United Nations
Educational, Scientific and
Cultural Organization

Montevideo Office
Regional Bureau for Sciences
in Latin America and the Caribbean

FORO ABIERTO DE CIENCIAS
LATINOAMERICA Y CARIBE

Science for Sustainable Development

(Agenda 2030)

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Support:

Cooperación Española
CONOCIMIENTO / MONTEVIDEO

Publicado en 2016 por la Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura, 7, place de Fontenoy, 75352 París 07 SP, Francia y la Oficina Regional de Ciencias de la UNESCO para América Latina y el Caribe, UNESCO Montevideo, Luis Piera 1992, piso 2, 11200 Montevideo, Uruguay.

Ciencia, Tecnología & Innovación como ejes transversales de la agenda global de desarrollo sostenible e inclusivo hacia 2030

Bajo el título "Transformando nuestra región: Ciencias, Tecnología e Innovación para el Desarrollo Sostenible" el Foro CILAC 2016 está concebido como una contribución a la implementación de la Agenda 2030 recientemente suscrita por la Asamblea General de las Naciones Unidas. Desde el consorcio de instituciones organizadoras del Foro regional de América Latina y el Caribe existe el compromiso de trabajar en pos de contribuir al logro de las metas y objetivos señalados en esta Agenda.

La UNESCO es la agencia especializada del Sistema de Naciones Unidas para cinco grandes campos vitales para el desarrollo humano y sostenible: educación, ciencias naturales, ciencias sociales y humanas, cultura y comunicación e información.

Para contribuir con el avance de estas amplias temáticas en los escenarios multilateral, regional, nacional y local, la UNESCO opera a partir de cinco estrategias: a) definición de estándares internacionales; b) desarrollo de capacidades; c) organización y difusión de conocimientos (*clearinghouse*); d) catalizar la cooperación internacional; e) laboratorio de ideas.

Es precisamente bajo la última de estas herramientas estrategias – laboratorio de ideas – donde se encuentra ubicada esta serie de *Policy Papers* que ustedes tienen en sus manos.

Estos documentos, elaborados por algunos de los principales expertos en sus respectivos campos de conocimiento, buscan subrayar conceptos, ideas y desafíos clave en cinco áreas centrales para el trinomio Ciencia, Tecnología & Innovación:

- "La ciencia para el desarrollo sostenible (Agenda 2030)", por Hebe Vessuri
- "Universidades para el desarrollo", por Rodrigo Arocena y Judith Sutz
- "Educación científica", por Beatriz Macedo
- "Los ritmos de las políticas CTI y de sus paradigmas tecno-económicos / organizacionales en ALC (1945–2030)", por Guillermo A. Lemarchand
- "Políticas de Ciencia, Tecnología, e Innovación Sustentable e Inclusiva en América Latina", por Isabel Bortagaray

El concepto de Laboratorio de Ideas es particularmente relevante aquí. Estos *Papers* no buscan ser la palabra final en estás temáticas. Ellos son, principalmente, *food for thought*, una invitación de la UNESCO a todas las partes interesadas para que, en conjunto, y sin olvidar nuestras diversidades y divergencias, podamos avanzar en el debate público sobre los roles de las ciencias, tecnologías e innovación para la construcción de sociedades del conocimiento más sostenibles, democráticas, inclusivas y con amplia protección a los derechos humanos de todos y todas.

Estos textos serán publicados por primera vez en el contexto del **I Foro Abierto de Ciencias Latino América y el Caribe**, un ambiente ideal para el puntapié inicial de estos debates. Sin embargo, deseamos que sea eso, el puntapié inicial, y que estas discusiones sigan en los meses que vienen, los cuales serán centrales para el avance sólido de la implementación de los objetivos de desarrollo sostenible.

¡Muy buenos debates!

Lidia Brito,

Directora, Oficina Regional de Ciencias
para América Latina y el Caribe - UNESCO

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Summary Statement

If we accept that a topic becomes an "emerging" or "new" scientific issue when the scientific community considers it important, then on several accounts of scientific opinion, expert involvement, and other standard views, the idea that the continued functioning of the Earth system as it has supported the well-being of human civilization in recent centuries is at risk is one such issue. If serious action is not forthcoming, the implication is that we could face additional threats to water, food, biodiversity and other critical resources: these threats risk intensifying economic, ecological and social crises, creating the potential for a humanitarian emergency on a global scale. The 2012 *State of the Planet Declaration* is a significant milestone in this enhanced awareness.

We have come to recognize that our increasingly interconnected and interdependent economic, social, cultural and political systems have placed pressures on the environment that may cause fundamental changes in the Earth system and move us beyond safe natural boundaries. But the same interconnectedness provides the potential for solutions: new ideas can form and spread quickly, creating the momentum for the major transformation required for a truly sustainable planet. The defining challenge of our age is to safeguard Earth's natural processes to ensure the well-being of civilization while eradicating poverty, reducing conflict over resources, and supporting human and ecosystem health.

Elaborating agendas for science for sustainability in the year 2030 is not day-dreaming or imagining open futures. Although the heavy lines of continuity with the recent past and the present are difficult to change, there is always change and transformation. The United Nations System have engaged in efforts toward achieving sustainable development until 2030 and beyond. Fifteen years is a short period when we look at the way science changes. So, the 17 Sustainable Development Goals and 169 Targets in the United Nations Document *Transforming Our World: The 2030 Agenda for Sustainable Development* (2015) seek to build upon the Millennium Development Goals and complete what they did not achieve. The agenda may be seen as contributing to a road-map for policy action in areas of critical importance for humankind and the planet.

Context and Importance of the Problem

Within 15 years, imagine an increasingly urban world of more than 8 billion inhabitants, with the population growth still concentrated in the less developed regions struggling to provide for even their current population. This soaring world population will put further pressure on already scarce resources of water, food and energy, potentially leading to increasing levels of poverty and conflicts. New technological advances will be required to overcome limitations in food production, to ensure sustainable energy resources, and to meet the medical needs of a growing and aging population. In spite of medical advances and vaccination campaigns, infectious diseases and global pandemics will remain a serious threat while there will be an increased prevalence of chronic diseases associated with aging and sedentary lifestyles. As though this were not challenging enough, climate change mitigation and adaptation, fighting pollution, preserving natural habitats, and maintaining a high level of biodiversity will demand global action, in the unpredictable economic and political climate of the future.

> "The defining challenge of our age is to safeguard Earth's natural processes to ensure the well-being of civilization while eradicating poverty, reducing conflict over resources, and supporting human and ecosystem health.

Progress in science and technology will continue to be a major force shaping social and economic development. On the other hand, society plays a major role in influencing the research agenda, in facilitating or impeding the conduct of science through funding decisions under strained public finances, and in promoting or obstructing international collaboration. Our highly interconnected global society has the potential to innovate rapidly. A new paradigm of science for sustainability has been acquiring

greater importance. The international scientific community must rapidly reorganize to focus on global sustainability solutions. We must develop a new strategy for creating and rapidly translating knowledge into action, in a new contract between science and society, with commitments from both sides. "As consumption accelerates everywhere and world population rises, it is no longer sufficient to work towards a distant ideal of sustainable development. Global sustainability must become a foundation of society. It can and must be part of the bedrock of nation states and the fabric of societies" (*State of the Planet Declaration* 2015).

> The agenda may be seen as contributing to a road-map for policy action in areas of critical importance for humankind and the planet.

Trust in science and the credibility of scientists in the eyes of the public and decision-makers are crucial for science to flourish and have an influence on policy. However, they have been impaired by a powerful attack characterized by denial of climate change and ideological fixation on 'free markets' and self-deception by industrialists, bankers, financiers, and government "regulatory" agencies linked to the carbon-combustion complex, in the name of employment, growth and prosperity. While there is knowledge about what is happening, human society seems unable to stop it. Indeed, the most startling aspect of the situation is how much people know and how unable they seem to be to act upon what they know. Clearly, knowledge does not simply translate into power.

In order to positively modify the organisational culture, for rationalizing the institutional ecosystem responsible for formulating, monitoring and evaluating science, technology and innovation policy and policy instruments, and in order to improve governance with all it involves in terms of political stability, government effectiveness, and control of corruption, the nexus between the natural sciences, the social and economic sciences is crucial. The scale and ambition of the new Agenda requires a revitalized Global Partnership to ensure its implementation, working in a spirit of solidarity, especially with the poorest and the people in vulnerable situations. Governments, the private sector, civil society, the United Nations system and other actors need to be brought together mobilizing all available resources. Each country is primarily responsible for its own economic and social development, but guided by the global level of ambition. Thus, public finance, both domestic and international, will play a key role in providing essential services and public goods and in catalysing other sources of funding. The diverse private sector from micro-firms to cooperatives to multinationals, and civil society organizations and philanthropic organizations all have a role in the implementation of the Agenda 2030.

Observable Megatrends related to the Sustainable Development Goals and Targets

Considering a number of observable megatrends related to the Sustainable Development Goals (SDGs) is a relevant exercise.

The **demographic** trends *can be delineated* fairly well over the next 15-20 years. By 2030, the world population is projected to surpass 8.3 billion people. Most of the total growth will enlarge the population in less developed regions, with a rise from 5.6 billion in 2009 to 7 billion in 2030. Sub-Saharan Africa, which contains most of the poorest countries in the world, is projected to experience more than a 50 percent increase in population (SDG 1). In contrast, the population of more developed regions is expected to change minimally, further widening the gap between poor and rich nations. The 2030 population will be more urban than ever before. Over the next two decades, the **urban population** is projected to grow steadily to around 60 percent of the world population, with most of the growth in the less developed regions. Generally, the urban areas are expected to absorb all the global population growth, and to draw in some of the rural population. Rapid urbanization, in particular fast growth of large cities and the associated slum areas, poses specific challenges includ-

ing transportation, unemployment, poverty, access to clean water and sanitation, environmental degradation and pollution, and related health issues (SDG 11, 8).

Globally, the prevalence of **age-related health challenges** is on the rise. In the more developed regions, the population aged 60 years or over is expected to increase by 40 percent over the next two decades, rising from about 21 percent of the population in 2009 to almost 29 percent in 2030. The older population of the less developed regions is projected to more than double, with a rise from about 8 percent of the population in 2009 to more than 14 percent in 2030. Although the population of all countries is **aging**, the population will remain relatively young in countries where fertility is still high. The youngest populations will be found among the least developed countries, mostly in Sub-Saharan Africa. Rapid population growth coupled with a youthful age structure pose challenges for the provision of education, employment, and health and social security services. Overall, **the nature of health problems will change**. Population aging will result in significant increases in most **non-communicable diseases**, in particular cancers. The four leading causes of death globally (including low-income countries) in 2030 are projected to be ischaemic heart disease, cerebrovascular disease (stroke), chronic obstructive pulmonary disease and lower respiratory infections (mainly pneumonia). In low-income countries the fight against a number of widespread and deadly **communicable diseases**, including acute respiratory infections, diarrhoeal diseases, tuberculosis, malaria, measles and AIDS, continues. Widely spread epidemic diseases and global pandemics remain a threat, in part due to ill-managed population growth in the urban environments of the developing world. (SDG 3).

> "The nexus between the natural sciences, the social and economic sciences is crucial.

Population growth and continued urbanization will heavily increase pressure on **ecosystems** (SDG 6, 14, 15). Numerous **ecosystem services** that we depend on, are already being degraded or used unsustainably, including capture fisheries and water supply. As of today, species are becoming extinct at the highest rate since the last global mass-extinction event. The **conversion of land to agricultural uses** continues to be the main factor threatening **biodiversity**, but in some regions other factors, such as the **build-up of nitrogen and phosphorous in rivers**, lakes and coastal waters, **ocean acidification** and potential effects of **climate change**, are becoming increasingly important, also with serious consequences to human health. Most published environmental change scenarios project continuing high levels of **extinctions** and ***loss of habitats***, with associated decline of some ecosystem services important to human wellbeing. If ecosystems are pushed beyond certain ***thresholds or tipping points***, there is a high risk of dramatic biodiversity loss and accompanying degradation of a broad range of ecosystem services. **Ecological degradation** is not the same as resource scarcity. The resources available to humankind increase constantly, and it is likely that they will continue doing so. This is the reason why catastrophic prophecies of resource scarcity are probably misplaced. Instead, fear of an ecological degradation is too well founded. The future can see Homo sapiens achieving control over a cornucopia of new materials and energy sources, while simultaneously destroying what remains of the natural habitat and leading to extinction of most of the remaining species. In fact, ecological disorder can risk the very life of Homo sapiens.

The importance of understanding and tackling **problems of governance and safety** are illustrated by developments with genetically modified crops, nano-technology, xeno-transplants, the expropriation of human genes by patenting, private-enterprise eugenic engineering The structural features of the global knowledge economy force governments into contradictory roles, acting both as promotors of global business enterprise in the knowledge sector but also as regulators on behalf of a sophisticated and mistrustful public that demands safety. As technology becomes more sophisticated in its manipulation of both biological and electronic information, the possibilities for unexpected

effects ramify beyond control. Questions about safety may seem paradoxical and pose new challenges in the management of uncertainty, ignorance and danger (SDG 16).

Total ***food production*** has increased by about two-and-a-half times while the number of people in the world has more than doubled since 1960. However, this has been partly at the cost of other ecosystem services. And, regardless of the increased food production, we are struggling to feed the global population. The recent increase in food insecurity was not a result of decreased food production but because high food prices and lower incomes have reduced access to food. In 2009, a little over one billion people were undernourished worldwide. To feed the ever-growing population, the food production needs to increase by 40 percent by 2030. This creates a major challenge over coming decades. In an increasingly urban world, new technologies will be needed to grow more from less land, with fewer hands. At the same time, climate change and increased biofuel production represent major threats for long-term food security (SDG 2, 5).

Insufficient and polluted ***water supplies*** remain pressing concerns in many regions, along with inadequate resources and capacities to manage this resource. Today, 13 percent of the world's population live without access to improved drinking water, and 39 percent without access to improved sanitation. In the absence of adequate policy and governance actions, almost half of the global population in 2030 is projected to live in areas of high water stress. Agriculture is the largest consumer of freshwater; 70 percent of all freshwater withdrawals go to irrigated agriculture. As over the coming decades the food demand further increases, improved water use efficiency will be needed to ensure adequate food production and supply. The combined impact of global changes, including population growth, urbanization and climate change, pose enormous pressure on freshwater systems, while increasing the risks from floods and droughts (SDG 6, 12).

There is a marked increase in the demand for commodities from the ***mining and metals*** industries. A critical issue is the geographical distribution of resources. Thus, the supply is particularly vulnerable to changes in geopolitical-economic frameworks. Additionally, many known reserves are located in developing regions with unstable political conditions and where a lack of infrastructure poses challenges for extraction, processing and transportation. The exploitation of natural resources in the Polar Regions is an area of increasing debate (SDG 9, 10).

Over the coming years, ensuring ***global energy security***, meeting the growing energy needs of the rising economic powers of the developing world, as well as facing climate change and other environmental issues will be the main concerns in the energy sector. With current technologies, continued reliance on fossil fuels would likely have critical consequences for climate change, acidification of land and water and human health. In the absence of policy changes and energy supply limitations, the world energy demand is projected to rise by 40 percent by 2030, with non-OECD countries accounting for over 90 percent. China and India alone represent about a half of the incremental demand and thus fossil fuels are projected to remain the dominant source of energy worldwide. However, in a country like Germany, with Europe's second highest consumer electricity prices, the public support for its *energiewende*—an aggressive transition to renewable energy—is at an impressive 92 percent. The support is rooted in an eco-friendly culture, a collective desire to abandon nuclear energy, and laws that allow citizens to profit from selling their energy to the grid. Roughly 27 percent of Germany's electricity in 2014 was from renewables; the goal is at least 80 percent by 2050 (SDG 7, 13).

The population of 2030 will create new massive demands for **transportation**. Over the coming years, personal and goods transport will grow rapidly, driven primarily by rapid economic growth in the developing world. The necessary transport infrastructure, however, is developing more slowly, generating traffic congestion, pollution and high accident rates. Road traffic accidents are expected to rise from the ninth leading cause of death globally in 2004 to the fifth in 2030. In the absence of policy changes, the total number of light-duty vehicles is projected to increase from an estimated

650 million in 2005 to about 1.4 billion by 2030. Most of this increase comes from non-OECD countries, with China alone accounting for almost one-third of the global increase in cars. Currently, transport accounts for nearly one-quarter of global energy-related CO2 emissions. Given the current trends, transport energy use and CO_2 emissions are projected to increase by almost 50 percent by 2030. Cleaner fuels and more efficient vehicles will be critical in the shift towards sustainable transportation (SDG 11, 13).

The future is ***warmer***. Until 2030, a warming of about 0.2°C per decade is projected for a range of emissions scenarios. Afterwards, temperature projections are increasingly dependent on specific emissions scenarios. Warming is expected to be greatest over land and at most high northern latitudes, and least over the Southern Ocean and northern North Atlantic, continuing recent trends. Warming will reduce the resilience of many ecosystems, increase the risk of species extinctions, aggravate stress on water and food resources, and possibly increase the number and intensity of extreme weather patterns. The less developed regions are particularly vulnerable and Africa is likely to be the most vulnerable continent, partly because the adaptive capacity in Africa is relatively low due to limited resources and governance, with conflicts exacerbating the situation. While at mid- to high latitudes the food production might even increase, at lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases. Over the coming years, in some African countries, yields from rain-fed agriculture could be reduced by up to 50 percent. This, combined with rapid population growth in the already energy and food-insecure areas, could have disastrous consequences with a number of climate change related conflicts and refugees (SDG 13, 12).

The trends in Latin America

Latin America progresses towards the attainment of the Sustainable Development Goals (SDG) facing unique challenges and opportunities.

The reduction of **poverty and extreme poverty** became accentuated in the 2002-2012 period, both in absolute and relative terms. Poverty decreased on average 15.7 accumulated percentage points since 2002 (from 43.9% to 28.1%). Extreme poverty also registered a notable decrease of 8 percentage points (from 19.3% to 11.3%), although its rhythm of diminution stopped in recent years, and poverty continues to be an important challenge for the region. In 2012 and 2013 the process of poverty reduction stagnated, in a context of low world economic growth, with the end of the super-cycle of basic products, a greater inflationary pressure and a reduction of the capacity of generation and formalization of employment (SDG 1).

Inequality is a structural feature of Latin American societies. Its most eloquent manifestation is income distribution, which constitutes both the cause and the effect of other inequalities in education and the labour force. The matrix of inequality in Latin America is strongly conditioned by the productive structure. Gender, race and ethnic origin are strongly co-related to poverty, extreme poverty and vulnerability. There are also pronounced regional heterogeneities and inequalities within the countries and between rural and urban areas, and important gaps persist in all these dimensions in the region. Currently 826 **indigenous peoples**, about 46 million people, are recognized by the Latin American states, either directly in the legislation or in public policy, but also by determinants of gender, race and ethnicity that cross-cut and reinforce each other. There is also an abundant **afro-descendant population**, estimated in over 120 million people, mostly in Brazil. The majority of social indicators show that these human groups are in situations of clear disadvantage relative to the rest of the population. Due to this, it is important to recognize that ethnic and racial inequalities, together with those of gender, are crucial components of the matrix structuring social inequality in the region (SDG 10).

Gender gaps in education, employment and political representation have narrowed, i.e.,

there is evidence of a reduction in gender stratification in most countries of the world for some (though not all) indicators, a shift that has been accompanied by more equitable gender attitudes. Nevertheless, there are still wide gaps in labor market outcomes, and in a number of countries where women's employment increased, men's has declined. There is also persistent and, indeed, worsening job segregation in industrial sector employment. Although gains in political representation of women have been positive, gaps in representation remain wide. This is an important impediment to gender progress. The failure to make substantial advances in women's representation means that their life conditions and needs are not fully reflected at the national level in the distribution and allocation of public goods and expenditures. Research shows that some forms of gender inequality can slow economic growth and development. In other words, in addition to the negative effects on gender stratification on women's relative capabilities and well-being more generally, there are societal costs to continued gender inequality (SDG 5).

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Despite the advances of the so-called "won decade," workers face the absence of transformation in the productive base of Latin American countries. Nevertheless, there is broad recognition that among the social domains that produce, exacerbate or mitigate inequalities, the most decisive one is the **world of work**. The largest part of the domestic income in Latin America is generated there, as well as the inequalities in its distribution. The world of work results a fundamental space in the conception of equality, since, together with education, they constitute the central bonds of social inclusion. Improving work conditions and incomes allows advancing toward overcoming poverty and extreme poverty. The majority of people have weak and incomplete government provided social protection systems, usually dependent on their formal link to the world of work. Health care is frequently neither available nor affordable, and access to needed services can lead to poverty. Between 1990 and 2013 the participation in the GDP of resources destined to social expenditure increased approximately 38%. Taking into account that the GDP grew 49%, the resources available for the social area doubled, both at a total level as per capita. Also central to the greater availability of resources was the strong increase in the region of the weight of social expenditure in the public budget, which passed from representing between 52% and 56% of the total public expenditure to somewhat more than 65% in 2015 (SDG 8).

With regard to **education**, in view that Latin America is approaching the universalization of primary schooling the mechanisms of transmission of inter-generational inequalities has shifted towards secondary education and, increasingly towards higher education. While several countries are far from reaching the universalization of full primary education, in others, the low quality of education and the social inequalities present in both primary and secondary levels, have become a major hindrance to progress towards a greater effective equality (SDG 4).

The region enjoys a multiplicity of **natural resources**: biodiversity, hydrological systems, coasts, small island states, many of them trans-boundary and highly vulnerable to **climate change** and to extreme events with widespread effects across the region. There is a marked scarcity of programs for climate change mitigation and adaptation and very insufficient protection to endangered environments and biodiversity. In order to ensure **water security**, sound scientific knowledge is needed for the development of water laws in the many countries that still lack it, to ensure universal access to drinking water and sanitation, for the treatment of the 80% of wastewater that is directly discharged into surface and ground

waters, and for the adequate management of water resources (SDG 14, 15).

Foreign direct investments in medium-high technology tend to be destined to Brazil and Mexico, where much of it is captured by the automotive sector. But the technological content of most of South American exports has not changed and on the whole Latin America specializes in primary production. **Multinational firms** have had a fundamental role in establishing certain consumption and production patterns (including the increase in the number of automobiles), with dire consequences for the environmental sustainability of the region. Therefore, it is necessary to change their investment strategies with adequate incentives and regulations to improve the environmental impact of economic activity. FDI related to mining and heavy industry, has had a particularly damaging environmental impact in receiving countries, although the concrete effect depends on governmental regulations and how effective they are in inducing the companies to abide by the rules. Since this reflects on the weakness of the political and economic autonomy of many countries, novel agreements and new rules of the game need to be defined and respected by all (SDG 8, 17).

Governments should attempt to guarantee the coherence between the policies of FDI promotion and other policies with effects upon the environment, such as those related to energy, transport, industry and urban development. All countries in the region have **environmental policies** but these are not usually coordinated with investment promotion measures. Even so, almost two thirds of the agencies for investment promotion state that they take into account the environmental impact of FDI and, that despite their limited space for maneuver, many have programs to attract FDI according to ecological criteria, with a strong emphasis on **renewable energies**. Most Latin American countries have adopted regulatory policies and fiscal incentives to drive the deployment of renewable energy. The sector has strong opportunities for further expansion (SDG 9).

> Substantial investments are required for Latin American economies to become more sustainable from the environmental point of view.

Substantial investments are required for Latin American economies to become more sustainable from the environmental point of view. It has been estimated that up to one billion extra dollars of investment would be needed to achieve the Goals of Sustainable Development relative to actions linked to climate change, clean water and sanitation. To cover the gap, the private sector in Latin American countries will have to contribute more and multinational firms will be key to the process for they have considerable assets in the region and have the technological and institutional means required to improve sustainability. The depressed world demand of recent years has translated into an important fall in the price of primary products, especially petroleum, carbon, copper, iron, zinc, silver, nickel, gold, soy bean, cotton, sugar, coffee and fishing products. This situation affects the region strongly, given its intensive export structure in those goods and their scarce offer of products with greater technological content, whose prices have diminished less (SDG 17).

Although Latin American countries use about 5% of the world's public cloud services, less than its share of global GDP (8.3% in 2013), it is expected that these services will be adopted more quickly than in Western Europe. However, firms in Latin America face several obstacles in adopting ICTT, like high fixed costs associated with purchasing and maintaining hardware and software and adapting it to production processes, owing to limited ICT literacy in the region, and the high rates charged for the service in relation to per capita income (SDG 4, 8).

The region has had **scientific-technological growth** but it has done it at a relatively low rate and at a considerable distance from the technological frontier. One of the big challenges continues to be to develop the capabilities needed to provide effective solutions in co-production with a multiplicity of social actors. Nevertheless, it must be admitted that the institutional ecosystem, legal framework for research and incentives to innovation have

changed significantly since the 1990s, overcoming several of the obstacles that persisted since the creation of the national systems of science and technology in Latin American countries (SDG 17).

Expected Advances in Industry, Science and Technology and the SDGs

An image of the future like the one offered by the SDGs seeks to organize multi-dimensional and complex information about future possibilities into a comprehensible narrative about how the future might look like as a result of a committed solidary global partnership. Particularly, it aims to display the interrelation between biophysical, technological and socio-economic aspects and put them together in a coherent way. The assumption here is that images as this one may help the general public and decision-makers to acquire knowledge and understanding to anticipate the context in which they have to act. A basic assumption of the SDGs is that the future not only is a continuum of past relationships and dynamics but can also be shaped by human choice and action. It cannot be foreseen, but extrapolation of the future can inform the decisions of the present. There is not one possible future only. Uncertainty calls for a variety of futures mapping a 'possibility space' and the future envisaged in the SDGs has a strong conscious moral commitment and demonstrative factual support.

Thinking of international science, in what ways will scientific capability and resources, and the resulting benefits of science be distributed among nations? To what degree will the scientific agenda be set by the 'grand challenges' involved in the SDGs? Will these be global or driven by economic competitiveness? What role will scientific advice have in shaping governmental policy across a range of areas? How effective has the message from the scientists got to be to convince society and the economy to alter the catastrophic planetary path currently being followed and, simultaneously, to help bear the production of wealth needed to set the new economy going and to insure the realization of the SDGs?

> A basic assumption of the SDGs is that the future not only is a continuum of past relationships and dynamics but can also be shaped by human choice and action.

The bulk of the industries that will drive the next 15 years of change to our economies and societies, are already on course.

Robotics: A few countries have already established themselves as leading robot societies. About 70 percent of total robot sales take place in Japan, China, the United States, South Korea, and Germany-known as the "big five" in robotics. This is easy to explain. Japan is home to the biggest elderly population of any country. Today, 25 percent of Japan's population is age 65 or older. By 2020, this is projected to increase to 29 percent and reach 39 percent by 2050. Japan's Ministry of Health, Labor, and Welfare predicts the need for 4 million eldercare nurses by 2025. Right now there are only 1.49 million in the country. Much of the rest of the industrialized world is on the verge of a period of advanced aging that will mirror Japan's own. In the decades ahead, the percentage of Europe's population aged 65 and older will grow from 17 percent to 30 percent. Caretaking robots, alongside robotic limb technology, may simply be the first in a new wave of complex robots entering our everyday lives. Robots will be the rare technology that reaches the mainstream through elderly users first, spreading down as grandma shows off her next cutting-edge gadget for the kids and grandkids. The literature offers very little in terms of how this new robot economy will affect poor countries, which have a very different demographic profile.

Computers and other digital advances are doing for mental power -the ability to use our brains to understand and shape our environments- what the steam engine and its descendants did for muscle power. They are allowing us to blow past previous limitations and taking us into new territory. How exactly this transition will play out remains unknown, but

whether or not the new machine age bends the curve as dramatically as Watt's steam engine, it is a very big deal indeed. Mental power is at least as important for progress and development -for mastering our physical and intellectual environment to get things done- as physical power. However, digitation is likely to bring economic rather than environmental disruption, stemming from the fact that as computers get more powerful, companies have less need for some kinds of workers. Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead.

> We need to link high-quality focused scientific research to renewed policy-relevant interdisciplinary efforts for global sustainability.

The effects of new ***information and communication technologies (ICT)*** are many-fold and pervasive. The world is rapidly changing, as a result of these technologies. For example, mobile cellular connections in the developing countries have more than doubled since 2005, reaching an estimated 57 percent of the population at the end of 2009. Remote operation of infrastructures through the Internet, as is already done for example in astronomy, is making it possible to be present in localities otherwise not easily accessible. **High speed computing** will profoundly affect all aspects of society and the conduct of science. We may already envisage the time when international conferences, education and collaboration in general will be fundamentally changed because of the rise in, and reduction of cost, of virtual-presence capabilities.

An important recent change is the **approximation between the natural and the social sciences**. The very concept of environment is a manifestation of a historical divide that looks increasingly damaging. In separating humans from the rest of the world, the environment identified the nonhuman component as something which carried particular aesthetic, recreational, or biological value. Sometimes the "natural" environment has been distinguished from the "built" environment, contributing to the difficulty that 20th-century humans have had in recognizing and admitting the pervasive and global extent of their impact. But slowly humans have begun to recognize that they are part of their environment and dependent upon it, and that its value is more than aesthetic and recreational; that the natural world is essential for human employment, growth, prosperity, and health. These arguments, which have been commonly disparaged, began to be countered by the idea of environmental protection which contains at least partial recognition of this point.

The approach proposing planetary boundaries framework aims to help human societies by defining a "safe operating space" in which civilization can continue to develop and thrive. It does this by proposing boundaries for anthropogenic perturbation of critical Earth System processes. Respecting these boundaries would greatly reduce the risk that anthropogenic activities could inadvertently drive the Earth System to a much less hospitable state. How to maneuver within the safe operating space in the quest for global sustainability requires the combined contribution of the social and human sciences. Although the PB framework does not provide guidance as to how sustainability can be achieved, the social and human sciences are deemed relevant for working together with the natural sciences in order to provide better orientations and clues to it.

The challenges facing the planet demand a new approach to research that is more integrative, international and solutions-oriented. We need to link high-quality focused scientific research to renewed policy-relevant interdisciplinary efforts for global sustainability. This research must integrate across existing research programs and disciplines, across all domains of research as well as local knowledge systems, across the North and South, and must be co-designed and implemented with input from governments, civil society, international research funders, and the private sector. A major research initiative, *Future Earth: research for global sustainability* has emerged as part of this new collaboration.

Technological advances have been perhaps the most important driver of change in the mod-

ern era. Such change is mostly gradual and incremental, but occasionally major breakthroughs occur. While we cannot know the nature and implications of the breakthroughs in advance, there is a high degree of certainty about some that will occur over the next few years, probably in several fields. Areas of potential technological breakthroughs include *environmental and energy technologies, materials science, medical advances, genetic engineering, geo-engineering, robotics, artificial intelligence, quantum computing, space exploration, complex system science and military applications*.

> **Data monitoring and accountability: Strengthened support for observing systems, particularly in developing countries, are required.**

Converging technologies are likely to be the key in several fields potentially revolutionizing medicine, materials and manufacturing, electronics and information technology, environmental remediation applications, energy production, water purification, and other fundamentals of everyday life in the 21st century. By 2030, the pervasive influence of life sciences on engineering, e.g. synthetic biology and molecular motors, is likely to be a major feature. And over the coming years, *Global Sustainability Research*, at the core of the Agenda 2030 by the United Nations development system, will be an area of increasingly integrated focus, with natural and social sciences pulling together for new innovations and a holistic approach in answering the pressing sustainability issues.

Recommendations to Implement and Revitalize the Global Partnership for Sustainable Development

Funding: Continuous efforts have to be made to strengthen domestic resource mobilization, to insure the commitment by many developed countries to achieve the target of 0.7 per cent of the GNI for official development assistance (ODA/GNI), in coherent terms between FDI promotion and other policies with effects on the environment, to developing countries; and to encourage them to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries. It is also needed to assist developing countries to improve domestic capacity for tax and other revenue collection and attain long-term sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt re-structuring, as appropriate, as well as address the external debt of highly indebted poor countries to reduce debt distress.

Governing global environmental change: It will be necessary to develop new mechanisms for governing global environmental change, in view that existing international arrangements are not dealing quickly enough with current global challenges such as climate change and biodiversity loss. World development within the biophysical limits of a stable Earth System has always been a necessity. However, only recently, for a number of reasons, has it become possible to identify, evaluate and quantify risks of abrupt planetary- and biome-level shifts due to overshoot of key Earth System parameters: (i) the emergence of global change- and Earth System- thinking, (ii) the rise of 'the Planetary" as a relevant level of complex system understanding, and (iii) observable impacts of the rapid increase in human pressures on the planet. Periodically revising and updating the Planetary Boundaries framework, with a focus on the underpinning biophysical science, and based on targeted inputs from expert research communities and on more general scientific advances, would allow to monitor and take measures for adjusting to change.

The initiative of High Level Political Forum on Sustainable Development (HLPF) provides a space where international policy-makers meet with scientific communities and development experts enabling improved access to the findings of existing assessments and highlight synergies and trade-offs; it also provides a forum for wide participation through multiple channels and features of a wide range of perspectives. It helps to bring the work of independent scientific advisory groups and assessments initiatives to the intergovernmental arena. It

may involve scientists in specialized fields to engage in the broader science-policy interface through the production of science digests. It provides frequent platforms for brief interactions between international assessments and regional and national policy-making. It enables the exchange of experience on how the Science-Policy interface at the national level has worked, as it promotes in-depth cooperation on integrated Sustainable Development scenarios.

Data monitoring and accountability: Strengthened support for observing systems, particularly in developing countries, are required, including new approaches that should fully integrate global observing systems for environmental and social issues, helping to improve decision-making for global sustainability. A wide range of emerging big data applications are supporting a whole range of SDGs at various geographical and time scales. Innovative approaches are being applied, among them, in Africa, to improve the timeliness, availability and use of data for monitoring of progress towards sustainable development. Satellite images, cell phone records, online prices at retailer's websites, tweets, online searches, remote sensing, voluntary reporting through internet, media reports etc. are some of the data sources used to measure questions as varied as poverty, socio-economic levels, food price crises, crop productivity, influenza, malaria, dengue, population movements during an epidemic, vaccine concerns, drug use, women's wellbeing and many others.

Continued **exploration of new areas of knowledge**, such as theoretical and applied research in social science and economics addressing ecological and social tipping points and irreversibility at multiple levels will help enable goals aimed at global sustainability. Opportunities to improve wellbeing and eradication of poverty at the individual level will also play pivotal roles in the transition towards planetary stewardship. A crucial transformation is the move away from income as the key constituent of well-being and the development of new indicators that measure actual improvements in wellbeing at all scales. Recognition of the monetary and non-monetary values of public goods such as education, health and global common resources such as the oceans and the atmosphere imply that they must be properly factored into management and decision-making frameworks at the national and sub-national levels to ensure that economic activities do not impose external costs on the global commons.

"A crucial transformation is the move away from income as the key constituent of well-being and the development of new indicators that measure actual improvements in wellbeing at all scales.

It is almost universally agreed among economists that governments should be involved in building and maintaining **infrastructure** -streets, highways, bridges, ports, dams, airports and air traffic control systems, and so on. This is because, like education and research, infrastructure is subject to positive externalities. Excellent infrastructure makes a country a more pleasant place to live, and also a more productive place in which to do business. But the space underneath cities also deserves more attention –research of sub-relief is important not only because of utility infrastructure, but also because of geological, geomorphological and ecological processes that can affect a city's resilience. Regional **collaborative environmental governance** is underway in some areas to balance economic development with ecological and social concerns, and ensure participation of civil society organizations, trade associations, the media and communities.

As technology steadily encroaches on humans' skills and abilities, and as digital **work** becomes more pervasive, capable, and powerful, companies will be increasingly unwilling to pay people wages that they will accept and that will allow them to maintain the standard of living to which they have been accustomed. An issue that is most likely to change and present challenges, is that in today's capitalist economies, most people acquire money to buy things by offering their labor to the economy. As we look ahead–into the 2030s and beyond-we see androids. A

serious challenge will be to solve the question of how to ensure the wellbeing of all humans in such a world in which a good portion of human labour becomes redundant. Jobs which have traditionally occupied the middle of the skills hierarchy and earnings range, such as white collar administrative roles and skilled/semi-skilled blue collar roles, are declining at a significant rate due to changes in work organization driven by technology and globalization. New types of jobs are emerging to fill the middle ground but these have markedly different entry routes and skills requirements. In relation to SDG 8 to prepare for tomorrow's world of work, key areas have to be considered by employers, individuals, education providers and policy-makers. These are not to be seen as definitive solutions to the opportunities and challenges but as starting points for further thinking and debate.

> "There is a truly urgent need to also raise information and understanding of the problems at stake in the Latin American region.

Conclusion

Our era faces huge challenges. A system this complex and tightly coupled has two related weaknesses. First, it is subjected to seeing minor initial flaws cascade via an unpredictable sequence into something much larger and more damaging. Second, complex, tightly coupled systems make tempting targets for spies, criminals, and those who seek to wreak havoc. Perils, from both accident and malice, will become greater. We will be increasingly concerned with questions about catastrophic events, genuine existential risks, freedom versus tyranny, and other ways that technology can have unintended or unexpected side effects. The sheer density and complexity of our digital world brings risk with it. Our technological infrastructure is becoming ever more complicated and interlinked.

The inputs from the scientific community around the world, in principle allow to recover the interests and perceptions of needed actions proposed not only in the global North but also in the global South, in crowdsourcing exercises that are being coordinated by the UN Sustainable Development Platform. However, this is not enough for it tends to be subsumed under the language and interests of people in the North. There is a truly urgent need to also raise information and understanding of the problems at stake in the Latin American region both at the level of governments, civil society and other stake-holders. Science, technology and innovation policies need to evolve, through international and regional coordination in the levels of conceptualization, implementation and practice. Greater dialogue must be promoted among Latin American scientists, engineers, practitioners, stakeholders and policy-makers. There is need for integrated assessment of cross-cutting issues related to SDGs simultaneously. This UNESCO meeting in Montevideo provides the setting for one such valuable exercise.

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