# Science and technology in the framework of the sustainable development goals

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## Abstract

**Purpose** – In September 2015, the UN member states approved an ambitious agenda toward the end of poverty, the pursuit of equity and the protection of the planet in the form of 17 Sustainable Development Goals (SDGs) and 169 targets. The purpose of this paper is to raise a concern about the context and framework that science, technology and innovation have in the finalized text for adoption that frames the SDGs especially regarding environmental degradation. The authors argue that emphasizing technology transfer in the agenda has the risk to do not recognize other technological alternatives such as eco-technologies, and endorse a limited vision of the role of science and innovation in the achievement of the SDGs. Science for sustainability has to go further than technology transfer, even questioning the limits of the current patterns of intensive use of natural resources and inequity in consumption. By discussing the historical backgrounds of this paradigm and elaborating on the role of science to achieve sustainability in a broader sense. It is in these terms that inter- and intra-discipline and the roles of researchers in sustainability transitions acquire relevance.
**Design/methodology/approach** – Although many theories regarding human development are in place and under discussion, the dominant view, reflected in the UN agreement, is that the progress of a country can be measured by the growth in the per capita gross domestic product. This variable determines if a society is able to reduce poverty and satisfy its basic needs for present and future generations (Article 3: United Nations (UN), 2015). Progress and economic growth in several aspects of human development has been substantial over the past 40 years. However, at the same time, the state of the environment continues to decline (UNEP, 2012). The obvious inquiry of these opposing trends is whether progress irremediably comes at the cost of environmental degradation. In 1972, the Club of Rome's report entitled "Limits to growth" (Meadows *et al.* 1972) confronted the viability of perpetual economic growth. The report alerted of the impossibility of endless growth in population and production in a finite planet (Gómez-Baggethun and Naredo, 2015). The essay forecasted future crises of food and energy if the population and economic growth continued to grow at the same rate of the first half of the twentieth century. Nevertheless, the catastrophic projections were not met, mostly because of great advances in agriculture, water and energy technologies.
**Findings** – The SDGs constitute a relevant international recognition of the importance of the three edges of sustainable development. However, the pathways toward the achievement of the SDGs need to fully recognize that poverty, inequalities and global environmental problems are expressing a deeper crisis in the shape of economic growth, patterns of production and consumption and, in general, the logic of no limits in the exploitation of natural resources (Sheinbaum-Pardo, 2015). For this reason, the science of sustainability requires a deep understanding of the technological change and that technology is not the only approach toward sustainability.
**Research limitations/implications** – The paper reflects a conceptual discussion of the narrow vision of science and technology in the SDGs and their UN framework. The most important objective in the UN documents is technology transfer. This has the risk to do not recognize other technological alternatives such as eco-technologies, and endorse a limited vision of the role of science and innovation in the achievement of the SDGs.
**Practical implications** – An important discussion of the key points regarding SDGs is developed.
**Social implications** – "Transforming our world: The 2030 agenda for sustainable development (UN, 2015)" presents a narrow vision and a limiting role to the science of sustainability. Moreover, if these issues are not recognized, the achievement of the SDGs will continue to gain only marginal success.
**Originality/value** – It brings out a very important discussion of the role of science and technology in the ambitious UN agenda of the SDGs.

**Keywords** Technology, Sustainable development goals, Science, Limits
**Paper type** Conceptual paper

World Journal of Science, Technology and Sustainable Development
Vol. 14 No. 1, 2017
pp. 2-17

2042-5945
DOI 10.1108/WJSTSD-04-2016-0030

## 1. Introduction

One of the key outcomes of the United Nations Conference on Sustainable Development (Rio+20), held in Rio de Janeiro in June 2012, was the agreement among the member states to launch a process to develop a set of sustainable development goals (SDGs; United Nations, 2012). Following a route of inter-governmental negotiations and based on the proposal of the open working group on SDGs, the member states agreed on a finalized text for adoption called "Transforming our world: The 2030 agenda for sustainable development (UN, 2015)."

The text of the SDGs constitutes an ambitious agenda toward the end of poverty, the pursuit of equity and the protection of the planet. In contrast to the Millennium Development Goals launched in 2000, the SDGs show empathy in the three dimensions of sustainable development, i.e., the economic, social and environmental aspects, in a future vision that engage all of the countries of the world. Nevertheless, there are certain concerns about the SDGs and the finalized text for adoption. For example, the International Council for Science and the International Social Science Council (2015) raised the concern that the SDGs are presented in "silos" with the danger of conflict among different goals and even trade-offs between overcoming poverty and moving toward sustainability. Namely, an action to meet one target could have unintended consequences on other goals if they are pursued separately.

In addition to the concern about the inter-linkages among SDGs in this paper we raised another important concern very much related to the how and the means to achieve the SDGs, and it is the context and normative framework that science, technology and innovation (STI) have in the finalized text for adoption, as well as in SDG 17th (Table I).

In the resolution adopted by the UN General Assembly on SDGs, the main focus of science and technology is "promoting the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries" (target 17.7) and the creation of "technology facilitation mechanisms (TFM)" (Article 70) to enable knowledge and technology transfer. Although this emphasis is important, it strongly supports the ideas that science operates only for the development of technology, which limits its role in the sustainable development vision and exalts technology transfer from north to south. It is interesting to note that in the finalized text for adoption (UN, 2015) that consists of 29 pages, the word culture appears five times, the word science appears ten times, and the word technology appears 36 times.

In this paper, we elaborate on the role of science for sustainability in a broader sense, beyond science for technology innovation and transfer. Under this context we recall that science is a human activity and that the choices we face are not only technological but mainly societal ones. In this view, the question of how to achieve the SDGs is indivisible with the SDGs themselves and, therefore, philosophical, social and economic sciences as well as other sources of knowledge must contribute as much as the natural and technical sciences toward an approach where the quality of life and sustainable patterns of

| Targets | |
|---|---|
| 17.6 | Enhance north-south, south-south and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism |
| 17.7 | Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favorable terms, including on concessional and preferential terms, as mutually agreed |
| 17.8 | Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology |

**Table I.** Targets regarding technology SDG 17th consumption and production can reconcile to reduce the environmental degradation, poverty and inequalities (MacKenzie and Wajkman, 1985; Asara *et al.*, 2015; Institute for Development Studies, 2013; Wittmayer and Schäpke, 2014; Kläy *et al.*, 2015).

The narrative of this paper presents four sections in addition to the introduction. Section 2 revises the role of SDI in the text of the UN resolution. Section 3 provides a critical historical background on the contemporary assumptions of the role of science and technology. Next, a revision of technology and the ecological limits of growth are presented. In Section 5, throughout a literature review of the complexity of the achievement of the 17 SDGs, we elaborate on the need to a broader assumption of STI, and show how technology transfer is a very narrow vision of the means toward sustainable development. The last section presents some conclusions.

## 2. SDG 17th and means of implementation

The resolution adopted by the General Assembly on September 25, 2015 (A/70/L.1) "Transforming our world: the 2030 Agenda for Sustainable Development" is divided in five main segments: Preamble and definitions; Declaration; Sustainable Development Goals and targets; Means of Implementation and the Global Partnership; and Follow-up and review. The core of the document is the definition of the 17 SDGs and their 169 targets. SDG 17th is on strengthening the means of implementation and revitalizing the global partnership for sustainable development. Targets of SDG 17th are divided in five segments: Finance; Technology; Capacity Building; Trade; and Systemic issues (that include policy and institutional coherence; Multi-stakeholder partnership; data, monitoring and accountability). Regarding technology, SDG 17th has three targets (Table I).

In addition, in the section of Means of Implementation, the UN (2015) agreement launched the TFM[1], that will be based on a "multi-stakeholder collaboration between Member States, civil society, the private sector, the scientific community, United Nations entities and other stakeholders and will be composed of a United Nations inter-agency task team on science, technology and innovation for the SDGs a collaborative multi-stakeholder forum on science, technology and innovation for the SDGs and an online platform."

Although target 17.6 and the TFM mentioned science and innovation, the main focus of the document is on technology transfer. Even the fact that science and innovation is not considered as the principal mean but as part of technology, shows the vision of the SDGs framework in the sense that regarding STI, technology transfer is the principal mean for sustainable development.

Placing technology transfer as the main resource toward the achievement of the SDGs limits the role of science and innovation toward sustainable development. The risks of this orientation are at least on three areas that historically have been already questioned: conceive science and technology as if they were a power outside of societal and political decisions; disregard that there are ecological limits of growth that technology transfer cannot solve; neglect the role of social sciences, humanities, and different sources of knowledge and minimize the role of other echo-technological approaches (Ortiz-Moreno *et al.*, 2015) toward the achievement of SDGs. In the next sections, these concerns are discussed. Even in the case of firms, technology transfer is part of component toward sustainability as discussed in Schneider (2014) and Hahn *et al.* (2015).

## 3. Historical background on the vision of science and technology

There is a predominant view that science is a human activity dedicated to understand nature and "reveal its language and laws" (Pinch and Bijker, 1987, p. 18). This approach has led us to conceive science and technology as if they were a power outside of societal and political decisions (MacKenzie and Wajkman, 1985, p. 7) that enables people to intervene in and alter the world (Ozolina *et al.*, 2009, p. 9). Probably, this view started with Plato (428-348 BC) who thought that mathematics was a special way to learn about the universe, and a language that did not require the involvement of the senses. For Plato (2005) numbers were ideas that had the characteristic of being eternal and the best of all; they did not demand the need of senses to establish accurate knowledge.

A few centuries after this Greek philosopher, Rene Descartes (1596-1650 BC) proposed his ideas, most of which reminds us of those of Plato. As the latter, Descartes also believed that the senses were not a truthful way of knowing the material world: Descartes was convinced that he had to think of a method that could guarantee the achievement of truth. Today we know it as the scientific method. This methodical guide was grounded in mathematics: "There is no more than one truth for each thing in mathematics. The one who finds it knows all that there is to know about it […] the method teaches how to follow the right and true order of things. It also enumerates with precision all of the circumstances that you are looking for and it confers the certainty of the arithmetic rules" (Descartes, 1999, 2013).

This perspective about science was the predominant view for a long time and was even accentuated with the enlightenment, where "after the work of Copernicus, Kepler, and Galileo, the Newtonian philosophy gave us nothing less than the coordinates for constructing the coordinates of reality" (Thiher, 2001, p. 13). In other words, the world established by the mathematical language constituted the cornerstone of our representation of reality. It seems that science was an external object and objective of construction that human beings use for the purpose of knowing the truth.

Contrary to this thinking, Giambattista Vico stated that science is a human construction. Even mathematics, the eternal and perfect language that Plato and Descartes claimed as the way of reaching the truth, is a human construction. It is as subjective as any other human way of understanding the world and, as any other subjective knowledge, it is anchored to the subject that is using and constructing it. Science is another way that human beings use to understand the complex and chaotic world that surrounds us (Vico, 1984).

To follow the argument above, we also should say that everything that is constructed or achieved in the name of science necessarily responds to human interests. There is no partial or disinterested knowledge; all of it comes from a subject, from an individual or a group of individuals who have a particular history. This history or path moulded their way of thinking and approaching the world. It also influenced the interests, inquiries and pursues that they will pursue in the name of science. Thus, we believe that the scientific knowledge is not intention free.

Likewise, it is fundamental to recognize that technology, made from scientific knowledge, can never be neutral. As Hebert Marcuse (1987) explains "progress is not a neutral term, it moves toward specific goals and these goals are defined by the possibility of improving human conditions" (p. 38).

Theodor Adorno and Max Horkheimer (1987) in the Dialectic of Illuminism sustain that: "What man wants to learn about nature is the way to use it to achieve the integral dominion of nature itself and of mankind" (p. 16). Therefore, technology is not only the way of dominating nature, but it has also become the way of dominating humans. It is time that we re-evaluate our relationship with nature and our conception of progress. This particular conception has dire consequences, for example, the destruction of the environment, as we know it and an economic system that only displays the inequality and dominion of man over man.

We could argue that if scientific knowledge is a social construction, then it is possible to assume that there is nothing epistemologically special about the nature of scientific knowledge. This statement does not disregard the importance to promote and develop STI. We want to emphasize that understanding the epistemology of science helps us to clarify that the choices we face are societal choices, not "scientific" or "technical" ones. Hence, the STI for sustainable development offers immense opportunities to reciprocally connect science with society, culture and traditional knowledge.

## 4. The benefits and limits of technology innovation and transfer

In 1972, the Club of Rome's report entitled "Limits to growth" (Meadows *et al.*, 1972) confronted the viability of perpetual economic growth. The report alerted of the impossibility of endless growth in population and production in a finite planet (Gómez-Baggethun and Naredo, 2015). The essay forecasted future crises of food and energy if the population and economic growth continued to grow at the same rate of the first half of the twentieth century. Nevertheless, the catastrophic projections were not met, mostly because of great advances in agriculture, water and energy technologies.

In agriculture, for example, the so-called green revolution and the post green revolution led the developing world to witness a period of food crop productivity growth. Although the population had more than doubled, the production of cereal crops tripled during the last 50 years, with only a 30 percent increase in cultivated land area (Pingali, 2012). However, the increase in agriculture productivity had consequences on the water use and soil degradation that affected at the end not just affect the natural environment but also the yields (Foley *et al.*, 2005).

In the case of energy, a decoupling between energy consumption and GDP growth was achieved in developed countries due to energy efficiency technologies. Between 1973 and 1985, the total energy use per capita in OECD countries decreased by 6 percent, while per capita GDP increased by 21 percent (Goldemberg, 2004). However, in spite of the achievements in energy efficiency, the fossil fuel consumption increased and nowadays is the main cause of greenhouse gas (GHG) emissions that lead to the increase in the surface temperature of the planet (Intergovernmental Pannel for Climate Change (IPCC) 2013).

These examples show the larger benefits of technology innovation, but also its limits. This apparent contradiction brings out a more general discussion on the ecological limits to both, economic and population growth and the role of technology. For these reason, Turner *et al.* (1994) recall the precatory principle in the sense that even if it is not certain that there are limits to growth, it would be prudent to behave as if there were to prevent or, at least, reduce major environmental damages that could seriously affect human well-being.

Several authors have proposed alternative theories and pathways to pursue human well-being and protect the environment, such as the steady-state economy (Daly, 1973, 1996, 2010; Jackson, 2009), the new economics of prosperity, or even the economy of degrowth (NEF, 2009; Schor, 2011; Nørgaard *et al.*, 2010; Odum and Odum, 2001; Rees, 2006; Victor, 2010; Kallis *et al.*, 2012; Martinez-Alier, 2009, 2012; Martinez-Alier *et al.*, 2010; Scott-Cato, 2009). More recently, the UNEP (2011) defined a green economy as the one that results in "improved human well-being and social equity while significantly reducing the environmental risks and ecological scarcities."

It is not the goal of this paper to discuss the difference of these approaches, but to recognize that there is an important international dialog and debate on how to transform the global and national economic systems into a pathway that recognizes the importance of poverty eradication, social equity and environmental protection for present and future generations, besides technology.

The underlying debate on the limits of growth is probably to understand that, besides technology, the reconciliation between nature and development needs to question the entire conception of progress and development, as we know it today. As the Mexican philosopher Luis Villoro notes, humanity has to stop seeing nature as a tireless exploitable object. We need to understand it as a never-ending source of revelations and as a worm dwelling (Villoro, 1993).

## 5. The need for a broader vision of STI, means and policies for the SDGs

Asking the right questions is the essence of good science (Lévi-Strauss, 1987). Some of the underlying questions of the decoupling between resource consumption and development are how to promote social welfare with limited resources? and how to enhance human development and reduce environmental degradation? These are, of course, part of the core of the international debate on sustainable development, and they are far from being solved. What is essential to recognize is that there are different questions and answers for different regions and countries that exceed the aspect of the technological transfer.

Under this background, literature revision shows different orientations toward the achievement of SDGs that we propose to group in four major areas: (a) technology transfer to ensure that scientific and technological developments are accessible to a wider range of users; (b) eco-technologies defined as the use of technological means for ecosystem management based on deep understanding of principles on which natural ecological systems are built and on the transfer of such principles into ecosystem management (Straškraba, 1993; Funtowicz and Ravetz; 1995; Ortiz-Moreno *et al.*, 2015); (c) inter-disciplinary science approach defined by the National Academies' (2004) report as a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice (Kaufmann and Cleveland, 1995; Rotmans and Loorbach, 2009; Scholz and Steiner, 2015); and (d) socio-economic policies, which refers in this analysis to public policies that are not necessarily related to technology innovation and transfer; and finally we include an additional area related to (d). Encounter visions that expose that there is no consensus but a scientific discussion on the visions to achieve some of the SDGs (Table II).

In the following sub-sections we discussed the 17th SDGs in the context of the five areas proposed above, according to literature review. Table II presents a qualitative expression of these review.

### *5.1 End of poverty and food security (SDGs 1 and 2)*

An open discussion of different scientific disciplines is dedicated to study poverty (Sen, 1981, 2011). It is not our objective to review them in this paper, but to link them to the discussion of food security. It is clear that meeting the world's future, the food availability must grow substantially while the activities that provide it shrink their environmental footprints considerably and adapt to climate change (Foley *et al.*, 2005; UNEP, 2011; UN Department of Economic and Social Affairs (UNDESA), 2013). Some of the transformations in agriculture, livestock and fisheries production that are desirable to reach food security are:

- The change in production technologies and methods toward halting agricultural expansion, closing "yield gaps" on underperforming lands, increasing cropping efficiency by shifting from heavy mechanized with intense use of water, inorganic pesticides and fertilizers to organic systems and precision agriculture and improvements in livestock management in order to reduce pasture area (echo-technologies); still there is an important discussion on the impacts of technology that even reach genetically modified organisms and food security (encountered visions) (Foley *et al.*, 2005; UNEP, 2011; UNDESA, 2013; Reddy *et al.*, 2016).
- Recognize the complexity of production systems within diverse social and ecological contexts (inter-disciplinary approach).
- Shift from high-input industrial farming and large vessels to traditional systems run by small farmers and fishers to produce the majority of stable crops and animal protein needed to feed the world population. This will require secure land rights, good governance, greater commercialization and integration of small farmers and fishers into supply chains with infrastructure development (socio-economic policies) (UNEP, 2011).

| Goal | Technology transfer | Echo-technologies | Inter-disciplinary approach | Socio-economic policies | Encountered visions |
|---|---|---|---|---|---|
| 1 End poverty in all of its forms everywhere | + | + | +++ | +++ | +++ |
| 2 End hunger, achieve food security and improved nutrition and promote sustainable agriculture | + | +++ | +++ | +++ | +++ |
| 3 Ensure healthy lives and promote well-being for all at all ages | +++ | ++ | +++ | +++ | +++ |
| 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all | + | + | +++ | +++ | +++ |
| 5 Achieve gender equality and empower all women and girls | + | + | +++ | +++ | + |
| 6 Ensure availability and sustainable management of water and sanitation for all | +++ | +++ | +++ | +++ | + |
| 7 Ensure access to affordable, reliable, sustainable and modern energy for all | +++ | +++ | ++ | +++ | ++ |
| 8 Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all | ++ | ++ | +++ | +++ | +++ |
| 9 Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation | +++ | ++ | +++ | +++ | + |
| 10 Reduce inequality within and among countries | + | + | +++ | +++ | +++ |
| 11 Make cities and human settlements inclusive, safe, resilient and sustainable | +++ | ++ | +++ | +++ | + |
| 12 Ensure sustainable consumption and production patterns | +++ | +++ | +++ | +++ | +++ |
| 13 Take urgent action to combat climate change and its impacts | +++ | ++ | +++ | +++ | + |
| 14 Conserve and sustainably use the oceans, seas and marine resources for sustainable development | +++ | ++ | +++ | +++ | + |
| 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 | ++ | +++ | +++ | +++ | +++ |
| 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 | + | + | +++ | +++ | +++ |
| 17 Strengthen the means of implementation and revitalize the global partnership for sustainable development | + | + | +++ | +++ | +++ |

**Notes:** + means less important; +++ means more important

**Table II.**
Qualitative importance of technology, inter-discipline, policies and visions in the discussion of achievements of the SDGs

- Adoption of more sustainable diets and reduction of waste. On average, the number of kilograms of cereal needed to produce one kilogram of meat ranges from 2 to 1 for poultry and from 7 to 1 for beef. On the other hand, approximately one-third of the total food produced for consumption, amounting to 1.3 billion tons per year, is lost or wasted (Food and Agriculture Organization of the United Nations, 2012; UNCCD, 2011), and about 30 percent of total harvested food does not reach the marketplace as a result of quality selection and cosmetic considerations (UN, 2013; Institution of Mechanical Engineers, 2013). Policies to amend this non-sense have to be one of the main objectives of a new food and agricultural model (socio-economic policies).

### *5.2 Education, health and gender equity (SDGs 3, 4 and 5)*

Provide inclusive and equitable quality education at all levels, and provision of health care is related to access to energy and technologies, but clearly, this SDGs are related highly to public policies in high-, medium- and low-income countries, as well as other means such as access to finance for infrastructure especially for LDCs. SDG related to gender equity is also clearly related to other means, besides technology transfer.

### *5.3 Water and energy (SDGs 6 and 7)*

Around 600 million people lack access to drinking water and about 35 percent of the world population do not have improved sanitation facilities, with poor rural population being the most affected. It is estimated that at any given time, over half of the world's hospital beds are filled with people suffering from water-related diseases (United Nations Development Programme (UNDP), 2006; United Nations Environmental Programme and United Nations Development Programme, 2012; Pruss-Ustun *et al.*, 2008; Olmstead, 2010). In this case, technology access is clearly an important variable of the equation, but knowing that most of the water goes to irrigation; echo-technologies are again an important element to agriculture productivity (Ortiz-Moreno *et al.*, 2015). Also water appropriation (Hoekstra and Mekonnen, 2012) and water governance (Bogardi *et al.*, 2012; Cook and Bakker, 2012; Pahl-Wostl *et al.*, 2013) represent an important challenge to water accessibility (socio-economic policies).

By 2010, around 15 percent of the World's population lacked access to electricity and about 29 percent of the World's population relied on the traditional use of biomass. There is a wide consensus that the eradication of extreme poverty as well is linked to the access of modern energy, especially electrification (UN, 2005). In 2010, the IEA and the UNDP developed an assessment on universal access to energy. Results were remarkably interesting. According to this study "to meet the more ambitious target of achieving universal modern energy services by 2030, additional investment of $756 billion or $36 billion of US dollars per year is required. This is less than 3 percent of the global energy investment in the new policies scenario of IEA to 2030. The resulting increase in primary energy demand and $CO_2$ emissions would be modest. In 2030, global electricity generation would be 2.9 percent higher, oil demand would have risen less than 1 percent and $CO_2$ emissions would be 0.8 percent higher, as compared to the new policies scenario[2]" (International Energy Agency (IEA), 2012).

The paths to a low-carbon economy to reduce GHG emissions are highly related to the access of more efficient and renewable energy technologies. However, even in this case, technology transfer is not the only variable of the equation, but also other technological approaches. But even more, technology efficiency has physical limits ruled by the second law of thermodynamics. At some point, the following question arises: is technology efficiency enough to meet the very ambitious emission reduction targets proposed by climate scientists? According to Allwood *et al.* (2013), in the case of industrial energy, within the present conditions of material substitution and technology efficiency it is simply not possible. According to these authors, the world is reaching the efficiency limits for certain industrial technological processes, and the ambition to reduce industrial emissions can only be attained through an increase of material efficiency which includes recycling and re-using components, but also reduction of overall material demand by promoting longer life of products as well as intensifying its use (UNDESA, 2013).

*5.4 Economic growth, employment and industrialization (SDGs 8 and 9)*

A deeper discussion on this matter is presented in Section 4. But in this case a large discussion that involve economic sciences, social sciences and even philosophical and ethical inquiries are in place. In this special case, there are encountered visions. One vision to the apparent contradiction between economic growth and environment argues that setting up the right signals to the market, internalizing externalities and strengthening property rights will solve this predicament. Based on historical data on agriculture yields and energy intensity, this (rather dominant) school of thought postulates that if a stock of non-renewable resources is consumed, technological innovation and price signals will prevent shortages. "As a resource becomes scarcer, the rising of relative prices mean higher potential profits for innovators and for the owners of assets that can be substituted for the diminished scarce resource" (United Nations Development Programme (UNDP), 2011). This idea leads to the approach that focuses on the total capital stocks (sum of physical, human and natural) and the possible substitution between production factors (Turner *et al.*, 1994; UNDP, 2011).

Another school of thought raises the limits of this approach by questioning the validity of the perfect substitution. Certain basic natural assets have no real substitutes and, thus, must be preserved. This perspective sets biophysical limits to the growth of economic activities in view of the irreversibility of certain processes that have triggered an impact on nature (United Nations Economic Commission for Latin America and the Caribbean *et al.*, 2003). These encountered visions are open discussions that certainly go beyond technology and technological transfer.

*5.5 Inequalities (SDG 10)*

If unequal distribution of income is maintained, a greater increase in GDP is needed for the poor to get access to better incomes because the economy has to fulfill the requirements of the highest income groups (United Nations Economic Commission for Latin America and the Caribbean (ECLAC) *et al.*, 2002; Rosas *et al.*, 2010). A study for Latin America shows that even very small reductions in inequality can have very large positive impacts in terms of poverty reduction (ECLAC *et al.*, 2002). In the horizon of the ecological limits of growth, equity acquires an additional value for the environment. Boyce *et al.* (2007) go even further when he proposed that wider political and economic inequalities tend to result in higher levels of environmental harm.

However, the 2011 HDR shows that income inequality has deteriorated in most countries and regions – with some exceptions in Latin America and Sub-Saharan Africa, although these regions continue to be the more unequal region and the poorest region in the world, respectively, (UNDP, 2011). Technology access could be important in the reduction of inequalities; however, it is clear that other areas of knowledge that redound in policies are needed to reduce the huge inequalities within and among countries.

*5.6 Sustainable cities (SDG 11)*

The percentage of global population living in urban areas has reached 50 percent at the beginning of the twenty-first century and is expected to reach 60 percent by 2030; the fastest rates of urbanization are found in the developing world (UNHabitat, 2013). Jenks and Jones (2009) suggest that there are four dimensions of the sustainable city: land use and build form, environmental conservation, environmental recycling and reuse, and communication and transport. The IPCC chapter (2013) on human settlements, infrastructure, and spatial planning proposes regulations, integrated spatial planning and implementation that go beyond technology transfer, in order for cities to mitigate climate change and be more resilient to climate change variability (Solecki *et al.*, 2013). Again, technology transfer is a small part of the agenda toward sustainable cities.

### *5.7 Sustainable consumption (SDG 12)*

According to the ecological footprint it would take three to four Earths to meet the consumption demands of the current human population, if every human consumes at the level of the average US inhabitant (Wackernagel and Rees, 1996; Wilson, 2002); and GHG emission will reach 3.8 times actual emissions if population in developing countries uses the same amount of fossil fuels per capita that developed countries use (IPCC, 2007). Technology has enabled growing efficiency of resource use, but it has its limits and unsustainable lifestyles with excessive consumption of energy, materials, and goods among the richer segments, place enormous pressure on the environment (Allwood *et al.*, 2013). The poorer segments, meanwhile, are unable to meet food, health care, shelter and educational needs. Changing consumption patterns will require focusing on demand, rather than only in technology transfer, meeting the needs of the poorest, and changing lifestyles and excessive material and energy demands of the richest. This requires building a new paradigm of success that is not based on increasing consumption.

### *5.8 Climate change, oceans, forest and biodiversity (SDGs 13, 14 and 15)*

Climate change is possibly the most dangerous of all environmental threats. Climate is changing mainly as a result of human activity (IPCC, 2013). Increased use of fossil fuels, particular industrial processes, land use change and heavily fertilized agriculture have augmented GHG emissions and their concentration in the atmosphere, leading to an increase in Earth's surface temperature with consequences on sea level, hydrological cycle, and higher presence and intensity of extreme events (IPCC, 2007; IPCC, 2013). The climate deal adopted in UNFCC COP 21 brings light to mitigate and adapt to climate change. In this case, technology transfer is highly important, however, to avoid dangerous climate change requires technological (accompanied by different regulatory and economic instruments) and behavioral changes made in many different sectors. Not one sector or technology can address the entire mitigation challenge but different technologies and measures from energy to agriculture and forest to waste management are needed in order to contribute to the total reduction of global GHG emissions (IPCC, 2007, 2013; UN, 2015).

Forests are a fundamental part of the Earth's ecological richness, and forest goods and services. Deforestation, although showing signs of decline, is still alarmingly high at 13 million hectares per year. Although net forest area loss amounts to five million hectares per year, this is a result of new plantations that provide fewer ecosystem services than natural forests (UNEP, 2011). Reduce deforestation and increase forest ecosystem services and goods is possible by promoting long-term financial, technological and training supports and policies for sustainable management that value forest goods in contrast to agriculture and livestock for land owners, promoting other activities with lesser impacts such as ecotourism and agroforestry, and valuing ecosystem services (Merino-Pérez and Barry, 2005; Fisher *et al.*, 2009; Food and Agriculture Organization of the United Nations, 2010; Toledo-Aceves *et al.*, 2011).

Concerning biodiversity loss and the changes in human activities that are linked to it, it is difficult, expensive, or impossible to reverse or fix through only technological solutions (Hooper *et al.*, 2005). The main causes of biodiversity loss are land use change (habitat change), overexploitation, pollution, invasive alien species and climate change, which is expected to become the first or second greatest driver of global biodiversity loss (Hooper *et al.*, 2005; UNCDB, 2010; Heller and Zavaleta, 2009).

Biodiversity loss is a clear example of irreversibility, not only because the permanent loss of certain species, but because it harms the ecosystem services, including the access to water and basic materials for a satisfactory life and security (Díaz *et al.*, 2006). Climate change is also an example of irreversibility because the major GHGs can remain in the atmosphere for tens to hundreds of years after being released; thus past emissions will have future impacts.

### *5.9 Peace and justice (SDG 16)*

It does not need a larger discussion to understand that peace and justice within and among countries is a human objective that requires more than technology transfer.

## 6. Conclusions

The SDGs constitute a relevant international recognition of the importance of the three edges of sustainable development. However, the pathways toward the achievement of the SDGs need to fully recognize that poverty, inequalities and global environmental problems are expressing a deeper crisis in the shape of economic growth, patterns of production and consumption and, in general, the logic of no limits in the exploitation of natural resources (Sheinbaum-Pardo, 2015). For this reason, the science of sustainability requires a deep understanding of the technological change and that science for sustainability goes beyond technology transfer especially the recognition of eco-technology innovation and promotion, inter-disciplinary approaches, socio-economic policies and the recognition of encountered visions to achieve SDGs.

As Asara *et al.* (2015, p. 381) noted in their particular discussion about degrowth, science needs to open the debate about the relations between economy, society and sustainability, including their cognitive, material and political interactions, to re-politicize the debates on science and the practice of sustainability. From our point of view, even if it does not agree with the degrowth approach, science needs to truly question the limits of growth. Under these circumstances, inter- and intra-discipline acquire relevance. Likewise, the roles of researchers on sustainability transitions (Wittmayer and Schäpke, 2014; Kläy *et al.*, 2015; Scholz and Steiner, 2015) should address that science is a human activity and that the choices we face are not technological, but manly societal and human ones.

For this reason, we believe that the finalized text for adoption, i.e., "Transforming our world: The 2030 agenda for sustainable development (UN, 2015)," presents a narrow vision and a limiting role to the science of sustainability. Moreover, if these issues are not recognized, the achievement of the SDGs will continue to gain only marginal success.

Social sciences, humanities and different sources of knowledge must contribute as much as the natural and technical sciences toward an approach where the quality of life and sustainable patterns of consumption and production can be reconciled to reduce the environmental degradation, poverty and inequalities. This approach will also lead to increasing peace and security.

Further research on the different approaches, methodologies for specific countries and regions on the need to develop new science for sustainability in an integrate vision to achieve SDGs needs to be developed.

### Notes

1. The TFM is also part of the "Addis Ababa Action Agenda of the Third International Conference on Financing for Development" held in July 2015.
2. These estimations are based on a minimum electricity consumption of 250 kWh/year in rural areas and 500 kWh/year in urban areas and 22 Kg of LPG per person per year (in comparison, average US consumption per household in 2011 was 11,280 kWh of electricity/year and 900 kg of LPG/year).

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