and Chertow 2013; Chertow and Park 2016).

Typology Development in Industrial Symbiosis

To synthesize trends and patterns in industrial symbiosis development, industrial symbiosis scholars focus on the complex interactions that develop robust industrial symbiosis over time. Jiao and Boons (2014) provide an approach to investigate the mechanisms of policy intervention and facilitation of industrial symbiosis that focused on the dynamics of policies. A dynamic approach emphasizes how policy is conceptualized and evolves over time as a process. They found that the key to reveal industrial symbiosis mechanisms is "to identify the sequence of events connecting policy process and industrial symbiosis practices" (Jiao and Boons 2014).

In response to the rapid development of industrial symbiosis scholarship and applications around the world, a group of interdisciplinary industrial symbiosis scholars proposed a conceptual and theoretical framework in comparative analysis of industrial symbiosis at a global scale. Based on advances made in the field over the last 15 years, the framework provides a comprehensive explanation of industrial symbiosis as a process and provides a typology of industrial symbiosis dynamics. Seven types of industrial symbiosis dynamics are outlined and characterized by their initial actors, their motivation, overall storyline, and typical outcomes.

Boons et al. (2017) synthesized seven main types of industrial symbiosis as follows.

1. Self-organization, in which "industrial actors expect benefits in developing symbiotic linkages, and subsequently search for suitable partners. After finding a suitable partner, they negotiate contracts and operationalize the plans." The eco-industrial park at Kalundborg, Denmark, is an example of this dynamic because its symbiotic network has developed based on the interactions among industrial actors without a grand plan.
2. Organizational boundary change, in which "an industrial actor expands its activities through vertical integration and develops internal exchanges. Then the industrial actor changes its strategy from vertical integration into outsourcing. Finally, the linkages remain and the system evolves into an interorganizational network." The Guitang Group in China is an example of this dynamic. Initially established as a sugar manufacturing facility, the Guitang Group has expanded its business to paper and other production activities through shifting its organizational boundary, allowing a greater number of facilities to contribute to the symbiotic relationship.
3. Facilitation through brokerage, in which "a third-party organization sets up a brokerage system. Then the broker establishes a market for industrial symbiosis development. Finally,

industrial actors engage and develop symbiotic exchanges through the market system." The National Industrial Symbiosis Program (NISP) in the United Kingdom and United States Business Council for Sustainable Development (USBCSD)'s industrial symbiosis facilitation program are two prominent examples of this dynamic. NISP has regional coordinators to facilitate communication and networking among industries. USBCSD serves as an information broker through compiling industrial symbiosis data and developing software for an online secondary resource marketplace.

4. Facilitation through collective learning, in which "a facilitator picks up the concept of industrial symbiosis from existing examples. Then the concept is translated into specific regional context. Finally, industrial actor and facilitator engage in collaborative learning to develop a symbiotic network." An example of this dynamic is the first phase of the Indicators of Education Systems (INES) Mainport Programme in the Rotterdam Harbor and Industry Complex in the Netherlands, where the business association facilitated and encouraged collective learning programs.
5. Pilot facilitation and dissemination, in which "a facilitator picks up the concept of industrial symbiosis from existing examples first. Then the concept is translated into specific national/regional context. Next, groups of colocated industrial actors are selected to serve as exemplary cases. Then there is further refinement of the concept through learning in pilot projects. Lastly, the experiences from pilot projects are transmitted by the facilitator to other groups of collocated industrial actors." A prominent example of this dynamic is the Eco-industrial Park Program in South Korea, where organizations such as Korea National Cleaner Production Center and Korea Industrial Complex Corporation facilitated pilot projects in three phases.
6. Government planning, in which "a government actor picks up the concept of industrial symbiosis from existing examples. Then the concept is included in policies and translated to the specific national/regional context. Next, the government actor develops a plan for the development of linkages through stimulating and/or enforcing policy instruments. Then the progress of implantation is mentioned, and the results of evaluations are fed back into the policy to realize continuation/renewal/closure." Examples of this dynamic include the Eco-industrial Parks approved by the Chinese Ministry of Environmental Protection or the National Development and Reform Commission such as TEDA and the Suzhou Industrial Park. The symbiotic relationships in these parks were initiated and driven by the national policy for eco-industrial parks and circular economy.
7. Eco-cluster development, in which "local governments and/or industrial actors develop a strategy for the development of an eco-cluster. Then symbiotic linkages are developed through participatory process among multiple stakeholders as part of the broader eco-innovative strategies." An example of this dynamic is the ReVenture Park in Charlotte, United States, where eco-innovation is an emphasis of the park's development (Boons et al. 2017).

Evaluating and understanding of industrial symbiosis from a process perspective helps researchers recognize the trigger conditions from technical, economic, and geospatial perspectives. It also advances understanding of the linkages between these dynamics. In particular, self-organizing dynamics "tend to correlate more often with communities that have greater social capital" (Ashton 2008). Furthermore, a dynamic perspective helps to recognize different types of outcomes as a result of industrial symbiosis. Typically, each industrial symbiosis dynamic leads to a predictable set of outcomes; the outcomes in some cases are more directly linked to starting conditions than others. Each industrial symbiosis dynamic could impact the structural characteristics of the industrial symbiosis networks (Zhu and Ruth 2014).

Tools and Approaches

Industrial symbiosis planning and analysis makes use of a wide range of tools. Broadly, the

tools can be categorized as material/location-based tools and social/stakeholder-based tools. The former focuses on analyzing the material or resource flows among firms, while the latter investigates the relationships and social ties among firms. In addition, information and communication technology tools have started to play an increasingly important role in industrial symbiosis development.

Material and Location-Based Tools

One popular group of tools used in industrial symbiosis analysis are the input-output matching tools that match resource and energy input and output of facilities. This tool group includes FaST (Facility Synergy Tool), DIET (Designing Industrial Ecosystem Tool), and REaLiTy (Regulatory, Economic, and Logistics Tool), all commissioned by the US Environmental Protection Agency (US EPA). These tools build data repositories of industry profiles, including the inputs and outputs of the facilities. Then the tools identify facilities whose inputs and outputs match based on scenario analysis. Some of these tools incorporate geographic information systems (GIS) as a component in the matching process. Material budgeting is another tool that relies on understanding the material stocks and flows of facilities to achieve industrial symbiosis planning. This tool maps out exact material quantities to enter or leave the system during a set duration. Traceability is critical in this type of analysis (Chertow 2000).

Life cycle assessment (LCA) is a tool used to evaluate the emissions and benefit of the entire life cycle of products, including their raw material extraction, manufacturing, transportation, use, and recycling. In the context of industrial symbiosis, LCA can be used to analyze the material and energy exchanges that take place in an industrial symbiosis system. For example, Eckelman and Chertow (2013) use LCA to review the impact of symbiotic exchanges within the Campbell Industrial Park in Hawaii. The exchanges include activates such as reuse of bottom ash, fly ash, sewage sludge, water, steam, old tires, granular activated carbon, and waste. They found that the presence of steam exchanges is the largest contributor to the overall primary energy, carbon dioxide emissions, and acidification of the entire system. The presence of sludge/fertilizer exchange is the largest contributor to nitrogen emissions of the system. As a tool, LCA can help quantify the environmental impact of industrial symbiosis and provide empirical evidence for policy decision-making (Eckelman and Chertow 2013).

Social and Stakeholder-Based Tools

The other set of popular tools used in industrial symbiosis is social and stakeholder-based tools. Research has identified relationships and stakeholder buy-in as critical factors in successful industrial symbiosis development. Therefore, these tools aim to analyze the stakeholders, the relationships, and the social processes involved in industrial symbiosis. Some examples of stakeholder engagement include having a representative advisory committee, building a set of principles based on community consensus, and convening stakeholders from business and government. The other stakeholder-based consideration is to decide if industrial symbiosis is stream-based or business-based. Stream-based industrial symbiosis is an idealistic version of planning where "linkages are made based on the flow of specific physical resources through an eco-industrial system." It does not consider the critical role of existing symbiotic relationships. The business-based approach designs industrial symbiosis based on existing tenants in the industrial system (Chertow 2000).

Social network analysis (SNA) has also been used to describe and analyze industrial symbiosis from the perspective of social ties. In particular, prior industrial symbiosis case studies indicate that communication and trust among managers plays an important role in industrial symbiosis development. SNA can be used to quantify "patterns in relationships among firms and managers, including formal relationships through supply chains, and informal ones through interpersonal interactions." Together with statistical methods, SNA can explore how social ties correlate with industrial symbiosis activities. An analysis of industrial symbiosis between pharmaceutical firms in Barceloneta, Puerto Rico, has showed that industrial symbiosis linkages were concentrated among firms at the core of the network (Ashton 2008).

Information and Communication Technology (ICT) Tools

The role of ICT in industrial symbiosis development is explicitly discussed in industrial symbiosis literature. On one hand, ICT can significantly reduce transaction costs and help optimize resource sharing. On the other hand, ICT is challenging to apply in "nonstandard, or nonmarket transactions" where the costs are not clear. Through reviewing ICT tools within the context of how they are used in industrial symbiosis development, Grant et al. (2010) identified an industrial symbiosis development process model with five iterative steps. Furthermore, they developed four user interaction models based on the targeted user of the ICT system. The user archetypes include designer/planner, facilitator, and participant. Facilitator and participant can also evolve to become network participant and network facilitator, respectively. Various users drive industrial symbiosis development from different perspectives (Grant et al. 2010).

Future Opportunities

There are a few exciting prospects of how industrial symbiosis could help reach the 12th SDG goal of responsible production and consumption. While there are many ongoing industrial symbiosis initiatives, this section focuses on several cases relevant to novel research direction, technology adoption, and policy design toward sustainable development.

Better understanding of the potential of industrial symbiosis (the sum of the wastes and byproducts that could be reused) could help facilitate sustainable development. For years, researchers have sought ways to understand the potential size of industrial symbiosis at different scales. This quest has become clearer because of the increasing documentation of industrial symbiosis cases around the world. For instance, researchers have developed algorithms to calculate industrial symbiosis potentials at city level. Furthermore, they use the results to propose specific policies. Using tools in life cycle assessment, Chertow et al. (2019) investigates industrial symbiosis's public benefits by "converting the maximum quantity of resources recoverable by local enterprises into an estimate of the capacity of municipal infrastructure conserved in terms of landfill space and water demand" in Mysuru, India. Based on the inputs and outputs of ~1000 urban enterprises, the study finds that the industrial symbiosis potential translates into 84,000 tons of industrial waste annually, greater than 74,000 tons of CO_2e emissions reduction annually, and 22 million liters per day of wastewater. Based on these potential benefits, the study proposes a waste feed-in tariff to subsidize industrial symbiosis toward responsible production (Chertow et al. 2019). This approach provides concrete evidence of the potential public benefits of industrial symbiosis that are directly policy relevant.

The coming age of Industry 4.0 could help improve the scale and efficiency of industrial symbiosis toward sustainable production. Industry 4.0 refers to the "fourth industrial revolution" facilitated by the Internet of Things (IoT), which include sensors and communication networks that connect factories and machineries (Xu et al. 2015). Faster networks such as the 5G technology will allow industries to track their material inputs and outputs more seamlessly, building stronger foundations for symbiotic exchanges.

In addition, the combination of IoT and machine learning tools could enable greater industrial symbiosis through more precise predictions. The increasing number of sensors and amount of network capacity would allow industries to collect massive amounts of data along their supply chains. Machine learning could leverage these "Big Data" and create useful predictions related to production and waste quantity, heating and cooling systems optimization, and energy efficiency optimization among industrial networks (Rolnick et al. 2019).

From a policy perspective, industrial symbiosis is increasingly adopted by the public and private sector toward sustainable development from a strategic level or as a part of a policy experimentation. Based on the success of the few well-established pilot projects, more public policymakers are considering industrial symbiosis as part of a comprehensive strategy. For example, in Israel the Ministry of Economy and Industry

in cooperation with the Ministry of Social Equality has launched a national project for industrial symbiosis (Blass 2019). As part of the process to streamline communication, the European Committee for Standardization is building a consensus on standard terminologies and methodologies for industrial symbiosis (The European Committee for Standardization 2018). The World Bank Group in collaboration with UNIDO and Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (German Development Cooperation) has developed an international framework for eco-industrial parks that leverages industrial symbiosis as one of the components (The World Bank Group 2017). There are also policy experimentations that incorporate industrial symbiosis as one of the topics. A good example from the developing world is the "Sustainable Enterprise Network Program (RedES-CAR in Spanish)" in Cundinamarca and Boyacá, Colombia. The program aims to build capacity toward cleaner production and has included industrial symbiosis as a topic since 2018 (Park et al. 2018).

Another exciting policy-relevant prospect is the role of industrial symbiosis in a circular economy where resources are used in a regenerative manner. The core principles of industrial symbiosis – connecting and sharing resources, waste, and networks – are in alignment with the concept of a circular economy. In fact, industrial symbiosis is introduced as a primary approach to achieve a circular economy by the Ellen MacArthur Foundation (Ellen MacArthur Foundation 2018). Industrial symbiosis theory and applications can offer context and resources to practitioners and policymakers, as the private and public sectors are paying more attention to building an economy with better circularity. One meaningful line of future work is to study how businesses can create value through applying a circularity-driven business model that includes symbiotic exchanges among industries.

Conclusion

Founded based on the notion of biological symbiotic relationships, industrial symbiosis has evolved over the past few decades from initial uncovering of individual cases to a field with a thorough theoretical framework that compares global industrial symbiosis patterns. Key aspects of industrial symbiosis such as geographic proximity, organizational enablers, and self-organizing factors are recognized in the literature.

The development of industrial symbiosis relies on the cross-pollination between researchers and practitioners. In particular, the development of eco-industrial parks and resource/waste exchange clusters has been closely studied in industrial symbiosis literature. The typology of industrial symbiosis enables a dynamic understanding of industrial symbiosis development over time. To understand and improve industrial symbiosis, various tools are applied to connect the material resources as well as the social ties necessary for success. Industrial symbiosis is further encouraged by the rapid development of ICT tools and the increasing connectivity of the industrial network. Given the rapid development of business and technology sectors in Industry 4.0 era, industrial symbiosis is anticipated to contribute to sustainable development in emerging economies, make better linkages of the production-consumption network, and reduce the environmental impact of industrial activities.

Cross-References

▶ Industrial Ecology in Support of Sustainable Development Goals

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Industry 4.0

▶ Factories for the Future: Toward Sustainable Smart Manufacturing

Influence

▶ Impacts on Environment and on Human Health

Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy

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Synonyms

Micro-service providers; Reclaimers; Recyclers; Waste pickers

Definitions

The informal recycling sector (IRS) refers to individuals or community enterprises who are involved in the recovery of material and waste management activities which are not necessarily

sponsored, financed, recognized, supported, organized, or acknowledged by the formal solid waste authorities (Scheinberg et al. 2010). "Waste reclaimers generate their livelihoods and sustain themselves and their families by retrieving reusable and recyclable materials from the waste stream – typically from streets, open spaces, garbage bins and garbage dumps. Historically their work has been considered informal and often illegal" (Samson 2009).

The term waste pickers (*recicladores* for Spanish in Latin America, *catadores* in Brazil) was adopted in the First World Conference of Waste Pickers in Bogotá in 2008 to replace the derogatory term "scavenger." Samson has further suggested that the terms recyclers and waste pickers do not fully portray their work and included the term "reclaimers" as they reclaim value for materials considered waste (Samson 2009). In terms of their participation in solid waste management operator models, the term coined by Wilson is micro-service providers (Wilson et al. 2017a). Many common names arise in different countries, cities, and contexts. Recyclers have embraced some of these names; others have been rejected as pejorative. A few of the names are listed below:

Africa

Récuperateur in Dakar, Senegal (Havey and Dias 2018)

Wahis and *Zabbaleen* (the latter translated to garbage people) in Cairo, Egypt (Castillo Berthier 2003)

Barbécha (means excavator) in Tunisia (Scheinberg and Savain 2015)

Asia (de Bercegol et al. 2017)

Dong nat of Hanoi, Vietnam

Kabariwalla in Delhi, India

Pengepul in Surabaya

Europe

Chiffonier in France (nineteenth-century chiffon sellers) (Dows and Medina 2000)

Lumpensammler in Germany (nineteenth century) (Dows and Medina 2000)

Roma people – (Greece and Balkans) referred to the ethnic Hellenic Roma population (Karagiannidis et al. 2008).

Latin America and Caribbean (EIU 2016)

Ciruja, *cartonero*, and *excavador* in Argentina; *catador* and *chepeiro* in Brazil; *cartonero*, *cachurero*, and *chatarrero* in Chile; *basuriego*, *costalero*, *zorrego*, and *botellero* in Colombia; *buzo* in Costa Rica, Cuba, Honduras, and the Dominican Republic; *minador* and *chambero* in Ecuador; *pepenador* in Mexico, El Salvador, Guatemala, Nicaragua, Panama, and Paraguay; *guajero* in Guatemala; *churequero* in Nicaragua; *metalero* in Panama; *ganchero* in Paraguay; *segregador* and *cachinero* in Peru; *hurgador* and *clasificador* in Uruguay; *excavador* and *zamuro* in Venezuela; "scavenger," "reclaimer," "binner," "poacher," and "salvager" in the English-speaking Caribbean; and "*chiffonier*" in the French- speaking Caribbean

North America

Peddlers in the United States (Medina 2007)

Binners in North America (Binion and Gutberlet 2012)

Garbage pickers in many English-speaking countries (Castillo Berthier 2003)

Informal Recycling Sector: A Theoretical and Historical Perspective to Understand Its Role in Solid Waste Management and Contribution to the Sustainable Development Goals and a Circular Economy

Introduction

The purpose of this entry is to understand the production and consumption patterns that have led to the existence of the informal recycling sector (IRS) and showcase the IRS' defining role in curbing the social, economic, and environmental impact of a linear economy. The presence of informal recyclers has been documented in all

high-, middle-, and low-income countries for centuries. The contribution of the IRS as an essential actor in solid waste management (SWM) systems has shifted throughout history with changing drivers for waste reclaiming. The following sections describe (1) the theoretical approaches from which the IRS has been studied, (2) a historical overview of this ancestral occupation and the drivers for waste picking and SWM, (3) the current role and size of the IRS in SWM and contribution to SDGs and circular economy, and (4) the path forward for the IRS.

Theoretical Approaches

Hart was the first to define the term "informal" through his work in northern Ghana (Hart 1973). Since then, studies about the informal sector have been performed worldwide. From the many occupations that informal workers perform, 80% correspond to waste picking and recycling activities according to Women in Informal Employment: Globalizing and Organizing (WIEGO) (WIEGO 2019). Therefore, the approach to understand the role of the informal recycling sector requires a broader theoretical context from the birth of the informal sector. Based on the analysis of the different theories proposed starting from the work of Hart and the International Labour Organization (ILO), Chen divides the literature into four main schools of thought: dualist, structuralist, legalist, and voluntarist (Chen 2012). The dualist school is derived from the ILO and Hart's initial assessment, attributing the existence of the informal sector to the marginalization of workers from the formal sector and their rising to perform different autonomous work, obtaining an income and a safety net (Hart 1973). The structuralist school argues the existence of the informal sector serves the accumulation of capital by reducing the costs of labor by a nonautonomous process (Castells and Portes 1991). The legalist school sees the informal sector as a group of individuals or enterprises that operate at the margin of legality due to cumbersome bureaucratic barriers and costs of formalizing (de Soto 1989). Lastly, the voluntarist school appears as a derivative from the legalist school in which the agents choose not to formalize as strategic, mostly to avoid the costs and efforts of legal involvement (Maloney 2004).

The following are several theoretical lenses from which the informal recycling sector has been specifically approached.

Marxist and Neo-Marxist theory

From the exploitation of labor forces and class division, capitalism functions via the social reproduction of capital through the separation of producers from their means of production and forcing them into waged labor (Marx 1887). Although the informal recycling sector does not receive wages, it has been separated from its means of production. Therefore, the approximation by Harvey through accumulation by dispossession (Harvey 2003) has been most closely related to the conception of Bauman's human waste (Bauman 2004), where the informal recycling sector becomes the surplus population, as described by the structuralist approach. Harvey's approach also goes beyond production to explain the affection to means of consumption (Webber 2008). This lens has been particularly useful in pointing to the epistemic injustice in South Africa where capitalism still profits from the IRS (Samson 2015a) and the analogy to a "global apartheid" through the segregation of waste pickers also as human waste in neoliberal globalization (Wenzel 2018).

Castillo Berthier elegantly summarizes the neo-Marxist and structuralist approach to the IRS through his formula (Castillo Berthier 2003):

$$\text{Garbage} + \text{Working force} = \text{Merchandise}$$

Urban Political Ecology (UPE)

Building on neo-Marxist theory, urban political ecology is the field that investigates the interaction of social process, material metabolism, and space, untangling the process that fosters uneven and unequal environments (Swyngedouw and Heynen 2003). The sociopolitical construct of material flows from UPE's perspective allows for the study of waste from its dualist construct as environmental refuse, taken from the natural environment and converted into a threat to human health, aesthetics, and sustainability, and a social construct – the reinforced production and consumption patterns that lead to its disposal

(Harvey 1989; Njeru 2006; Parizeau 2015). It further defines the city as a socioecological process (Heynen et al. 2005). Crucial to the UPE perspective is also a geographical analysis that defines waste in its relationship to space and its multi-scalar effects (Fernandez 2012; Solíz 2014a; Parizeau 2015).

Based on the combination from modes of production in Marxist theory and urban political ecology, the health conditions of informal recyclers have been widely studied in different contexts, showing higher mortality and morbidity rates and a lower life expectancy in different contexts (Staffeld and Kulke 2011; Parizeau 2015; Yang et al. 2018). Furthermore, UPE offers the opportunity to understand the effects of the sociopolitical change as embodied at individual scale (Parizeau 2015). This standpoint has reached the development of epidemiological profiles of informal recyclers depending on their position in the hierarchical value chain (Solíz 2014b). A review of the overall health of waste pickers also attempts to differentiate the occupational hazards from the conditions of living in poverty, which are entangled in low- and middle-income countries (LMICs) (Gutberlet and Uddin 2017).

Social and Solidarity Economy (SSE)

The SSE refers to a "third sector" defined by the values of cooperation and reciprocity and initially defined by Gide as the study of all efforts made to improve the condition of the people (Gide 1912). Historically, the social economy has transitioned into the solidarity economy to create processes of social innovation with the objective of obtaining social justice (Moulaert and Ailenei 2005). Furthermore, as a third sector, according to Lipietz, it is expected to create synergies between the private and public sector that benefits society through social capital, a better environment, and an improvement of the livelihoods of all neighbors (Lipietz 2001). Cooperatives, unions, and associations are common organizational frameworks for recyclers in many LMICs. These organizational structures have accompanied the movement of recyclers to gain recognition in the SWM systems in cities worldwide. This theoretical approach has been consistently used in case studies in Latin America where legislation in SSE has been instituted (Caruana and Srnec 2013), particularly in cities in Brazil by Gutberlet (2009, 2015). Many of the new social enterprises are uprooted in SSE and its social innovation mission (Moulaert et al. 2013). This lens has also been useful in explaining the barriers of formalization and inclusion in SWM systems, consistent with the legalist approach, but that also include other factors such as institutional, financial, technical, and social hurdles (Abarca et al. 2013; Aparcana 2017).

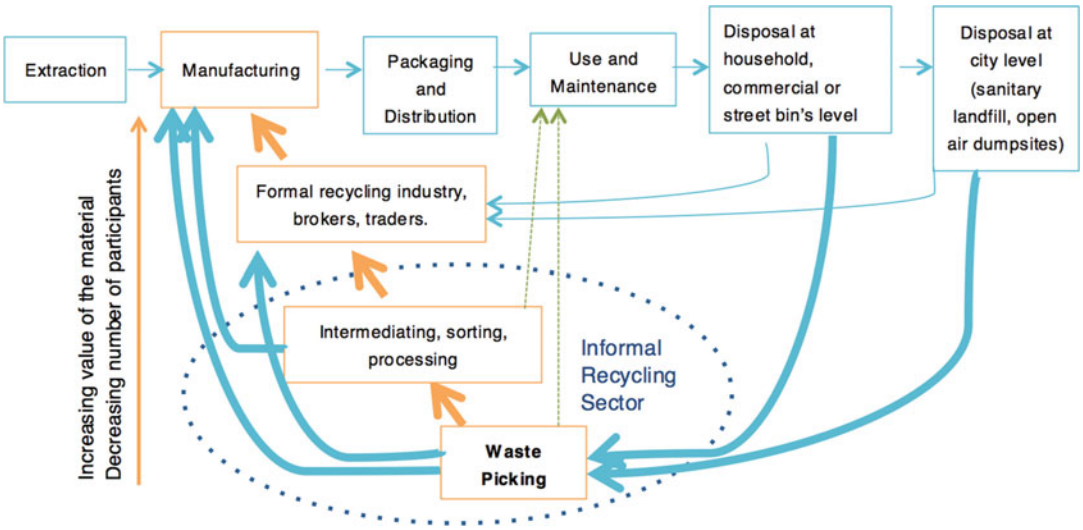
Ecological Economics: An Umbrella Including Urban Metabolism, Industrial Ecology, Life Cycle Thinking, and Circular Economy

Ecological economics provided a theoretical basis to consider physical laws in the study of economics with seminal work from Herman Daly with steady-state economics (Daly 1991) and its further development to include built, human, environmental, and social capital for sustainability (Costanza et al. 2014). In further analyzing the city and its urban metabolism, Broto emphasizes the importance of cross-disciplinary synergies to connect it to industrial ecology, highlighting six important themes: (1) the city as an ecosystem, (2) material and energy flows within the city, (3) economic–material relations within the city, (4) economic drivers of rural–urban relationships, (5) the reproduction of urban inequality, and (6) attempts at re-signifying the city through new visions of socioecological relationships (Broto et al. 2012). In this connection, the tools available for the assessment of environmental and economic impacts of production and consumption through life cycle thinking include life cycle analysis (LCA) (Vergara et al. 2016) and value chain analysis (Jaligot et al. 2016). These tools also portray the role of IRS in resource recovery processes, value added in material or "waste" flows (Guibrunet et al. 2017) and its contributions in lowering greenhouse gas (GHG) emissions both by material recycling (King and Gutberlet 2013) and in lower emissions compared to formal sector processes and logistics (Vergara et al. 2016). Methods have also been developed to take social

aspects into account through social life cycle analysis (sLCA) (Aparcana and Salhofer 2013). Furthermore, a combination of theoretical approaches from ecological economics and social and solidarity economy has also been used for the analysis of the role of the IRS in the circular economy (Gutberlet et al. 2017). For the purpose of this analysis, the circular economy concept is adopted from Murray et al. as "an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being" (Murray et al. 2017). Ideally, the circular economy uses a hierarchy for production and consumption that transcends into a zero waste model. This hierarchy, proposed by Zero Waste Europe, prioritizes (1) refuse/rethink/redesign, (2) reduce and reuse, (3) preparation for reuse (check, clean, repair), (4) recycling/composting/anaerobic digestion, (5) materials and chemical recovery, (6) residuals management (stabilization prior to landfilling), and (7) unacceptable practices that no longer feed into zero waste models such as waste to energy incineration due to its environmental and health detrimental impacts (Zero Waste Europe 2019). Although recycling falls below the main priorities of a zero waste model, it has been the major contributor to resource recovery and has been mostly performed by the IRS in LMICs. Therefore, the participation and inclusion of IRS in circularity speaks to the human well-being aspect intended to be achieved. Figure 1 shows the role of the IRS, comprised of waste pickers (associated or not) and intermediaries, in feeding material into the manufacturing industry through a life cycle thinking perspective and closing the loop for recyclable materials.

An Ancestral Occupation and Its Drivers

Waste "is not a trans-historical given, either in form or content; rather, it is a mobile description of that which has been cast out or judged superfluous in a particular space–time" (Gidwani and Reddy 2011).



Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy, Fig. 1 Schematic of the role of the IRS in SWM from a life cycle perspective. Waste picking, in this case, represents individual recyclers as well as cooperatives. Depending on the material and the level of association, waste pickers sell to intermediaries, formal recyclers, or directly to the manufacturing industry. The IRS connects waste generated at household, commercial, street level, and final disposal sites to manufacturing facilities. The green dashed lines represent the recovery from the IRS into reuse, either recovery for own usage or sales, as in the case with clothing and food. The orange arrows represent the hierarchy presented by Wilson et al. and WIEGO (2006, 2013) in the general transition from the informal recycling sector into the formal sector, with the value of material increasing up the ladder and the number of participants going down

Considering this definition of waste, the informal recycling sector has also had a changing focus of materials to be reclaimed in different times and spaces and a different role in society. Starting from the definition of scavenger, now a derogatory term, the story does begin early in humanity with the salvaging of meats left over from predators. Medina, in his historical analysis of "scavenging," suggests that throughout history, it has been an adaptive response to scarcity (Medina 1997).

"Scavenging: A Historical Perspective" (Adapted from Medina 2007)

Prehistory and Antiquity Two million years ago, "scavenging," or recovering leftover meats, may have been more common than hunting for early hominids. During nomadic times, waste was organic and would biodegrade. It is in the beginning of settlements that different attitudes toward solid waste management arise.

Already in 5000 BC copper could be cast and melted, showing that metal recycling may have existed since early metallurgy. The Minoans in Crete (2500–1500 BC) were already digging holes to put waste and covering it with layers, giving rise to archaeological stratigraphy and the first version of a sanitary landfill. Similar practices are documented in Troy (1200 BC) and in ancient African civilizations. The city of Athens, boasting over 315,000 inhabitants in 500 BC, created the first dumpsite and directed all sewage to be used in the fields. In Rome, with over one million inhabitants by 31 BC, to manage waste was considered shameful and thus assigned to slaves and convicts. There was, however, recycling of metals, peddlers also bought and sold clothes, and manure merchants recovered organic waste and excrement to sell to farmers as fertilizer. Emperor Vespasian installed urinals and charged operators a "urine tax" arguing that they were making a profit.

China had already installed a "sanitary police" by 200 BC to remove carcasses from the street and "traffic police" also in charge of supervising sweepers. Chinese farmers also bought excrement from peddlers as fertilizer or "honey pots."

Religion has also had a big role in determining who handles waste. By 1600 BC, Jews had a law that required them to bury their own waste outside the city. The rules of cleanliness in Islam also relegated the role of waste management to non-Muslims; this is still true in many Muslim countries today. However, many Muslims partake in waste reclaiming in India today, alongside *dalits*. The feudal caste system in Japan assigned the task of waste collection to the *hinins*.

Middle Age, Renaissance, and Early Modernity In medieval Europe, glove makers would install operations downstream from dyers to take advantage of the alum in the effluents. Organic waste was still being sold as fertilizer and animal feed but also to make gunpowder; scrap metal dealers for copper were also on the rise. By the ninth century, paper was being made from rags in Samarkand, Baghdad, Damascus, and Cairo; therefore, rag collectors recovered hemp, ropes, and clothing to be sold to papermakers. This practice was spread throughout North Africa and Europe leading to Arab and Bedouin lootings of Egyptian graves to steal clothing between the twelfth and thirteenth centuries.

In the Americas, the Mayans were known to have recycled jewels, construction material, and pottery. Between the fourteenth and sixteenth century, the Aztec had the *pepenilia*, who sold organic waste as fertilizer, animal feed, and dyes for fabrics. By the time the Spanish colonies had been installed in the Americas, rags were already a high commodity for which incentives were created to promote the export of rags for papermaking in Europe. There aren't many records of exports, most likely explained by the conditions of poverty in the colonies that forced them into resource efficiency and local recovery of materials. At the same time in Osaka, Japan, landlords had the property rights to excrement and tenants to urine; only outcasts were in charge of the collection outside this system.

In early United States, rag pickers fed the first paper mill installed in 1642 for 125 continuous years. Metal recycling made economic sense in comparison to mining and refining operations. By the eighteenth century, people were trading materials through newspaper articles, and rag picking was a patriotic duty. After the independence of

the United States, industry grew. Towns specializing in materials increased the sophistication of rag pickers to look for more products. Means to perform the job more efficiently also gave rise to the sight of peddlers as they went around towns with backpacks, sacks, and later on with horse wagons collecting material from the streets and dumps. The immigrant and the poor were making a living from these activities, while many of the higher classes also benefitted from brokering the material and using it for their own industries.

Nineteenth Century It is in the nineteenth century that waste-picking activities boomed. The rapid urbanization of European and American cities with its respective waste generation, the high demand for raw materials, and the willingness of many to provide this material increased the involvement in this occupation as well as its levels of complexity. By the end of the century, the majority of waste collection was still performed by waste pickers, sometimes paid by citizens such as in New York (though briefly), otherwise, supporting themselves from the sales of materials.

Drivers for SWM and the Beginning of Regulation

In 1800 United Kingdom, the majority of households start using coal for heating and cooling, and this raw material is useful for the production of bricks (Wilson 2007). At the time London installed a system to derive the ash to a private company for brick production. Driven also by the results of the Sanitary Commission from 1839, making the first connections between infectious disease and poor sanitary conditions, the United Kingdom was the first to install the Public Health Act 1875, putting the obligation of waste management on the city and requiring households to put their waste in bins by the curbside (Velis and Vrancken 2015). At the same time, Eugene Poubelle created the first bins "poubelles" that started being used for waste collection in France (Sandras 2011).

In most of Europe and North America, throughout the 1900s up to the 1970s, the main drivers for SWM were public health with the exception of both world wars when resource scarcity led to the scrap metal drives that would be recycled and used instead of virgin materials. In the 1950s entrance to American dumpsites was forbidden due to sanitary risks (Dows and Medina 2000).

By 1974, the recommendation in the United States was to not include informal recyclers in the waste management process (SCS 1974). The growing awareness of the impacts of dumpsites on water, soil, and air quality led to an environmental driver for SWM. The passing of environmental laws and regulations such as the Clean Air Act and RCRA set the stage for the technological modernization that led to the installation of landfills (Scheinberg 2003). In this scenario, previous metal scrappers and family-based businesses could no longer respond to the demand for recycling. The choice was to stay in activism, be marginalized or to become part of the bursting recycling industry (Scheinberg 2003). This process of exclusion of informal recyclers from dumpsites –where many live – has also been occurring in multiple places in LMICs, such as the case of Montevideo with presidential plans since 1990 (Fernandez 2012).

In Europe the control phase of regulating waste collection began in the 1970s, followed by technical interventions of landfilling and developing by 1977 a waste hierarchy, promoting reduction as a first strategy and landfilling as the last (Wilson 2007). By 1999, the EU Landfill Directive already included the hierarchy toward a more integrated policy. Further along, extended producer responsibility measures put the responsibility of the products' end-of-life management on the producer. This leads to more institutional drivers in Europe. New and upcoming drivers are also the public awareness and concern with waste management and the advent of the zero waste movement in the early 2000s and the professionalization of recyclers into a technical field in the United States (Wilson 2007). As new circular economy directives are published for countries worldwide, rediscovered drivers derived from resource depletion are raising again, ranging from avoiding consumerism to landfill mining.

The IRS, SWM, and the SDGs

The drivers of environmental and public health are now mostly taken for granted in the United States and Europe, yet LMICs are still struggling with

those two and further considering inclusivity and resource value (Wilson 2007). The collection of recoverable material by the informal recycling sector supports the drivers for solid waste management characterized and connected to the SDGs by Rodic and Wilson. Table 1 shows these drivers, the relationship to the sustainable development goals, and the relevance for the informal recycling sector.

From the Public Health Driver The IRS has been effective in increasing collection areas to peri-urban regions of cities in LMICs, a target for SDG 1 and 6, avoiding inadequate dumping (Wilson et al. 2017a). This avoids the accumulation of waste in drains that lead to the stagnant water fostering environments for the spread of vectors and disease to which children are most vulnerable (Rodić and Wilson 2017). The burning of waste is also a major source of pollutants detrimental to health and well-being from which the collection by the IRS is being avoided as within targets of SDG 3.

From the Environmental Driver At the local level, land degradation from inadequate dumping and the release of hazardous chemicals is being avoided by the IRS intervention, particularly with the recovery of metals from waste electrical and electronic equipment (WEEE) supporting the achievement of SDGs 12 and 14. Nonetheless, practices are not always standardized and without adequate capacity building may be polluting, leading to damaging health effects of waste pickers (Grant et al. 2013).

At the global level, recycling is one of the cheapest methods to reduce GHG emissions contributing to SDG 13. Avoiding 1 ton of CO_2 emissions through recycling costs 30% less than doing so through energy efficiency and 90% less than wind power (WIEGO 2019). Using the WARM model developed by the USEPA, the Chintan initiative estimated that the informal recycling sector in Delhi avoided the emission of 962,133 tons of CO_2 equivalent annually, referring to waste pickers as "cooling agents" (Chintan 2009). Furthermore, the logistics and methods used by recyclers emit significantly less GHG than formal sector recycling practices (Vergara et al. 2016).

From the Resource Value Driver The main driver from ancient times, the depletion of resources, is leading the creation of concepts such as cradle to cradle, in which waste is avoided through better design and the recapturing of biological and technological material in their own cycles (McDonough and Braungart 2002). Despite the hierarchy to manage waste, the majority of waste is still landfilled or disposed of in dumpsites (UNEP 2015). The involvement of the IRS is critical as 45% of all recycling is being performed by them (Linzner and Lange 2013). In most LMICs they have higher rates of recycling than formal SWM systems and gain substantially higher net revenues per weight as seen in Table 1 (Scheinberg et al. 2010). Moreover, the recovery of organic waste is practiced by many waste reclaimers for many purposes, including its transformation to biogas for energy usage in India (Gokaldas and GAIA 2019), contributing to SDG 7, or to use as animal feed or compost, returning the organic nutrients to soil and thus contributing to SDG 2 by reducing food waste. In these six cities, the materials recovered by the recyclers were paper 15%, plastic 11%, glass 3%, metal 4%, organics 51%, and other 17% (Scheinberg et al. 2010). However, these percentages can vary widely worldwide depending on the market available and the volatility of prices driven by globalization (Dias and Samson 2016) (Table 2).

From the Inclusivity Driver Formalization processes and recognition and support for the IRS can be key contributions to the achievement of SDGs 1 and 8 (Rodić and Wilson 2017). Furthermore, the support to the IRS has been consistently regarded as a poverty eradication strategy (Medina 2008; Gutberlet 2012). Recycling is considered to lead to net gains in employment quantity and quality in comparison with working in landfilling or incineration of waste. The United States and United Kingdom have both performed studies that put recycling as offering ten times more employment than landfilling or incineration; the ratio is 24:1 in India (ILO 2013).

According to the ILO and UNEP, work in recycling can be a green job. These jobs (1) reduce

Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy, Table 1 The relationship between the drivers for SWM systems, the SDGs, and the relevance for the informal sector. The connection between drivers and SDGs by way of understanding the relationship to solid waste management goals was initially established by Rodić and Wilson (2017). The addition of SDGs 5 and 10 as well as the connection with the IRS was added by the author, described in table with an asterisk∗, SDG2 is mentioned by Rodic and Wilson in the initial table but only as complimentary to resource value

Driver		Sustainable development goal (SDG)	Relevance of/for the informal recycling sector∗
Protection of public health		SDG 11: Sustainable cities	The IRS has been effective in catering to peri-urban areas that would otherwise have no collections services available, preventing inadequate dumping of waste and the proliferation of associated vectors
		SDG 3: Good health and well-being	
Protection of the environment	Local	SDG 6: Clean water and sanitation	
		SDG 12: Responsible consumption and production	The IRS, particularly in their involvement in recycling of electrical and electronic waste, avoids the release of hazardous chemicals into the environment, many times at the expense of their health, although better capacity building is needed to reduce the environmental impact of mismanagement by the IRS
		SDG 15: Life on land	
	Global	SDG 7: Affordable and clean energy	The recovery of organic waste by informal recyclers to produce biogas for energy usage has been documented in India with a scalable model
		SDG 13: Climate action	Recycled material used for manufacturing reduces GHG emissions through avoided energy consumption and land use change during extraction
		SDG 14: Life below water	IRS already provides services of collection and recycling, avoiding inadequate dumping and feeding manufacturing material to industry
Resource value		SDG 12: Responsible consumption and production	Waste reclaimers recover material for new production in technological cycles, and many use organic waste as food to eat, animal feed, or compost, also feeding biological cycles. The recovery of organic material further supports SDG 2 by reducing food waste
		SDG 2∗: Zero hunger	
Inclusivity		SDG 1: No poverty	Around 15 million people earn 0.7–4 times a minimum wage through waste picking. Conditions need to improve in order for this green job to be "decent" based on ILO standards
		SDG 8: Decent work and economic growth	
		SDG 5: Gender equality∗	In Latin America and India, the majority of recyclers are women. Many women recyclers have been directing the movement of IRS to be included in SWM worldwide. Many women in IRS still earn less than their male counterparts
		SDG 10: Reduce inequalities∗	In many cities worldwide, the IRS is comprised of minorities and migrants who have been historically marginalized

consumption of energy and raw materials, (2) limit GHG emissions, (3) minimize waste and pollution, (4) protect and restore ecosystems, and (5) enable enterprises and communities to adapt to climate change. However, in order to be a green job, it has to be decent (UNEP 2008). According to the most recent update from the ILO in the face of the sustainable development agenda, "decent work sums up the aspirations of people in their working lives. It involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men."

Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy, Table 2 Comparison of recycling rates in six cities by the formal and informal recycling sectors, including net revenues after material sales (Scheinberg et al. 2010)

	Formal sector			Informal sector		
City	Tons	Percent of total (%)	Net revenue €/ton	Tons	Percent of total (%)	Net revenue €/ton
Cairo, Egypt	433,200	13	8	979,400	30	145
Cluj, Romania	8900	5	18	14,600	8	396
Lima, Peru	9400	0.30	0.5	529,400	19	118
Lusaka, Zambia	12,000	4	20	5400	2	4
Pune, India	0	0	2	117,900	22	297
Quezon City, Philippines	15,600	2	3.5	141,800	23	93

Supporting waste pickers can also be a strategy to reduce inequalities, SDG 10. Waste pickers usually belong to socially and economically marginalized populations – e.g., *dalits* and minorities in India, blacks in South Africa, Vietnamese refugees in Cambodia, displaced rural people in Colombia, and Zabbaleen/Coptic Christians in Egypt (WIEGO 2013). In terms of gender equality, women still earn less than their male counterparts in recycling, due to many aspects, including access to waste (Crivellari et al. 2008). In a study with waste pickers in Nigeria, age and gender were identified as crucial determinants in the dynamics of power and bargaining (Adama 2012). Nonetheless, it is women who have led the major informal recyclers movements to recognition, such as the case with India with the Kagad Kach Patra Kashtakari Panchayat (KKPKP) that started organizing in the 1990s when mothers realized their children could go to school if they took over the recycling activities (Chikarmane and Narayan 2005). Other examples are in Brazil with the recognition of *catadores* and the Movimento Nacional dos Catadores de Materiais Recicláveis (MNCR) and Colombia with the Asociación Nacional de Recicladores (ANR). In fact, Norah Padilla, leader of the recycler's association of Bogotá, was the Goldman Prize Recipient for South and Central America in 2013. Also, Maria Monica da Silva, leader of the recycler's association of Diadema, was awarded the Living Legacy Prize at the Women International Conference in 2014. Women reclaimers have been positioning themselves to take on leadership and decision-making positions as desired in SDG 5.

Role and Size in SWM

By 2008 it was estimated that approximately 15 million people or 1% of the urban population in LMICs was involved in the IRS (Medina 2008). The ILO estimates at least 20 million people are currently in the IRS (ILO 2013). This is consistent and falls within the range of the systematic review by Linzner and Lange assessing the role and size of the IRS in SWM.

The main results of their work are summarized as follows (Linzner and Lange 2013):

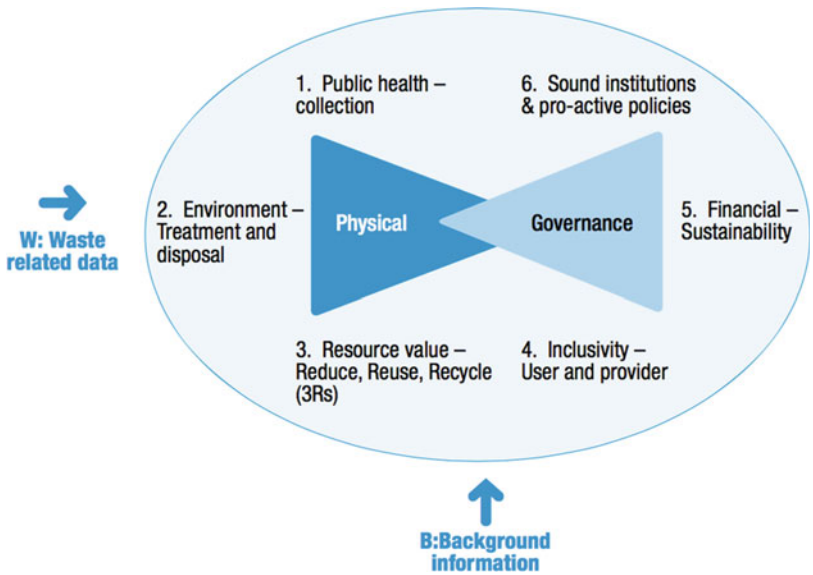
- 0.6% of the total urban population is the proportion of informal waste workers in cities. This ranges from 0.5% to 2%, determining that approximately 12.5–56 million people are involved in the IRS worldwide.
- Forty to 2000 kg daily collection rates per waste picker, the range is due to means of transport.
- Forty-five percent recycling of generated waste is performed by the IRS, in some cases more.
- Three times the factor of per kg prices going up the recycling hierarchy.
- 0.7 up to 5.0 the ratio of income to minimum wage.
- Ten to 40 times more jobs in IRS than industrialized SWM systems.

Wilson et al. in their typology of common operator models (coms) for the collection and

management of solid waste determined the operator model to be the combination of client, operator, and revenue collector within a framework that also includes policy, regulation, and planning. Based on their analysis, cities in LMICs use an average of 2.5 coms with combinations from public, private, and micro-service providers (Wilson et al. 2017b). Informal recyclers, classified within micro-public–private partnerships, accounted for the service delivery of 42% of waste management in 330 case studies analyzed in developing countries. Micro-service providers showed to be effective in expanding primary collection from urban to peri-urban areas as well as providing a recycling service that is not necessarily offered by public or private operators. This is consistent with findings from UN-Habitat in which informal recyclers are attributed to recover 15–35% of all waste in LMICs (UN-Habitat 2010) and the already mentioned 45% from Linzner and Lange.

In the last "What a Waste" report from the World Bank, in most LMICs over 80–90% of the budget dedicated to waste management was only allocated to collection (Hoornweg and Bhada-Tata 2012), rendering final disposition as secondary, let alone considering recovery. This is in contrast to the practices by high-income countries where only 10% of their budget is spent on collection. In this regard, the role of IRS also has to be considered from a budgetary standpoint. In fact, the IRS has saved local governments 20% of the budget they would otherwise spend in SWM (Velis et al. 2012). UN-Habitat refers to the work performed by the IRS as a positive externality the municipality benefits from and does not pay (UN-Habitat 2010).

There are several tools to aid municipal governments in determining the best solid waste management systems according to their context. Figure 2 portrays the framework for the benchmarking tool "Wasteaware" from Integrated Sustainable Waste Management (Wilson et al. 2013). In this tool the role of IRS is taken into account considering its contribution to recycling rates in benchmarking indicator 3 (resource value) as well as in benchmarking indicator 4 with provider inclusivity. There are also decision support protocols financed by the GIZ (Soós et al. 2017) for LMICs to install inclusive solid waste management systems, depending on their interests. Soos and colleagues determine that the main drivers for municipalities to integrate the informal sector are (1) awareness of the local authorities about the social, environmental, and economic benefits of the IRS, (2) existence of representation



Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy,
Fig. 2 Integrated Sustainable Waste Management (ISWM) framework used in GWMO considering the convergence of six physical and governance benchmark indicators that are measured through the Wasteaware tool (Wilson et al. 2013). (Derived from UN Habitat, 2010. David C Wilson, Costas A Velis and Ljiljana Rodic ©)

of the informal sector providers, and (3) lack of barriers according to social acceptance and environmental standards (Soós et al. 2017).

Barriers to Formalization

The works of Abarca and Aparcana in their reviews to understand the barriers and processes to formalize the IRS identify five key factors: (1) policy and legal arrangements, (2) economic and financial instruments, (3) institutional and organizational arrangements, (4) social acceptance and welfare, as well as (5) technical or operational constraints (Abarca et al. 2013; Aparcana 2017). Aparcana goes further into analyzing 20 cases of formalization, characterizing the processes based on 3 approaches of organizing informal recyclers into (1) associations and cooperatives, (2) community-based organizations (CBOs) or micro- and small enterprises (MSE), or (3) formal employment with the municipal sector. The initiator of the formalization processes varied in different contexts, municipalities, nongovernmental organizations (NGOs), and waste picking organizations, with some successes such as diversion of activities and higher awareness by the population to improve access to waste but also persistent challenges such as corruption and lack of adequate infrastructure to perform the tasks despite having the legal permit (Aparcana 2017).

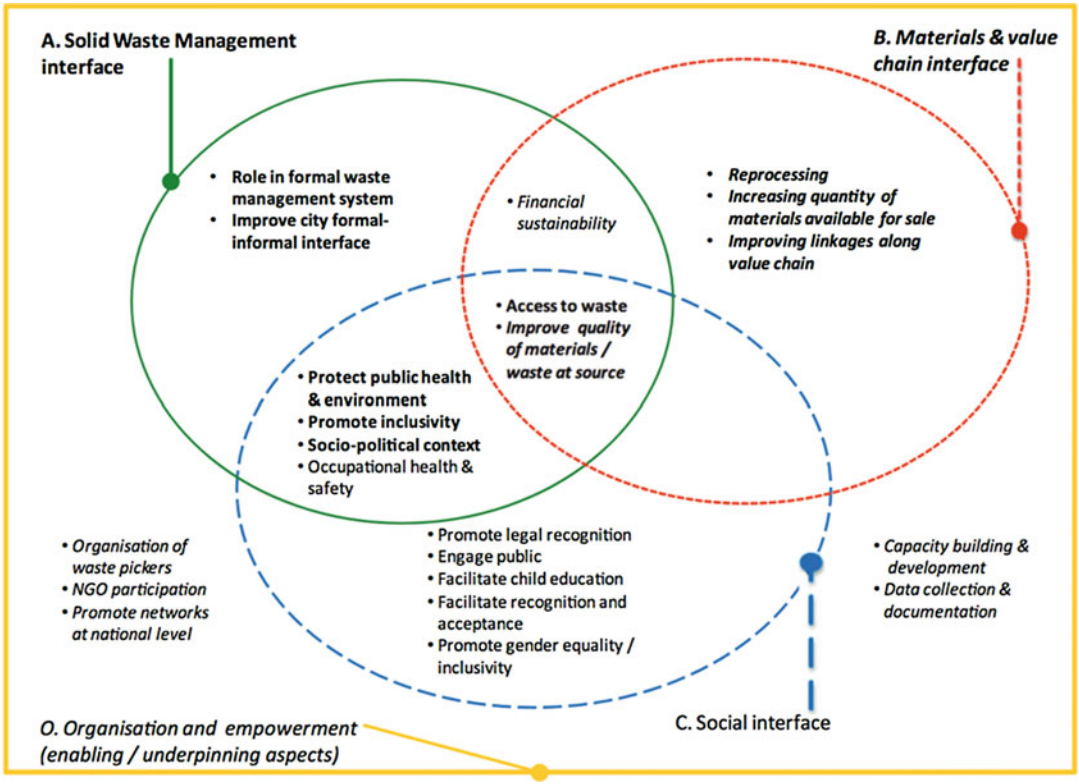
Kashyap and Visvanathan also describe three other factors that although covered in social acceptance and welfare are more specific and entrenched in internal barriers to formalize; these are (1) territoriality and fierce competition over waste in different spaces alongside scrutiny for recycling practices that may be polluting, (2) loss of identity and fear for the loss of independency and the possibility of forcible "dismissal or merger" with government and/or formal private entrepreneurs, and (3) mistrust and lack of common grounds for formalization, which in many cases have led to unhealthy competition of collection fees and even pushing players out of the business (Kashyap and Visvanathan 2014).

Many of these concerns have been encountered in different contexts. Velis and colleagues have developed the tool Integration Radar "InteRa" to understand the array of possible interventions to include the IRS successfully (Velis et al. 2012). They classify them in four main categories: (A) solid waste management, (B) material and value chain, (C) social aspects, and (D) organization and empowerment as enabling aspects that encircle all interventions. They are summarized in Fig. 3.

Path Forward

In many high-income countries in North America and Europe, governmental policies have led to the technocratic handling of waste. Some cities and countries have successfully increased recovery rates; others widely practice incineration and landfilling. In many LMICs, the replication of these policies is leading to the displacement of informal recyclers from open-air dumps and the regulation of sanitary landfills where they are no longer welcomed, such as recent cases in Senegal (Havey and Dias 2018), Ghana (Siaw-Marfo 2018), and Ecuador (MAE 2010). Unfortunately, in this process, if a recyclable material handling system is not installed, the result is an increase of recyclable waste being buried or burned instead of recovered.

An analysis of 20 cities performed by Wilson shows that in cases such as Quezon, Philippines, the IRS is able to recover an equivalent percentage of city's waste as Rotterdam's formal sector, despite the much lower gross net income it has (Wilson et al. 2012). San Francisco offers a case study in the United States where a city has set ambitious goals with zero waste by 2020 and already diverts 80% of all waste from landfills (USEPA 2018). In the selection of the 20 cities, it has the highest recovery rate by the formal system (Wilson et al. 2012). Recology, the company that takes care of waste management processes in San Francisco, started as an association of recyclers in 1921; together they established two companies: Scavenger's Protective Association and Sunset Scavenger Company (Recology 2016). The company still holds the license to manage all waste in San Francisco without a contractual agreement but rather by ordinance where the city sets rates since 1931. Recology has maintained its association's goals and is one of the largest 100% employee-owned companies in the United States, serving 127 communities in 4 states (Recology 2016). Differentiating San Francisco from other cities in the United States



Informal Recycling Sector (IRS), Contribution to the Achievement of the SDGs, and a Circular Economy, Fig. 3 InteRa analytical framework and typology of interventions to include the IRS in SWM, showing their interdependencies (Velis et al. 2012) Sagepub ©

is particularly relevant due to current practices by other cities. Due to China's 2018 regulations to prohibit imported waste, many US cities are struggling to find an alternative market for its waste and rising costs of SWM, leading in some cases to burying and incinerating recyclable materials (Cockerty 2019). This regulation has also had disadvantageous effects on China's IRS which was already collecting 17–34% waste and had approximately 3.3–5.6 million recyclers, many also recycling imported waste (Linzner and Salhofer 2014). The new regulation and directives for a circular economy in China, displacing the IRS, call to question the possibility of a future for the IRS in the country (Steuer et al. 2018).

There are still many uncertainties in understanding the right path for the involvement of the IRS in SWM. Both Scheinberg and Fernandez have separately questioned the process of "modernization" of SWM in LMICs copying the developed country mechanisms (Scheinberg et al. 2011; Fernandez 2012). In fact, many European countries have informal recyclers that are currently cast out of the SWM system and often collide with authorities because they are not considered in EU directives; Scheinberg recommended their inclusion in the EU circular economy directive (Scheinberg et al. 2016).

Recyclers' main demands are adequately summarized with the new 3Rs that include recognition, source separation (recolección diferenciada in Spanish), and remuneration (EIU 2016). In the 2013 ILO conference for green jobs, waste pickers prepared a position paper titled "Waste Pickers: The right to be recognized as workers" in which they show the multiple economic, environmental, and social benefits they contribute to society with their labor. Taylor argues that "recognition is a vital human need" presenting the psychological standpoint from which social

resistance and demands can be understood (McCormack and Honneth 2006). Waste pickers, through their associations, have had many successes in the process of the recognition for their work, allowing them to continue providing an environmental service to cities while sustaining themselves. There are dozens of organizations by waste pickers or supporters, from the Global Alliance of Waste Pickers Alliance, WIEGO, the Global Alliance for Incineration Alternatives (GAIA), and Red Lacre (Latin America), to hundreds of established associations, cooperatives, and unions of waste pickers worldwide that are rising to be recognized but also to be remunerated. The cases of Brazil and Colombia, where waste pickers receive the payment per ton as equivalent to the cost of landfilling, and the case of Pune, India, with the direct payment from residents with initial support from the municipality, begin a process of retribution (Samson 2015b). These last cases are pertinent since they are not necessarily accompanied by the direct employment of recyclers in the formal sector or the formation of a company by the association such as the case with San Francisco. Many associations and cooperatives are trying to institutionalize their role from the SSE or third sector as activists against neoliberalism (Samson 2009). Many of them argue that waste is a commons that should not be a merchandise (Zapata and Zapata Campos 2015; Dias 2016). Regardless of the formalization process, this new institutionalization of waste picking leads to the idea of "former informal" of the IRS (Velis 2017), where other factors not in cooperatives become the new informal.

According to the Global Waste Management Outlook (GWMO) report of 2015, beyond reaching adequate disposal as an intermediate goal, ultimately, the protection of the environment should be achieved through the transformation of a linear to a circular economy (UNEP 2015). Velis argues that if current systematic issues are not addressed, a circular economy will not be possible, such as improving governance conditions as well as the adequate working standards and better practices by the IRS (Velis 2018). Wilson et al. also point to the need for a strong "client" (municipality) to be able to install an effective operator model of any form in LMICs, including the ones that have the IRS involved (Wilson et al. 2017a). Norah Padilla and the Association of Recyclers of Bogotá carry the motto "Recycling (source segregation) without recyclers is trash," referring to the efforts to segregate waste at source as useless if there are no recyclers to actually take that material into the recycling/recovery process. Although recycling activities are not the highest priority in the transition into a zero waste model, they have been the main contribution to its advancement, particularly in LMICs with the contribution of the IRS. Countries like India and Colombia have already established plans to achieve circular economies with the involvement of the IRS. The evidence suggests that as the waste picking movement strengthens, society reaps many benefits with their involvement in SWM and toward the achievement of the SDGs and an inclusive circular economy, particularly as they mobilize, organize, and improve their practices with political, technical, legal, and social support.

Conclusion

The role of the IRS throughout history has been instrumental in resource recovery. At the same time, the rise of this sector has been approached from different theoretical perspectives, according to informality from the structural approach of neo-Marxism, their role in urban metabolism from the UPE perspective, their organization through the SSE, and their environmental contribution to SWM from the ecological economics and life cycle thinking perspective. Although the drivers for waste management have shifted from public health concerns to environmental protection and resource value, it is the latter that has mostly defined the role of IRS in connecting material once considered waste into a valuable resource. These materials can either be used directly or sold for manufacturing and creating an income for the IRS. As the inclusivity driver for waste management pushes for the formalization of the IRS, there are many barriers that must be overcome, depending on context and stakeholders who facilitate that process. The IRS' contribution to the

SDGs and a circular economy has been highlighted throughout this article alongside their demand to be allowed to continue to perform their job with better conditions that include source separation, recognition, and remuneration.

Cross-References

- Approaches to Define Environmental Debt in the Framework of Sustainable Development
- Awareness Rising of Consumers, Employees, Suppliers, and Governments
- Business Environment: Emerging External and Internal Pressures for Sustainable Production
- Capability Building Through Dynamic Capabilities and Organizational Learning
- Carbon Footprints of Organizations and Products
- Circular Economy: Enabling the Transition Towards Sustainable Consumption and Production
- Cleaner Production and Technologies
- Cradle to Cradle
- Economic Growth and Long-Term Competitiveness: Contribution of the Private Sector
- Efficient Use of Natural Resources
- Greenhouse Gas Emissions
- Hazardous Substances
- Impacts on Environment and on Human Health
- Material Flow Analysis
- Material Footprint: Understanding Resource Efficiency by Considering Actual Raw Material Consumption
- Natural Capital and Ecological Ecosystem Services: Methods of Measuring Socio-economic Value of Nature
- Prevention of Wastes: Concept and Its Implementation
- Recycling of Materials for Sustainable Development: Reasons, Approaches, Economics, and Stakeholders of Recycling
- Responsible Consumption in Anthropocene
- Reuse, Reduce, Recycle
- Supply Chain Management
- Sustainability Assessment Through Internalization of Environment and Society
- Social Aspects of Sustainability

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Integrated Assessment

▶ Sustainability Assessment and Reporting of Companies

Interaction

▶ Stakeholders' Dialogue and Engagement

Internal Business Environment

▶ Business Environment: Emerging External and Internal Pressures for Sustainable Production

Internally Oriented Values and Sustainable Behavior

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Definition

Internally oriented values are individual human values substantially characterized as self-oriented and development-oriented values of an individual possessing a strong sense of self-motivation and believing in his ability to control himself, his life, and his ambiance. People having internally

oriented values are convinced that they do set their priorities and goals themselves and do make their best effort to reach those goals. People with externally oriented values are convinced that the achievement of any goals mainly depends on others and on the external complex and hardly foreseeable events. Individuals with internally oriented values are more likely to have sustainable behavior and more inclined to sustainable consumption, as they believe that their individual actions may impact the environment.

Introduction

The sciences continue the studies of values which show that: (1) values are the most abstract element of social cognition and differ from norms, personal traits, needs, and attitudes; (2) values are developed in people by adulthood, and, though rather stable during the life of a person, they may alter, for example, under the influence of the changes in social values in general; (3) values may influence any aspects of a person's behavior including consumer behavior, though however, an assumption exists and is being developed that the situational context or broader cultural social structures may transform or mitigate such influence; (4) individual values may be divided in internally oriented values and externally oriented values, which helps to explain many aspects of human behavior including consumer behavior.

Concept of Values

According to E. Durkheim (Gofman 1995), society itself is the supreme value and it generates a set of values that are adopted by its members and taken as a basis of their further behavior.

A value is a concept of something personally or socially preferable, something that people worship and believe to be a priority (Wuthnow 2008). "A value is an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence" (Rokeach 1973, p. 5). Values may be regarded as "broad motivational goals that transcend specific situations, serve as guides to behavior and as criteria for judging people and events. Values are ordered hierarchically according to their importance. Each value is defined by the goals towards which it is directed, that is, the motivation it expresses" (Sortheix and Schwartz 2017, p. 2). Values are often considered as the most abstract ideals of societies and individuals, the superior rules concerning the most important things (Kahle and Chiagouris 1997).

Values Impact on Behavior

Values can determine behavior, including consumer behavior. Once internalized, values start to influence an individual's behavior (Rokeach 1979). However, not all of the scientists share this point of view and believe that people can use the commonly established notions of values, after the performance of actions, and that a person's behavior depends on the extent permitted by the regulatory and material environment rather than on such person's deeply held values (Geels et al. 2015; Warde 2017; Wuthnow 2008).

There can be obstacles hindering the achievement of a person's goals: even a conscious consumer may face difficulties related to incomplete understanding of some information or to the pressure of prevailing norms, when using sustainable consumption values in a specific choice of goods (OECD 2017). For example, consumers tend to consider sustainable consumption as one of the vital social issues but at the same time, their daily behavior may not comply with their values, as sustainable products are more expensive and harder to procure, or due to their personal habits, or due to the fact that others do not buy them (Vringer et al. 2015).

Therefore, it is necessary to introduce changes in the environment that would cover the maximum number of factors. As an example, in respect of sustainable consumption this may be a reduction of pure technologies price (United Nations 2012), i.e., a combination of wider opportunities and an appeal for economic (pragmatic) values. For instance, households that pay for the volume or weight of

garbage, produce 20–30% less waste. Similarly, the lower the prices are, the more consumers are inclined to buy organic food (OECD 2014).

It may be necessary to combine the influence on intrinsic motivations and values with broader effect (Stern 2008). According to A. Warde (2017), the consumer behavior is less influenced by the notions of rationality, personal values, and self-expression and more by individual habits and routine repeated actions along with stable socially organized practices and the influence of a group on an individual. Thus, taking into account that personal habits are developed in a material context, such material context surrounding the individual should be gradually changed (Warde 2017).

At the same time, individual values can influence one's behavior, including consumer behavior (Miles 2015; Schwartz 2017a). For example, highly environmentally concerned people more frequently recycle wastes and use public transport, spend more to buy organic food and animal welfare-labelled products, and demonstrate more energy and water-saving behaviors (OECD 2014; Serret and Brown 2014). Values are often regarded as one of the core concepts for the understanding of consumers (Beatty et al. 1985; Kahle and Chiagouris 1997; Kamakura and Novak 1992; Madrigal 1995; Vyncke 2002; Wikström 1997; Wikström et al. 2016) who buy, possess, and use products largely to fulfil their values (Holbrook 1999a, b; Kahle and Kennedy 1988).

Although researches continue to study conflicts between values and behaviors often arising in reality, as R. Wuthnow put it, "the influence of values on behavior remained evident in study after study: people with conservative values voted Republican, people with religious values attended religious services, people with altruistic values did volunteer work, and so on" (Wuthnow 2008, p. 337).

The scope of studies devoted to values demonstrates the importance of values for the understanding of human behaviors: studies of personal values initiated by scientists such as G. Hofstede, R. F. Inglehart, S. H. Schwartz, are followed up in 100 countries, along with minor research conducted throughout the world.

Sustainable development, and consequently, sustainable consumption are dependent on material, infrastructural, and regulatory factors, as well as on the promotion of values more compatible with sustainable consumer patterns and lifestyles (United Nations 2012; World Commission 1987; World Economic Forum 2013). Values may be considered as important determinants of lifestyle (United Nations Environment Programme 2016; Vyncke 2002).

For an individual those things are more attractive that protect his/her personal valued goals (Schwartz 2017b), so the individual will be more inclined to sustainable behavior if the related actions are oriented to the satisfaction of the individual internal values.

Concept of Internally Oriented Values

Personal values are divided in internally oriented values and externally oriented values.

Such division in two categories is based on the theory about the locus of control proposed by psychologist J. Rotter (1966). The locus of control is defined as generalized expectations of people about reinforcement (reward, gratification) to be received. It is the level at which the individual thinks that the reward is attributed to his/her personal actions or characteristics vs. the reward is controlled by external forces and may arrive regardless of his/her actions. The belief that a person has control over the possibility to receive a reward is the belief in the internal control, while the faith in the external control is the conviction of an individual that his/her personal effort hardly influences the possibility to receive a reward which rather depends on complex and uncontrolled forces. The reward itself is perceived as something beyond his/her control, and the success of his/her behavior is determined only by good luck, fate or powerful others (Rotter 1966). Meanwhile "it seems likely that the individuals at both extremes of the internal versus external control of reinforcement dimension are essentially unrealistic" (Rotter 1966, p. 4).

The locus of control tends to manifest itself in challenging and new situations, as externals understand that they have skills that may be rewarded in a certain situation (Rotter 1992). The development

of a personality into a mainly internally or mainly externally oriented personality depends on the regularity and predictability of reinforcement in childhood (Mearns 2018; Rotter 1966).

Internally oriented individuals believe that they can control themselves and their environment and make greater effort to cope with the environmental and personal problems, and they strive for achievements and appreciate the reward as a compensation for their own effort rather than as a good chance (Lefcourt 1981; Rotter 1966).

Internals consider the events of their life as resulting from their own actions and, accordingly, they believe that they can control such results. For example, medical service consumers with an internal locus of control feel younger, socially and physically active, and their family is more important for them than for the externals (Goldsmith 1995).

L. R. Kahle (1983) ascertained that people's values were related to the locus of control (Homer and Kahle 1988) and identified and developed the nine basic human values so that they could embrace both more fundamental values and pragmatic values important in the day-to-day life and related to lifestyle and consumption (Kahle 1983; Kahle et al. 1999).

L. R. Kahle (Gurel-Atay et al. 2010) established that internally oriented people are capable of developing internally motivated, or oriented, values (to the extent permitted by the external social structures), assuming that such people are more likely to determine the criteria of an adequate behavior themselves. Internals believe that they have obligations towards themselves and not towards others (Gurel-Atay et al. 2010). Their personality is characterized by a more stable Self with an independent inner-directed identity; they are oriented to the development of their skills, thoughts, and senses and are more straightforward in communication (Kahle et al. 1999; Weeden 2014). Externals are more likely to evaluate themselves as they think others evaluate them. As regards their self-development, they are more focused on such external factors as their status, roles, and relations with others. They are more inclined to consider themselves as a part of a group and comply with its rules and expectations, adjust to and share the group's values; they are more concerned about the others' views and the enhancement of their image in the others' eyes (Kahle 1996; Kahle et al. 1999; Orth and Kahle 2008).

Respondents pointing out certain values as the core values in their life differ from each other and their values differ depending on the significance of the internal factors, or the Self, and the external factors for the value fulfilment (Kahle 1996).

Individuals with internally oriented values believe that they can control the value fulfilment and that such fulfilment to a lesser extent depends on external forces and other people. Individuals with externally oriented values are convinced that their value fulfilment is to a lesser extent under their control, and the achievements based on such values are to a greater extent influenced by others (Limon et al. 2009).

Internally oriented values include: (1) self-respect (brief description: "to be proud of yourself and confident with who you are" (Limon et al. 2009, p. 34)), implying that it can be achieved by oneself, characterized by smaller need in conformity, better personal internally oriented harmony, satisfaction with oneself and the environment (Kahle 1986, 1995a, b); (2) self-fulfilment ("to find peace of mind and to make the best use of your talents" (Limon et al. 2009, p. 34), and "I feel I did my best and I am satisfied" (Beatty et al. 1993, p. 56)), implying a high estimation of achievement and the quality of life; (3) sense of accomplishment ("to succeed at what you want to do" (Limon et al. 2009, p. 34)) strongly connected with self-respect, hard work, and competition; has a strong element of achievement, and though less frequently stated among the most important values, might be a significant secondary value. It is slightly less internally oriented than self-fulfilment and often related to conspicuous consumption. It is more often stated by people who have achieved much and have a good income (Gurel-Atay et al. 2010; Kahle 1995a, b; Kahle and Kennedy 1988; Kahle et al. 1986, 1999).

Externally oriented values include: (1) being well respected ("to be admired by others and to receive recognition" (Limon et al. 2009, p. 34)); (2) warm relationships with others ("to have close

companionships and intimate friendships" (Limon et al. 2009, p. 34)) which is more frequently stated by friendly women having lots of friends (Kahle 1996); (3) sense of belonging ("to be accepted and needed by family, friends and community" (Limon et al. 2009, p. 34)) associated with stronger conformity and dependency than the previous one. People choosing the two latter values are similar in demographic criteria and in receiving psychological benefit from relationships with others, but the former are better adjusted and the latter manifest stronger neuroticism and stress (Kahle 1985); (4) security ("to be safe and protected from misfortune and attack" (Limon et al. 2009, p. 34)) is also an externally oriented value as it is associated with concern about external factors such as unemployment or delinquency.

L. R. Kahle distinguished two other values: fun and enjoyment in life ("to lead a pleasurable, happy life" (Limon et al. 2009, p. 34)) and excitement ("to experience stimulation and thrills" (Limon et al. 2009, p. 34)). These two values may be both externally and internally oriented, as people sometimes can fulfil them by themselves and sometimes in conjunction with others.

The internal orientation of personal values may also be classified as follows.

D. Riesman (1950) analyzed the inner-directed type of personality. In this concept, the source of the internal orientation is the type of society that early instills in its members the set of values and goals to strive for during their lives. Thereafter an individual is not too much concerned about the messages received from external forces, be it media or other people. Such society is characterized by the expansion of production, markets, people, and discoveries, thus requiring self-motivation of its members to solve any emerging problems by themselves. The main values here are property, power, money, fame, knowledge, and virtue (Riesman 1950).

Values oriented to the inner world of an individual or to end-states related to the person's inner dimension were presented by M. Rokeach (Tuulik et al. 2016). Among them, the scientist stated self-focused or self-centered, and not other-focused or society-centered values such as: a comfortable life, an exciting life, a sense of accomplishment, happiness, inner harmony, pleasure, salvation, self-respect, and wisdom (Tuulik et al. 2016).

Internally oriented values are also similar to a number of values on the continuum developed by S. H. Schwartz. Values associated with self-enhancement represent person-focused values, which highlights the orientedness to personal interests and success, and self-transcendence values are connected with social-focused objectives of others' welfare and interests (Sortheix and Schwartz 2017). The self-enhancement values, such as self-direction (independent thinking and choice, creativity), may be in line with self-respect and self-fulfilment by L. R. Kahle; and the value of achievement (personal success) by S. H. Schwartz – with the sense of accomplishment (Kahle et al. 1999).

Intrinsic motivation is also associated with the motivation to act in accordance with internalized values to get internal satisfaction with the activity (Stern 2008). An internalized value is a value that, once adopted by an individual, is considered as his/her personal value intrinsic to his/her personality. The difference between intrinsic motivation and extrinsic motivation consists in the sense implied by the latter – performance for the achievement of an external result, a reward, social appreciation from a reference group. Behavior may sometimes be oriented towards a third person's benefit without expecting any external material reward or social appreciation but rather as fulfilment of an internal value. For example, a farmer with such outer-directed self-concept may behave environmentally friendly, if he/she thinks that his/her neighbors will highly appreciate such practices, while a farmer with inner-directed self-concept will (if he/she shares environmental values) feels rewarded merely by the fact of his/her pro-environmental behavior (Quinn and Burbach 2008).

Finally, to understand the difference between self-oriented and other-oriented values, an important division was offered by M. Holbrook: if an individual does something for others because he/she likes it, such action will be self-justifying and other-oriented at a time, but not self-oriented or selfish (Holbrook 1999a). Basing on the estimates of self-orientation and other-orientation,

M. Holbrook (1994, 1999a, b) developed a concept of consumer values, i.e., values related to the evaluation of consumer goods or experience by the consumer.

A self-oriented value is associated with high evaluation by the consumer of a product or experience as a source of satisfaction of self-interest, "for my own sake" (Holbrook 1999b, p. 11); for the effect the personal experience has on the consumer. Other-oriented values are associated with such consumer aspects that are out of one's Self concept – starting from the family and up to the galaxy, i.e., with other-oriented value sources, when the consumer likes something "for their sake" (Holbrook 1999b, p. 11), for the sake of the effect on and the reaction of others. Such consumer value is more socially and other-oriented (Wikström et al. 2010). Consumer self-oriented values are: play (fun), aesthetics (beauty), and excellence (quality). Other-oriented values are: esteem (reputation, materialism, possessions), status (success, impression), ethics (virtue, morality, justice), and spirituality (faith) (Holbrook 1994).

If an individual has internally oriented values, this does not necessarily mean that such individual is an introvert and does not care about others, the environment or society. For example, surveys showed that, first of all, people with internally oriented values are more often members to a greater number of different unassociated groups (and they are less sensitive to norms, expectations, and manipulations of others) (Orth and Kahle 2008), and people with the externally oriented value of security show more introversive behaviors (Hofstede and McCrae 2004). Secondly, although internally oriented values are more popular in the West where obedience is not a priority and achievement, and quality of life and choice of lifestyle are valued higher (Minton et al. 2018b), while in collective cultures identity depends on the membership in certain groups often not being an independent choice of a member and group activities are usually valued higher (McCarty and Shrum 1994), i.e., externally oriented values are more often in priority, – the value of commitments to others was higher in developed Western countries (Vignoles et al. 2016). Thirdly, the conviction of individuals having inner locus of control, that their actions can influence the environment (McCarty and Shrum 2001), positively associate the internally oriented values with the environmentally responsible behavior.

Individual and social aspects are indispensable aspects of human life in any society (Vignoles et al. 2016). At the same time, some studies have found that subjective well-being may be to a greater extent positively associated with internally oriented values, especially when the aspiration for the achievement of the underlying goals is based on intrinsic or innate psychological needs (Schwartz and Sortheix 2018). Internal value-based behavior may involve an individual in volunteer (not obligatory or externally controlled) work with others based on personal, self-oriented interests. The development of personal traits and interests is positively associated with the sense of satisfaction with one's life rather than with depressive feelings (Sortheix and Schwartz 2017). At the same time, aspiration for fulfilment of externally oriented values may be associated with the sense of anxiety, depression (Kahle and Kennedy 1988), and negative feelings of concern about the opinion of others or about the possibilities to coordinate with others for a long time, which is important in a situation of uncertainty (Schwartz and Sortheix 2018; Sortheix and Schwartz 2017). The motive to rank such values high exists when an individual is missing something. In general, when people have better personal, financial security and conditions for self-development, more of respect and are less dependent on others, such people are less inclined to consider values such as security, being well-respected and sense of belonging as important (Gurel-Atay et al. 2010).

For example, among the millennials (born in 1979–1996) in UK in 2017, 46% wished to have a wide circle of friends and felt externally pressed to look better (compared to 30% of the population of any age with the same opinion), and 82% of millennials stated that having influence over society is an indicator of success (68% of the population of any age believing the same). Thus, the respondent age category demonstrated a higher, as compared to the population in general, share of externally oriented value associated with the sense

of belonging. At the same time, 52% of the same age group suffered from stress as compared to 43% of the population in general (Schuller 2017).

Generally, the internally oriented value such as self-respect prevails in the USA, Venezuela, and Denmark, and self-fulfilment in France. A sense of belonging prevails in Germany, Norway, and Russia (Kahle et al. 1999).

Internally Oriented Values and Consumer Behavior

The studies showed a positive association between externally oriented values and neuroticism, anxiety, greater dependence on the opinion of others and need in external respect, and internally oriented values showed a positive association with extroversion. Thus, as for travel consumption, externals are more likely to choose group tours to secure and known destinations, highly prized and popular with large group of tourists. People with internally oriented values are more likely to choose an independent, sports-related, or adventurous voyage (Madrigal 1995; Stinson et al. 2015).

Internally oriented individuals like to present gifts for they enjoy the process of choosing and presenting, and externals appreciating, for example, warm relationships with others, present gifts rather to prove their friendly attitude (Beatty et al. 1993).

Generally, an internally oriented individual usually makes consumer choice based on his/her inner sense of what suits him/her best and is affordable financially (Kahle 1995a, b).

Thus, people adherent to the value of self-respect show more care about their health in the consumption issues. Self-fulfilment is associated with consumer values such as quality, convenience, or fun. The excitement and fun and enjoyment group contains the greatest number of fashion leaders, i.e., elegance consumers. The value of security is associated with consumption for self-indulgence, quality, and convenience (Kahle 1996). Consumers motivated by the security value are less involved in consumption of new unknown products (Kamakura and Novak 1992).

As externals highly appreciate conformity, they are more likely to purchase things due to the visible social benefits they represent (brand, style, expensiveness, i.e., thing visible to others) that may be appreciated, as externals believe, by the relevant group, rather than due to their useful properties (Kahle 1996). Internals are inclined to choose brands associated with positive emotions and high quality (Limon et al. 2009).

Individuals with internally oriented values tend to control the majority of aspects of their life including food, and consequently spend more to buy natural food as it is good for health (self-respect associated directly with the tendency to self-care) (Homer and Kahle 1988), and generally show responsible consumption as they more often act in favor of their ethical principles (Weeden 2014).

At the same time, people with prevailing selfish or self-interest values may also show concern about the environment, as they understand its influence over them and over those people they care about (Dietz et al. 2005), or when environment-responsible behavior is in line with their personal benefits, for example, demonstrative sustainable consumption may ensure others' appreciation (Dam van 2016). Thus, it may be useful to demonstrate to such externally oriented consumers that the responsible behavior can raise the respect of others, to involve them in sustainable consumption. Generally, marketing proposes to promote sustainable products subject to the ultimate values of different consumer segments. For example, solar batteries for the externally oriented value of security may be associated with the motive of independence from energy suppliers and for the internally oriented value of self-respect with the contribution in the environmental protection (Kahle and Gurel-Atay 2015). Individuals with internal locus of control are easier to persuade: it is sufficient to remind them that their actions will be really useful for the environment (McCarty and Shrum 2001).

A number of studies have found a positive association between the internally oriented values and certain aspect of sustainable consumption.

Thus, the value of self-direction has been positively associated with more fair trade and organic products purchases (Balderjahn et al. 2018). In Norway, the association has been identified between the value of self-realization and close

relationships, religion, self-development, good health and security, and environmental responsibility (Syse and Mueller 2015).

Individuals stating self-direction and achievement as their principal values, usually bought more success indicators, but at the same time donated more to environmental organizations and ate more brown rice and whole wheat bread (Kamakura and Novak 1992).

The internal locus of control is positively associated with environmental concern and better treatment of nature. Internals believe that they can maintain environmental protection by taking part in local strategies, unlike externals, who may be anxious about the environmental issues but tend to believe that others are more responsible for it (Pavalache-Ilie and Unianu 2012).

People with the internally oriented value of self-fulfilment have been found considerably positively associated with self-perfection, environmental consciousness, ecologically friendly consumption, including the choice of sustainable products and recycling (Fraj and Martinez 2006).

Environmentally friendly products, i.e., those products that have a minimal impact on the environment, may be more expensive. Still, it is not their price or the level of income of buyers but another important predictor of such purchases that has been identified in UK among older consumers: such consumers considered self-respect as their principal value. In Japan such indicator was the value of being well respected, as social opinion is more important in this country in general (Riley and Kohlbacher 2015).

On the one hand, researchers have fixed a growth in the sustainable consumption value. Generally, people show environmental awareness and consciousness and tend to buy green brands and organic products (Paço do and Raposo 2009; Paço do et al. 2013; Wikström et al. 2016): in 2018, 17% of global consumers were concerned about global issues, wished to consume products with green labels, products of higher quality and durability, and believed that their consumer behavior could "make a difference" (Shridhar 2018, p. 3).

On the other hand, the real behavior may be less associated with sustainable daily purchases and practices as people often believe that the government or organizations (i.e., "others") shall take the environmental issues under their control (Fraj and Martinez 2007), which may be an indicator of globally expanded externally oriented values.

Besides secular internally oriented values, researchers have identified the influence of religious values over sustainable consumption: religiousness has turned out to be highly positively associated with sustainable consumption and the latter with better subjective well-being (Minton et al. 2018b).

Religiosity can be divided in external and internal types. Internal religiosity is the extent to which an individual has self-motivation towards the internal spiritual connection and an inner desire to know more about the religion. External religiousness is a set of external actions associated with the religion, for example, participation in collective religious rituals. People with strong external religiosity showed higher levels of materialism and aspiration for the achievement of a higher status. Both internally and externally religious consumers demonstrated a higher level of sustainable consumption – external behavior. However, people having stronger internal religiousness were more concerned about the environment which meant that the environmental values were more important, or core, for them, and individuals who were at the same time highly internally and externally religious, were strongly inclined to responsible consumption both at the level of values and at the level of behavior (Minton et al. 2018a) (Table 1).

Conclusion

Sustainable Development Goal 12 is to ensure sustainable consumption and production patterns. Sustainable consumption and production is about promoting resource and energy efficiency while improving well-being and allowing for the regeneration of natural resources on which human life and biodiversity depend. The implementation of the SDG 12 targets, such as efficient use of natural resources, reduce food losses and waste generation through prevention, reduction, recycling, and reuse (United Nations 2019) depend on

Internally Oriented Values and Sustainable Behavior, Table 1 Personal values and consumer behavior

Dimension	Value	Characteristics	Consumer behavior
Internally oriented values		Values can be fulfilled without depending on others; more individual control over all aspects of life, including value fulfilment; less demand for external approval, less sensitive to expectations of others; obligations towards yourself; choosing your own goals Active in structuring internal self-perceptions People with prevalent internally oriented values are more often members to a greater number of different groups	Take experts' advices in order to make a consumer choice Look for the best ratio quality/price Prefer high-quality brands and brands linked to positive emotions Strive to control the health and the food they consume, concern about nutrition and food additives, consequently, spend more money on natural food, buy it more often and prefer natural food brands In travel consumption would prefer independent, sports-related or adventurous voyage Perform environmentally responsible behavior and consumption as a result of the belief that individual's actions can influence the environment It is efficient to remind that their actions will be really useful for the environment
	Self-respect	To be proud of yourself and confident with who you are Better personal internally oriented harmony, satisfaction with oneself	Know social expectations very well, but make consumer choice based on the inner sense of what suits him/her best and is affordable financially Frequent motives of purchases, among other: social identity, care about the health, importance of nutrition to the individual health Give presents because it feels good, and gifts reflect the receiver's taste Read more than individuals who less highly endorse this value, but prefer group sports less and hunt or fish less More than the others buy goods that contribute to the least amount of environmental damage (green products) Irrespective of what anyone else thinks, they know the importance of acting in environmentally friendly way Would perform sustainable consumption through understanding that individual actions make a difference in the world and contribute to the environmental protection
	Self-fulfilment	To find peace of mind and to make the best use of your talents "I feel that I did my best and I am satisfied" A high estimation of achievement and the quality of life Especially young professionals	In purchases important are: quality, convenience, patriotism, self-indulgence, quality, brand loyalty and fun Like to attend the movies, ski, but hunt or fish less Are highly environmental conscious consumers, strive for self-perfection, and environmentally friendly consumption/behavior, including the choice of sustainable products, natural food and recycling
	Sense of accomplishment	To succeed at what you want to do This value is strongly connected with Self-esteem, work hard and competition Has a strong element of achievement It is more often stated by people who have achieved much and have a large income It is less frequently stated among the most important values, but might be a significant secondary value	Often related to conspicuous consumption People who highly endorse this value are less influenced by friends on choice of leisure activities, and they entertain, drink, listen to music, dance and play games less May make sustainable consumer choices along with understanding that their actions would make a difference in the world or if they would be in line with conspicuous consumption
	Internal religiosity	Internal desire to know more about religion, self-motivation towards the internal spiritual connection	Highly associated with sustainable consumption, and the environmental values are more core values

Externally oriented values		Values fulfilment in many respects depends on others and beyond the control of individual; belief in strong external forces' influence on their lives; rely more on fate and luck; high conformity to the social and role demands; more susceptible to the normative influence of others; communal obligations Rely mainly on the influence of others to structure the social identity Feel externally pressed to look better	To receive information about products from others and to follow others' advices The desire to comply with others' expectations about one's purchases Consumer choices concerned with social approval The importance of enhancement of the image in the opinion of others by buying goods and displaying brands The importance of visible social benefits (fashionable brands, company reputation, style, price), i.e., display aspects of clothing/thing rather than utilitarian properties To give presents due to social norms, and the gift selection is based more on grantor's taste In travel consumption they are more likely to choose group tours to secure and known destinations, highly prized and popular among tourists May be concerned about the environmental issues but tend to believe that others are more responsible for it
	Being well respected	To be recognized or admired by others Individuals with larger incomes	Frequent motives of purchases, among other: quality, company reputation, patriotism, social identity, health, brand loyalty Have less hobbies Sustainable consumption can be motivated by demonstrating that the responsible consumption can raise the respect of others
	Warm relationships with others	To have close companionships and intimate friendships Sociability Psychological benefit from relationships with others Often these are friendly women having lots of friends Better adjusted	Importance of patriotism and advertisement in consumer decisions Give presents mainly to show and receive friendship, and give gifts for "no occasions" more May buy sustainable products if it gives opportunity to bond with others
	Sense of belonging	To be accepted and needed by family, friends, and community Sociability Psychological benefit from relationships with others, but demonstrate stronger stress Stronger dependency, feel of belonging to their family, being possessions of their family Tendency to comply with the culturally dominant attitude, may be in order to feel like part of the dominant culture	Importance in consumer decisions of patriotism, nostalgia, brand, health, company reputation, family, and home In leisure activities prefer attending movies and cultural events, sports and hobbies

(*continued*)

Internally Oriented Values and Sustainable Behavior, Table 1 (continued)

Dimension	Value	Characteristics	Consumer behavior
	Security	To be safe and protected from misfortune, attack and poverty/unemployment More introversive behaviors	Purchases often motivated by self-indulgence, quality, convenience, nostalgia Less consumption of new unknown products More inclined to watch sports events than engage, and have many hobbies, also hunt and fish more If promotion may be associated with the motive of independence from energy suppliers, they may choose eco-friendly and independent source of energy
	External religiosity	External actions associated with the religion	Highly associated with sustainable consumption
Mixed values		Can be both externally and internally oriented Can be fulfilled sometimes by individuals themselves, and sometimes with others Possess both internal and external characteristics, but closer to the internal dimension	
	Fun and enjoyment in life	To lead a pleasurable, happy life	More often than average would choose sport coupe They are usually fashion leaders and elegance consumers Prefer natural food More control over their leisure activities Prefer more sports and other activities in their life
	Excitement	To experience stimulation and thrills	Prefer sports, including group sports, swimming, jogging They are usually fashion leaders and elegance consumers Prefer natural food

Sources of table: Beatty et al. 1985, 1993; Fraj and Martinez 2006; Gurel-Atay et al. 2010; Hofstede and McCrae 2004; Homer and Kahle 1988; Kahle 1985, 1986, 1995a, b, 1996; Kahle and Gurel-Atay 2015; Kahle and Kennedy 1988; Kahle et al. 1986, 1992, 1999; Kamakura and Novak 1992; Limon et al. 2009; McCarty and Shrum 2001; Minton et al. 2018a, b; Orth and Kahle 2008; Pavalache-Ilie and Unianu 2012; Riley and Kohlbacher 2015; Schuller 2017; Stinson et al. 2015.

sustainable practices at the production level (but only this will not be sufficient to lower environmental impact) as well as on shifts in consumption patterns that need to be made sustainable (United Nations Global Compact 2015).

Consumer behavior depends on a number of factors, from laws and infrastructure to personal circumstances, needs, or values. All these factors require transformation in order to shift consumer behavior to more sustainable consumer patterns. Along with the needful for sustainable development transformation of business, social, and material infrastructure, the changes may be necessary in consumer values in favor of more sustainable lifestyles and practices, especially in such domains with the highest environmental impact as food, housing, mobility, and purchases (e.g., to buy products with a lower environmental footprint).

In this context, there are two main approaches. The first assumes that the day-to-day human behavior is little related to the abstract values, and this is the material environment surrounding the individual that should be changed in order to promote behavioral changes and to achieve the SDGs (United Nations Environment Programme 2017). The second approach tends to attach more importance to the values. It supposes that it is harder to achieve sustainability without touching upon values, and that for sustainable development it is necessary to promote proper values that would keep consumer standards in line with the ecological possible (United Nations 2012; World Commission on Environment and Development 1987).

People with the mainly internal locus of control of reinforcement regard the events of their lives as the results of their own acts, while individuals with external locus of control more often think that external uncontrolled forces influence their lives. That is why internals are oriented towards the development of their skills and tend to develop internally motivated, or oriented, values and goals, and actively strive for them. Externals often have as a priority externally oriented values and goals implying that their achievement depends mainly on other people and forces.

People with a belief in internal control are more responsible for their health and they think that their actions can impact the environment, and this fact connects internally oriented values with sustainable (consumer) behavior.

Although externally oriented values are associated with belief that other people or institutions are responsible for the environment, they also can be tied to sustainable consumption. Since externals highly value group conformity, it may be useful to demonstrate to them that the responsible consumption can raise the respect of others.

The influence of the external conditions on human values is great, although much is unknown and the studies are in progress. The formation of a mainly internal or a mainly external personality depends on the predictability of reward in childhood. School and workplace are also very important and efficient sources of values.

Personal values may be considered as representations of wider social values, and individuals may follow and reflect these social values if they are changing (Kahle 1986). While maintaining universal human values and diversity of lifestyles and values, the shift in external conditions and environmental issues, the necessity to take into account human well-being and the resource needs of future generations may cause the need to adjust to these challenges of sustainable development and to shift values to sustainable consumption values. Especially, taking into consideration accumulated knowledge on values' transformation that may affect new generations' values.

Cross-References

- ▶ Awareness Rising of Consumers, Employees, Suppliers, and Governments
- ▶ Code of Conducts: Catalyst for Sustainable Consumption and Production
- ▶ Improving the Quality of Life of Urban Communities in Developing Countries
- ▶ Mass Market and the Rise of Consumption
- ▶ Middle-Class Consumers and Consumerism as a Lifestyle
- ▶ Perceived Consumer Effectiveness
- ▶ Sustainable Consumer Lifestyles/Sustainable Consumption

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