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Use of ICT and the relationship with the goals of Sustainable Development in Ecuador

Uso de las TIC y su relación con los Objetivos de Desarrollo Sostenible en Ecuador

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Abstract

In the United Nations in 2015, the 17 Sustainable Development Goals (SDGs) were approved. The objective of this research is to know the current status and perspectives of the Information Society (IS) in relation to the achievement of the goals of the SDGs, through the analysis of historical information and projections of IS indicators, and actions of research, development and innovation (R&D+i) in Ecuador. The research methodology has a quantitative, non-experimental and longitudinal approach. Secondary information sources were used as national and foreign reports, which once converted into time series allowed to analyze projections and determine the future trend of those indicators. As results, it was found that the behavior of indicators of ICT use and R&D+i indicators are directly or indirectly related to the fulfillment of the goals of the fourth, fifth, eighth and ninth SDGs. On the one hand, it was concluded that the trend of five SI indicators is in relation with the achievement of the SDG goals, while three other indicators require a strong impulse to change the trend and achieve its associated goal; on the other hand, the need for the different actors of Ecuadorian society to commit to work based on the potential of the use of ICT and R&D+i activities in order to achieve the SDGs.

Resumen

En 2015, en la Organización de las Naciones Unidas se aprobaron los 17 Objetivos de Desarrollo Sostenible (ODS). El objetivo de esta investigación es conocer el estado actual y perspectivas de la Sociedad de la Información (SI) en relación con el logro de las metas de los ODS, mediante el análisis de la información histórica y pronósticos de los indicadores SI, y actuaciones de investigación, desarrollo e innovación (I+D+i) en Ecuador. La metodología de investigación tiene un enfoque cuantitativo, no experimental y longitudinal. Se utilizaron fuentes de información secundarias como reportes nacionales y extranjeros, que convertidos en series de tiempo permitieron analizar pronósticos y determinar la tendencia futura de esos indicadores. Como resultados se encontró que el comportamiento de indicadores de uso de las TIC e indicadores de I+D+i están relacionados en forma directa o indirecta con el cumplimiento de las metas de los ODS. Se concluye que, por un lado, la tendencia de cinco indicadores de la SI sintonizan con el logro de las metas de los ODS, mientras que otros tres indicadores requieren un fuerte impulso para cambiar la tendencia y lograr su meta asociada; y, por otro lado, la necesidad de que los diferentes actores de la sociedad ecuatoriana se comprometan a trabajar a partir de las potencialidades del uso de las TIC y actuaciones en I+D+i con el fin de lograr los ODS.

Keywords | palabras clave

Ecuador, development and innovation, gender, sustainable development objectives, projections, information and communication technologies.
Ecuador, desarrollo e innovación, género, objetivos de desarrollo sostenible, pronóstico, tecnologías de la información y la comunicación.

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1. Introduction and state-of-the-art

We live in a society marked by the exchange of information flows and an accelerated use of knowledge as a platform for the development of almost all human activities in a globalized world. This new way of doing things has increasingly required the input of Information and Communication Technologies (ICT), which has made authors such as Area *et al.* (2012) to suggest a new model of collective participation called "Information Society", the one that has allowed a deep interconnection between human beings and machines, with important effects in the political, social and economic fields at the global level.

The contribution of the use of ICTS has transcended some social impacts such as improving the quality of education, ensuring healthy lives, strengthening economic growth and/or generating quality jobs. However, in the perspective of a sustainable world, there is the need to use these technologies in solving problems such as poverty, exclusion, economic and social development, climate change, among others, by associating them with the rational use of resources provided by the nature (Ziemba, 2017).

The concern to eradicate poverty made the representatives of the countries of the United Nations (UN) to propose, at the beginning of this century, eight Millennium Development Goals (MDGS) that served as a framework for the Global development up to 2015, as summarized in the report of the United Nations Organization (2015). This report recognizes important global, regional, national and local efforts that have been implemented in the member countries to eliminate human inequality, to save millions of lives and to improve conditions for many more.

Recognizing that the work to alleviate poverty and achieve sustainable economic progress must be a global effort, at the Rio+20 Summit in Rio de Janeiro, Brazil, UN representatives renewed the political commitment to sustainable development and the promotion of an institutional framework to promote an economic, social and environmentally sustainable future for our planet and for the present and future generations (United Nations Organization, 2012).

Years later, the UN by recognizing that work to reduce poverty and close gaps in inequality between poor and rich countries should have continued, it proposed new strategies. In September 2015, representatives from 193 countries adopted a resolution at this global forum that included 17 Sustainable Development Goals (SDG) and 169 targets for 2030 (United Nations, 2015). These objectives – shown in Table 1 – are part of the Agenda 2030 for Sustainable Development (United Nations Organization, 2016), and comprise aspects ranging from environmental preservation to governance.

Section 15 of the agenda 2030 states that the expansion of ICT and global interconnection have great potential to overcome the digital gap between the poor and the rich, and to develop knowledge and scientific societies and technological innovation (United Nations, 2015); idea that that is shared by the International Telecommunication Union (ITU) and the Global e-Sustainability Initiative (GeSI), when agreeing that ICT and its associated digital solutions could directly contribute to covering more than half of the 169 goals collected in SDG, since it is possible to contribute to a sustainable future through a responsible transformation based on Collaboration of ICT companies and organizations around the world (GeSI, 2016; ITU, 2018).

Table 1. Sustainable Development Goals

ODS	Description
1	To end poverty in all its forms all over the world.
2	To end hunger, to achieve food security and to improve nutrition, and to promote sustainable agriculture.
3	To ensure a healthy life and to promote wellbeing for all people in all ages.
4	To guarantee inclusive, equitable and quality education and to promote lifelong learning opportunities for all.
5	To achieve gender equality and empower all women and girls.
6	Ensure the availability of water and its sustainable management, and sanitation for all.
7	To ensure access to affordable, safe, sustainable and modern energy for all.
8	To promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.
9	To build resilient infrastructures, to promote inclusive and sustainable industrialization, and to promote innovation.
10	To reduce inequality in and between countries.
11	To guarantee that cities and human settlements are inclusive, safe, resilient and sustainable.
12	To guarantee sustainable consumption and production modalities.
13	To take urgent action to combat climate change and its effects.
14	Conservation and sustainable use of oceans, seas and marine resources for sustainable development.
15	To promote the sustainable use of terrestrial ecosystems, to combat desertification, to stop and reverse land degradation and to reduce the loss of biological diversity.
16	To promote peaceful and inclusive societies for sustainable development, to facilitate access to justice for all and to create effective, responsible and inclusive institutions at all levels.
17	To strengthen the means of implementation and improve the Global Alliance for Sustainable Development.

Source: United Nations Organization (2016).

According to Pintér *et al.* (2017), observation, measurement and evaluation are integral parts of strategic management and governance to recognize, understand and address sustainability-related issues. Therefore, this study emphasizes the contribution of ICT and actions of Research, Development and innovation (R+D+i), and its relationship with the achievement of the goals of four SDG (4, 5, 8 and 9) shown in Table 2. For this purpose, the indicators of the SI and the actions carried out by the different public and private actors of the Ecuadorian Society from 2008 to 2018 are taken into account. The following is a summary analysis of the relationship between ICT and SDG involved in this research.

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According to the ITU website (2018), when referring to SDG 4, ICTS are driving a revolution in online training that has turned these technologies into one of the world's fastest growing industries. Mobile devices allow students to access learning resources at any place and time, while teachers use wireless devices for interactive training and mentoring. In the report developed by the United Nations (2016) and for Tawil *et al.* (2016), this objective is divided into seven goals and three means of implementation; and according to Salvia *et al.* (2019), this objective is the third in importance addressed by experts from Latin America and the Caribbean (LAC), due to its relationship with the main problems and local challenges of each country in the region.

Regarding SDG 5, and according to the ITU (2018) there are up to 250 million women less than men on the internet, reason for which ICTS can offer great opportunities to eliminate gender gap, enabling everyone to have access to the same resources and opportunities on-line. The expected impact would be to achieve broad participation of women in their community, in government and at the global level, through economic empowerment and the creation of job and business opportunities.

SDG 8 has also been taken into account, according to the ITU (2018), skills in ICT management have become a prerequisite for almost all jobs; therefore, the development of the capacity to use these technologies in the strategies of youth employment and entrepreneurship of all countries should be prioritized. It is not simply that most jobs and businesses now need ICT skills, but that these technologies are transforming the way to do business everywhere and creating new job opportunities.

With regard to SDG 9 for the ITU (2018), digital infrastructure is essential given its potential in industry and innovation in its different forms. An enabling factor for innovation is investment in research and development (R+D), as it has economic consequences in countries' inhabitants. In this regard, the global framework has shown that there is a very high positive correlation between this investment and income per capita (ECLAC, 2016), and according to the OECD (2016) through R+D, it is possible to develop products and technologies in relation to sustainability, and create value chains that beyond their social and environmental value also contribute to increasing efficiency and benefits.

This study analyses a set of indicators on ICT use and R+D+i actions, relating with the goals corresponding to SDG 4, 5, 8 and 9. This examines the historical behavior of these indicators, makes projections for the next four years and sets trends to demonstrate the probable fulfillment of the goals established in the four SDG chosen. The results will be a reference point in order that the actors involved in the fulfillment of the objectives can plan actions that go in direction of the achievement of the sustainability goals; therefore, it justifies the development of this research and its contribution to the theory (Whetten, 1989).

Table 2. SDG goals analyzed for Ecuador

Objective	Goal	Description of the goal
SDG 4	4.a	To build and adapt educational facilities that take into account the needs of children and people with disabilities and gender differences, and that would provide safe, non-violent, inclusive and effective learning environments for all.
SDG 5	5.b	To Improve the use of instrumental technology, specially information and communication technology in order to promote women's empowerment.
SDG 8	8.2	To achieve higher levels of economic productivity through diversification, technological modernization and innovation, inter alia focusing on high-value-added sectors and labor-intensive use.
	8.3	To promote development-oriented policies that support productive activities, the creation of decent jobs, entrepreneurship, creativity and innovation, and encourage the formalization and growth of microenterprise and small and medium-sized enterprises, even with access to financial services.
SDG 9	9.5	To increase scientific research and improve the technological capacity of industrial sectors in all countries, in particular developing countries, by encouraging innovation and considerably increasing, from now to 2030, the number of people who work in research and development per million inhabitants and the costs of the public and private sectors in research and development.
	9.b	To support the development of national technologies, research and innovation in developing countries, by ensuring a normative environment conducive to industrial diversification and the addition of value to commodities, among other things.
	9.c	To increase the access to information and communication technology and strive to provide universal and affordable access to the Internet in the least developed countries, from now to 2020.

Source: United Nations Organization (2016).

2. Materials and methods

This exploratory and descriptive study uses a quantitative methodology to analyze the probability of meeting SDG goals from the SI indicators and the actions carried out in the field of R+D+i in public and private institutions of Ecuador. Table 3 shows the indicators related to the goals of the four SDG considered, the information that was obtained from sources such as the National Institute of Statistics and Censuses (INEC), and the Ministry of Higher Education, Science, Technology and Innovation, World Economic Forum (FEM), World Economic Forum (WEF), International Telecommunication Union (ITU), among others.

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Table 3. ICT Indicators and R+D+i analyzed for Ecuador

Objetive	Goal	Indicator
SDG 4	4.a	• Number of national information centers.
SDG 5	5.b	• Percentage of people who use the computer. • Percentage of people who have activated cell phone. • Percentage of people wo use Internet.
SDG 8	8.2 8.3	• Percentage of people who use internet for educational and learning purposes. • Percentage of people who use internet for working activities.
SDG 9	9.5	• Real investment and diagnose of science, technology and innovation activities (ACTI) in relation to the gross domestic product (GNP). • Number of researchers per 1000 members of economically active population (EAP).
	9.b	• Legal norms of the State to promote R+D+i in the public and private areas.
	9.c	Networked Readiness Index (NRI) and its areas a. Regulatory political environment. b. Innovation and business. c. Infrastructure and digital content. d. Resources. e. Skills and abilities. f. Individual use. g. Business use. h. Government use. i. Economic impact. j. Social impact.

This study was divided into two stages. In the first stage, statistical data were obtained of the indicators of the Ecuadorian SI, corresponding to the period between 2008 and 2017, in order to estimate the future value of the indicators of the SI in Ecuador projected to 2021. In a second phase, data from R+D+i indicators from 2009 to 2014 was used since they are the last ones published by the Ecuadorian public institutions involved, and projections to estimate their behavior in the next four years were done by using the information.

The definition of projection used states that it is a process of estimating a future event by means of the data projection of the past; i.e., the systematic combination of data that allows an estimation of future events (Guerrero, 2003; Lind, Marchal & Wathen, 2012). The projection model was done by analyzing time-series indicators with data recorded annually. The behavior was projected by decomposing historical information in reference elements such as trend and seasonality.

The most widely used technique was the double exponential smoothing, since after doing a first analysis of the predicted data, the data series presented trend

but not seasonality (Guerrero, 2003; Webster, 2001). Double exponential smoothing requires calculating projected data through equations 1 and 2.

$$S_i = \alpha x_i + (1-\alpha)(S_{i-1}+T_{i-1}) \quad \text{Eq. 1}$$
$$T_i = \beta(S_i-S_{i-1}) + (1-\beta)T_{i-1} \quad \text{Eq. 2}$$
$$F_{i+1} = S_i+T_i \quad \text{Eq. 3}$$

Where
S_i = exponentially smoothed average of the series in the period *i*,
T_i = exponentially smoothed average of the trend in the period *i*,
α = smoothing parameter for the average, with a value between 0 and 1.
β = smoothing parameter for the trend, with a value between 0 and 1.
F_{i+1} = projection for the period *i+1*.

Additionally, as a result of the projection, an error measure was determined, demonstrating the goodness of the adjustment method to obtain the projection. This measure was the root of the mean quadratic error (Root Mead Squared Error, RMSE, for its acronym in English). According to Chai and Draxler (2014), RMSE is the most popular measure of error, also known as "quadratic loss function". On the same measure of error, Lakshmivarahan *et al.* (2017) and Shcherbakov *et al.* (2013) define the RMSE as the average between absolute values of projected errors, and is used as a selection criterion for the best fit of time series models. Its calculation form is made from equation 4.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(R_i - F_i)^2} \quad \text{Eq. 4}$$

Note: Where Ri corresponds to the current period data i, Fi represents the predicted data for period i, and n represents the number of periods that have real value and and a predicted value.

The quantitative analysis of the indicators was carried out by applying time forecasting series to the historical data obtained from the secondary sources. The Risk Simulator 2016® software was used to perform the forecasts (Software-Shop, 2017). This software allowed to automate the calculations described in equations 1, 2, 3 and 4, and applies the best forecasting method that fits the data series with the lowest RMSE. As a result, at the end of the adjustment, the software provides a table and graph showing the actual data, projections, and trend to four years from next. According to Lind *et al.* (2012), these trends may be secular trend, cyclic variation, seasonal variation, or irregular variation.

3. Analysis and Results

To compare the use of ICT and R+D+I action with the goals of SDG 4, 5, 8 and 9, the projections of the indicators are analyzed, considering the last available statistical data, and determining whether the trend of these indicators fulfill those goals.

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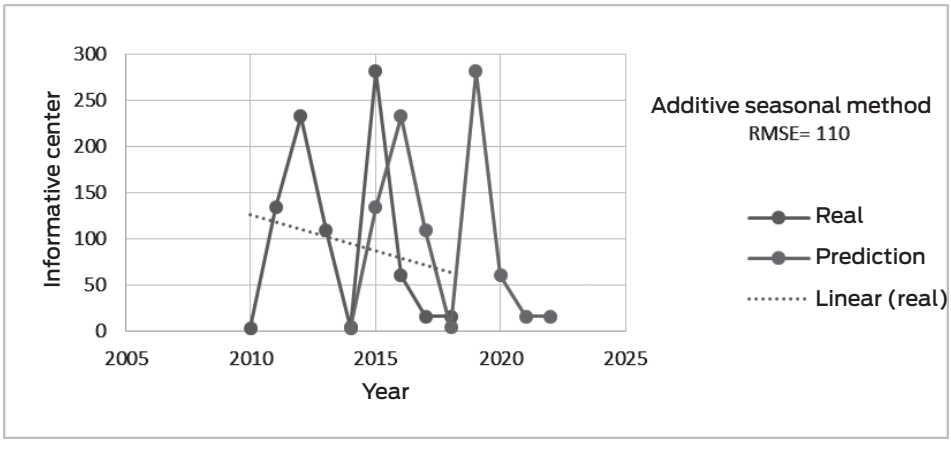
3.1. Projection and trend of SDG 4-related indicators

In order to analyze the progress of the fulfillment of the goal 4. a. the amount of information centers implemented by the MINTEL in Ecuador is considered. The information centers are public areas for accessing Internet and digital information services that mainly operate in rural communities nationally. At the end of 2018, there were a total of 857 located in the 23 provinces of Ecuador (MINTEL, 2018b). Figure 1 illustrates the number of information centers installed from 2010 to October 2018. Next to this curve is also shown the forecast of implementation until the year 2022, assuming that the same government policies are maintained in the historical period analyzed.

Figure 1. Implementation behavior of the information centers



3.2. Forecast and trend of SDG 5-related indicators

To analyze goal fulfillment 5.b. the percentages of men and women over five years of age using computer, cell phone and access to the Internet were taken as reference. Figures 2, 3 and 4 have been elaborated with the data obtained from INEC (2013, 2017b), which expose the curves of the historical values of these indicators by gender, their tendency and projection until the year 2021.

Figure 2. Real percentages and projection of computer use by gender

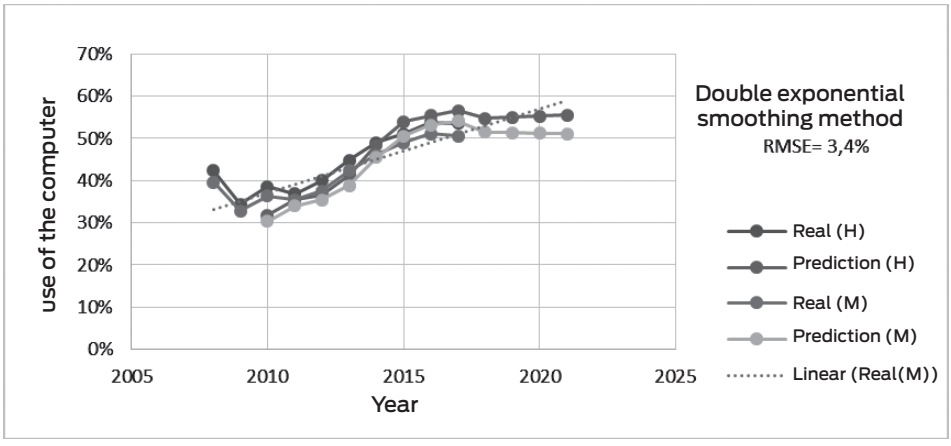
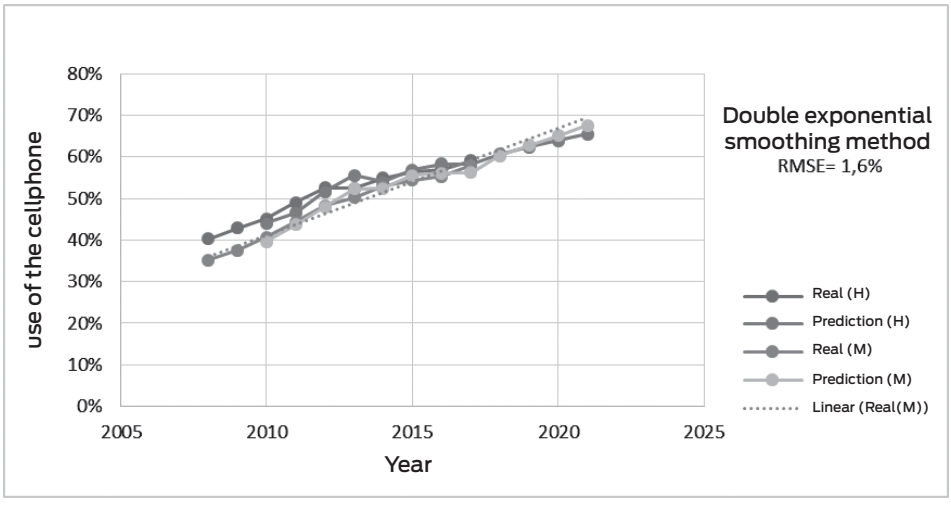


Figure 2 shows that the behavior of computer use in men (H) and women (M) in recent years has been almost similar, and at the end of 2017 it was around 55%, with a tendency to increase to 2021. Figure 3 shows the projection and growing trend of cell phone use according to gender up to 2021.

Figure 3. Real percentages and projections of cell phone use by gender



Regarding the use of the Internet by gender, Figure 4 indicates that there is a rather similar behavior. The indicator is around 60% in both men and women. In addition, it is forecast that its use will increase up to 2021.

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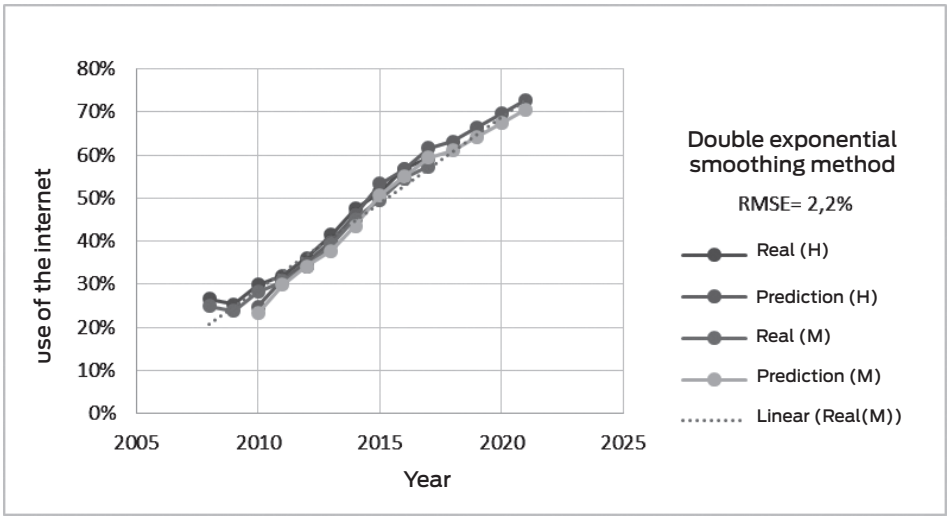
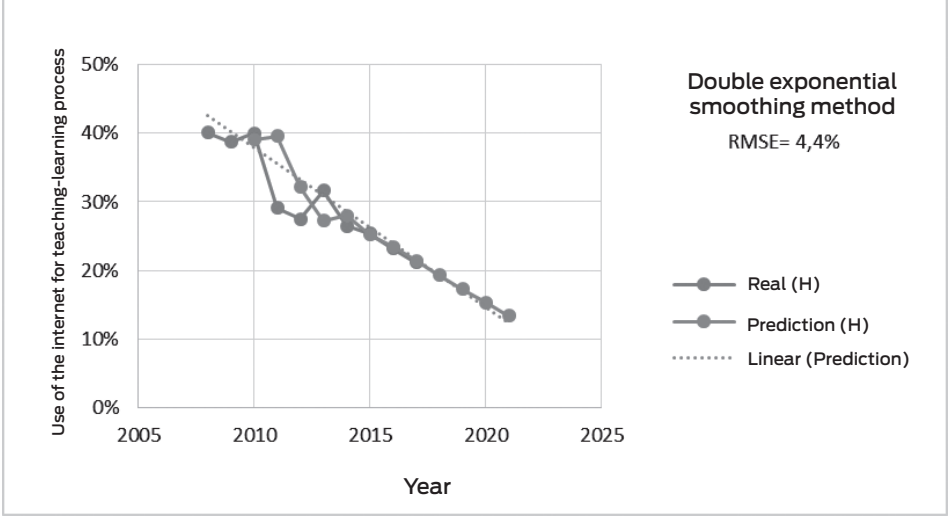
Figure 4. Real percentages and projection of Internet use by gender



3.3. Projection and trend of SDG 8-related indicators

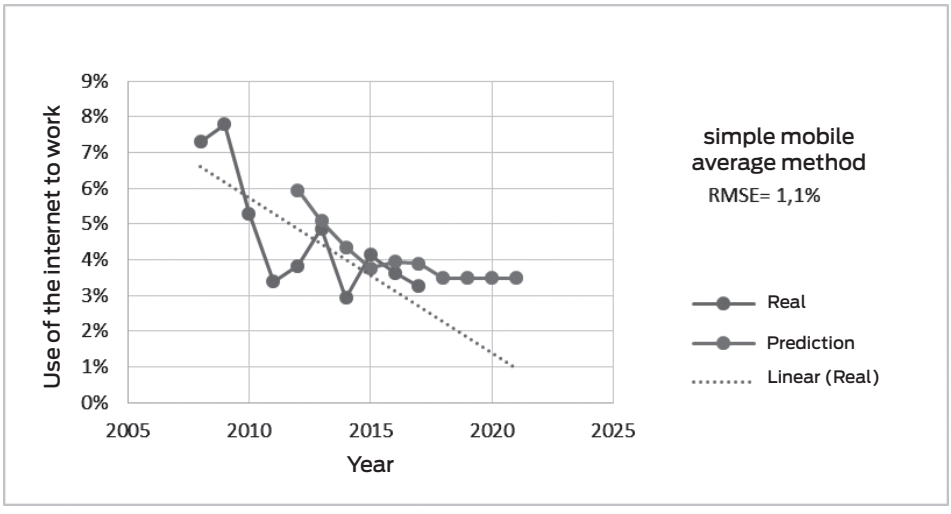
To know the progress of compliance with goals 8.2 and 8.3, the data published by the INEC (2013, 2017b) were used. With respect to goal 8.2 and according to Figure 5, from 2010 onwards, the use of Internet for educational and learning purposes has been declining from 40% to 21% in 2017. In addition, there is a declining trend if the indicator is projected up to 2021.

Figure 5. Real percentages and Internet use forecast for education and learning



On goal 8.3, and observing the results of Figure 6, it is evident that since 2009 the use of Internet has reduced for working activities, from 8% to 3% in 2017. In addition, according to the forecast, the trend is to gradually decrease.

Figure 6. Real percentages and Internet use forecast for working activities



3.4. Forecast and trend of SDG-related indicators

To know the probable fulfillment of the goal 9.5, the economic indicator that measures the investments in Activities of Science, Technology and Innovation (ACTI) with respect to the Gross Domestic Product (GDP) is taken into account in institutions like universities, governmental and non-governmental institutions. As shown in Figure 7, from 2009 to 2014 with the latest official data, the percentage of ACTI with respect to GDP represented an increase of 1.63% to 1.88% (SENESCYT-INEC, 2015). Moreover, the investment in these activities has been increasing and it is predicted that this indicator will maintain a growing trend.

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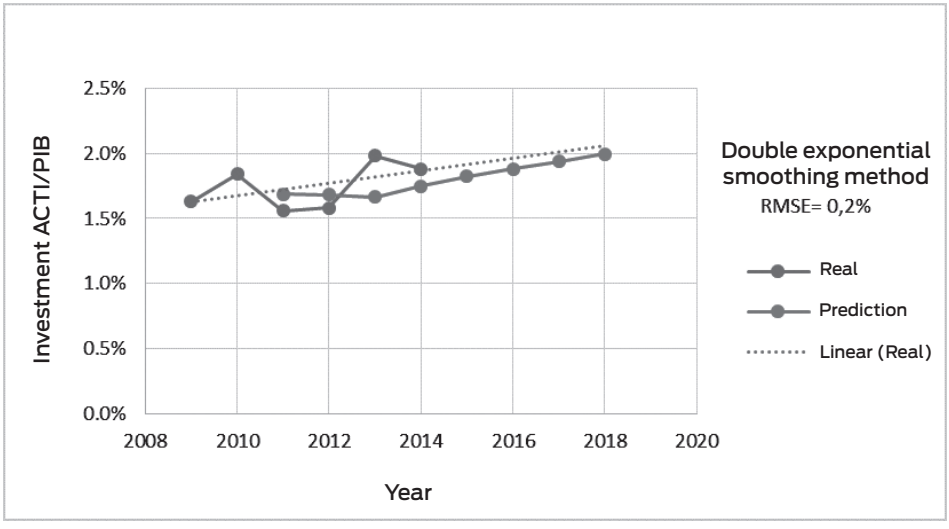
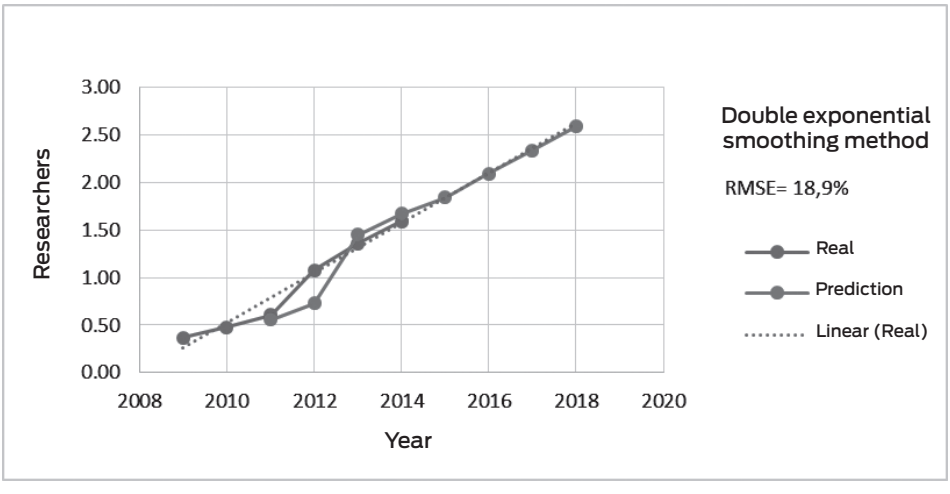
Figure 7. Real and forecasted investment of ACTI with respect to GDP in Ecuador



To predict the future of goal 9.5, the number of researchers per 1000 members of the Economically Active Population (EAP) is used as an indicator – see Figure 8 –. As can be seen, this indicator has been growing until the last year when there was official data obtained from SENESCYT-INEC (2015). In Addition, it is predicted that the number of researchers (researchers with fourth level of academic training and doctoral fellows) will grow in 2018 to an estimated 2.5 researchers per 1,000 members of the EAP.

Figure 8. Number of researchers per 1,000 members of the EAP

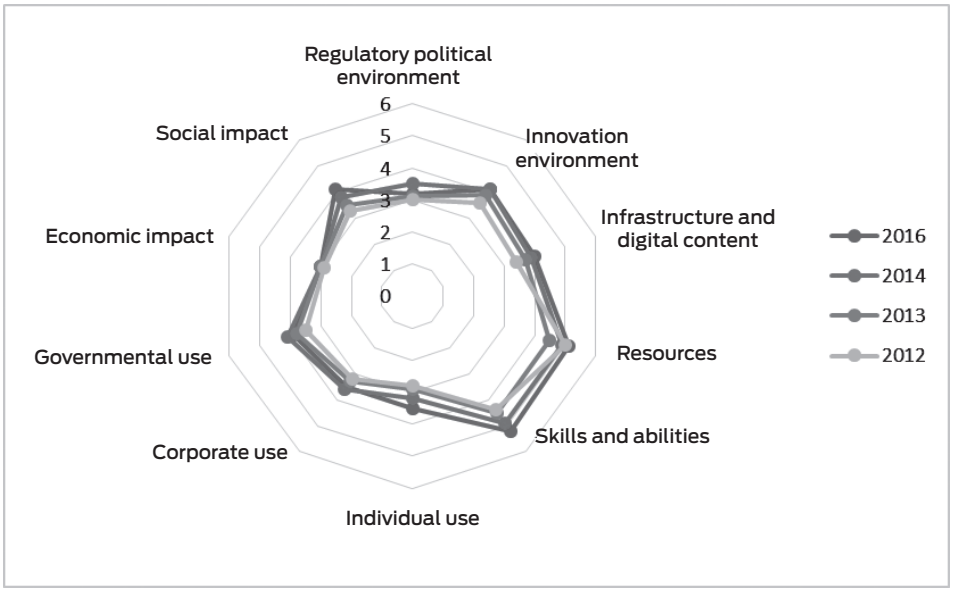


To predict the state of goal 9.b, it can be said that there are efforts in Ecuador presented in public policy such as the "Ingenious Code" (National Assembly of Ecuador, 2016), which promotes the development of the Information Society and the Knowledge as a main principle for the increase of productivity in the factors of production and working activities. Another legal legislation enacted is the "Industrial Policy of Ecuador", issued by the Ministry of Industry and Productivity (MIPRO, 2016), which details the policy guidelines to facilitate compliance with the role of the industry from the perspective to contribute to the impulse of innovation and entrepreneurship.

In order to know the compliance status of Goal 9.c, the Networked Readiness Index (NRI) indicator is used, which measures the preparation degree of a nation to participate in the benefits of ICT developments (Baller, Dutta, & Lanvin, 2016). This indicator is created annually by the World Economic Forum, from the analysis of 139 economies of the world and a set of 53 variables grouped into four sub-indexes and ten pillars, related to the political framework, Infrastructure, ICT use and ICT-related impact (Baller *et al.*, 2016).

Figure 9 shows the behavior of each pillar of the NRI according to Table 3, whose scale ranges from 0 to 7 (maximum value). The last four reports have been considered (Baller *et al.*, 2016; Bilbao-Osorio, Dutta & Lanvin, 2013, 2014; Dutta & Bilbao-Osorio, 2012). In the report of 2015, information of Ecuador is not present, since according to Dutta, Geiger, & Lavin (2015) the information was not available at the time of the edition of the report, reason for which the forecast calculation could not be made for 2020 of each of the ten pillars of this indicator.

Figure 9. NRI indicator pillar behavior for Ecuador



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As shown in Figure 9, it is the skills, skills and resources that contribute to the growth of the indicator, while the pillars pertaining to infrastructure and digital content are lagging, and individual use and economic impact. The evolution of NRI for Ecuador in recent years has been as follows: In 2008 ranked 116 of 134 countries (Dutta & Mia, 2009), for 2016 was ranked 82 in 139 countries (Baller, Dutta, & Lanvin, 2016); it is, he went up 35 positions. In Addition, for the same year, it was found in ninth place above the average of the Latin American and Caribbean region (LAC).

4. Discussion and conclusions

Forecasting the indicators of the use of ICT and actions of R+D+i and comparing with the goals of SDG 4, 5, 8 and 9 has allowed to know the current situation and to observe the trend of the SI. There is a seasonal fluctuation from 2010 onwards, with a declining trend when examining public policy that encourages the use of ICT in the informative center; situation that could explain the reason for the slow progress of the literacy digital process in Ecuador. According to INEC (2017b), digital illiteracy is 10.5%, and it falls by approximately 1% each year, i.e., if the policies of access of the population to ICT are not improved, the partial fulfillment of objective 4 will require important public and private efforts to comply with it before 2030.

With regard to the use of ICT by gender, it is concluded that there is sustained growth in the use of the cell phone, computer and the Internet in men and women older than five years old. Moreover, it is observed that the digital gender gap is gradually being eliminated in terms of the use of ICT analyzed. To continue this growing trend, the generation of equal educational and employment opportunities could be strengthened, and could promote the empowerment of women in different economic activities.

By analyzing the use of the Internet, it is evident that it will increase more than the use of the computer and cell phone. This situation would ensure that the services offered by the network, such as communication, information search and education and work opportunities would continue to increase to 2021. To this end, the Government should promote policies that eliminate gender barriers to access to ICTS, as according to Oña *et al.* (2016), the use of these technologies has generated a deep gap in the educational, social, cultural and productive aspects at the local, regional and global levels.

Throughout this study, it has been shown that the production of statistical information of gender in Ecuador is still very little, so the Government, motivated by working on the indicators of the Agenda 2030, is executing the Plan of the Development Statistics for SDG (INEC, 2017a, 2018). This lack of statistical information is consistent with what was stated at the UN World Data Conference, in which it has been ratified that only 13% of the countries of the world have a specific budget for gender statistics, an assertion that agrees with what is stated at that conference by Courey (2018), who has expressed that women generally are not part of the official statistics, and, even more critically, that when they are present they are considered by numbers that represent them as more dependent and less productive people than they are.

Another worrying conclusion is that the use of Internet for education, learning and working activities has reduced since 2009, and a declining trend for 2021 is fore-

casted. Unfortunately, these results are reflected in the position of the country in the ranking of the human capital index, since according to the World Economic Forum (2017), Ecuador is in the position 76 of 130 countries, and although it is about the world average, it is just ahead of some countries in the LAC region. Consequently, the compliance of goals 8.2 and 8.3 is difficult.

With regard to innovation, an investment of about 2% of GDP in ACTI is forecasted for the year 2018 and there is a small growth trend. According to the ranking Global Innovation Index 2018, Ecuador barely reaches a score of 26.8 out of 100 in innovation, which places it in the place 97 of 126 economies in the world, five posts lower than in the year 2017 (Dutta, Lanvin, & Wunsch-Vincent, 2018). This unfortunate position is also evident in the LAC region, where it occupies the 14th place of 18 tabulated economies; this being one of the reasons why it becomes necessary and urgent to work on proposals to improve the innovation processes in the different areas of the economy.

At the end of the second decade, the Ecuadorian society will have to work with perseverance in the approach of policies and structural plans that broaden the ICT infrastructure and strengthen its use to develop digital skills in all citizens, as proposed by authors such as Moreno-Navarro *et al.* (2014) and documented the MINTEL (2018a) in his *Libro Blanco*. In addition, it is important to deep into lines of research related to the rest of SDG in which issues such as governance, influence and interests of political and economic actors are included, which according to O'Neil (2017), it is necessary to consider them to understand the complexity of achieving the goals that lead to sustainable development.

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