Food and Nutrition Security in Ecuador

High angle view of food street market in Azuay province, Ecuador © Shutterstock

Ecuador

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Ecuador: a megadiverse country with potential, yet with challenges for its future regarding food security. However, the use and development of biotechnological products will help Ecuador achieve food security

Summary

Ecuador has three distinct natural regions (Coastal, Andean and Amazonian), along with the Galapagos Islands, represents a wide diversity of ecosystems. Due in part to the land-use patterns of the oil sector, which accounts for more than half of Ecuador's export earnings, Ecuador is not self-sufficient in food and the population's access to food is limited. Iron deficiency is the most widespread problem and there are also moderate levels of vitamin A and zinc deficiency. Through salt fortification programs, iodine deficiency has been eradicated. At the same time, problems of obesity have been detected, even among children. Food safety has improved throughout the country over the past decade.

Ecuador is relatively vulnerable to natural disasters such as volcanic eruptions, floods, droughts, earthquakes and climate change.

Simple, effective, low cost technologies could significantly increase yield of certain agricultural products. Although water availability and quality are sufficient for agroindustrial processes, changes in management practices are required to preserve it. Ecuador has the opportunity to expand its markets to European and Asian countries, with the greatest challenge being to increase production, with competitive and differentiated product costs. The permanent provision of resources and support for both basic and applied research is necessary.

I. National Characteristics

Ecuadorian workforce is largely based in agricultural, but the value of those jobs is in decline. In 2014, agriculture accounted for 24.5% of the country's employment. However, the slowest growth in Gross Domestic Product (GDP) took place in agriculture and mining, while the construction and services sectors experienced the highest growth. A total of 8.9% of Ecuador's total GDP was produced by agriculture, hunting, forestry and fishing, with electricity, gas and water accounting for a smaller amount. Workers in the agricultural sector earned 44.3% less than the national average (National Institute of Statistics and Censuses [INEC], 2014a).

a. Geography of Ecuador

Ecuador is located in the NW of the South American continent. It covers an area of 283,561 km², including the Galapagos Islands. It borders Colombia to the North and Peru to the South and East. Its climate is tropical in the coastal and Amazon regions, and temperate in the highlands of the Andes mountain range.

Heterogeneity of the landscape and environment
Ecuador has three distinct natural regions: Coastal, Andean and Amazonian. Ninety-one types of ecosystems have been identified in continental Ecuador: 24 on the coast; 45 for the Andean region, and 22 for the Amazonian region (Ministry of the Environment, [MAE], 2013). Ecuador also has 21 of the 27 marine and coastal ecosystems recognized worldwide. However, the MAE notes that not much is known about the state of conservation of these ecosystems, without specifying the causes for this discrepancy (MAE, 2015: 30). The Galapagos Islands are unique and generally not included in this type of description.

b. Demographics and future trends

The majority of Ecuadorians (57%) live in urban areas, and 43% in rural areas. The largest ethnic group in Ecuador are mestizos, in other words, people with a mixed Spanish and Amerindian ancestry. Mestizos account for 65% or more of the population, which includes persons of 28 different nationalities. Average life expectancy for all nationalities is 71.89 years (http://www.ecuador.com.demographics/). As of July 2016, the estimated population of Ecuador was 16,080,778, with an annual growth rate of 1.31% (CIA, 2017). If this growth rate continues, Ecuador's population is expected to reach 30,833,000 in the next 50 years.

c. Population suffering from food insecurity and malnutrition

A significant portion of the population lacks proper nutrition. In 2015, 10.9% of the population suffered from malnutrition, although this was significantly less than the 19.4% reported in 1991. In 2012, 6.4% of children under 5 were underweight, slightly above the 6.2% reported in 2004 (United Nations Food and Agriculture Organization [FAO], 2017a). However, according to Freire et al. (2014), there has been a dramatic increase in the number of Ecuadorians with overweight and obesity, particularly among women of reproductive age, while nutritional deficiency rates have failed to decline. In over 13% of households, there is an overweight mother living with a child with stunted growth, while one-third of women of childbearing age are overweight and zinc-deficiency. The authors suggest that the "double burden" of people and households with overweight and malnutrition is due to excess consumption of carbohydrates (rice) coupled with a low intake of fruit and vegetables.

There are various forms of agriculture, depending on the crop and the region where it is grown. Fruit, for example, is produced on large industrial plantations for export in the western tropical lowlands, whereas in the highlands, there are small farms for the local market, and family farming in the Amazon region. According to the most recent agricultural census published in 2002, farms with fewer than 5 hectares (ha) account for 63% of all farms, occupying only 6.3% of agricultural land, whereas those with 200 ha accounted for 0.78% of all farms, occupying 29% of the total agricultural land. Intermediate-sized farms occupy between 14% and 19% of agricultural land (FAO, 2006).

d. Main crops by production in tons

According to the most recent information available at FAOSTAT (http://www.fao.org/fastoat/es), the top ten crops in Ecuador - by millions of tons of production in 2014 - are shown in **Figure 1**. **Table 1** lists the values in millions of tons of the main crops, and the average changes in production over the past five and twenty years. Maize, palm oil, cocoa and quinoa saw a significant increase in tons harvested in the past 20 years, whereas green coffee, barley and wheat suffered the largest decline in area and tons harvested.

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In the case of bananas, of the total area planted, only 14%, 33%, and 34% receive irrigation, fertilization and pest control, respectively; in other words, roughly 60% of the area lacks access to technology. Ecuador is the third largest producer of bananas by weight, but the leading producer in terms of the amount of US dollars generated by exports. The country supplies 26.5% of the world banana market on the basis of its dollar value. Latin American and Caribbean countries are responsible for 59.3% of world banana sales.

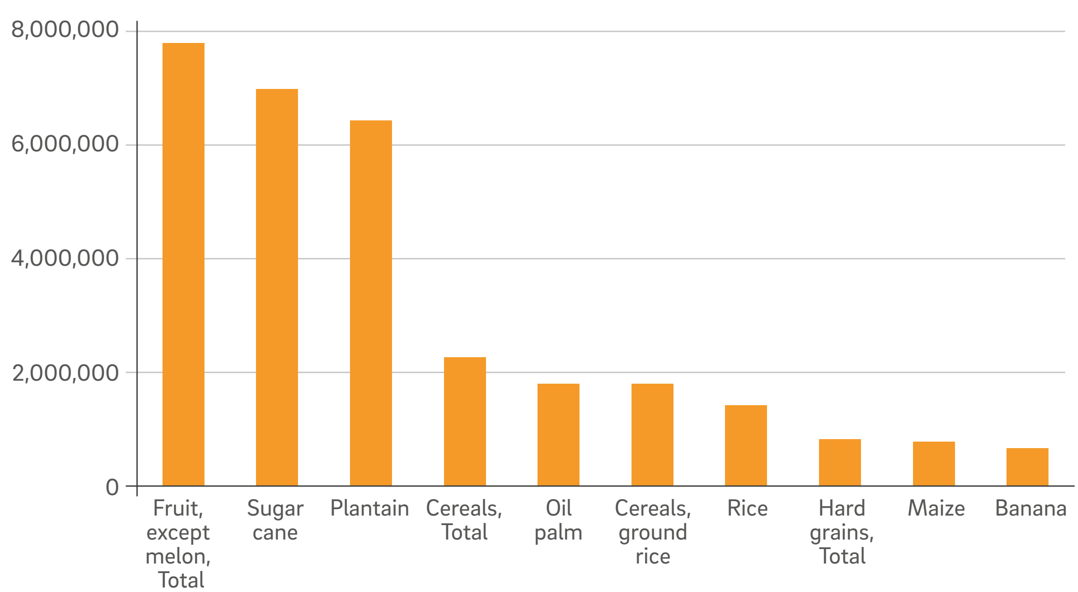
e. Animal agriculture

Like plant crops, the number of heads of many types of livestock decreased between 1995 and 2014. Sheep and goats have declined by more than 50% and only hens have significantly increased (164%) over the past 20 years (**Table 2**). Economics and disease have played an important role in animal production in Ecuador. According to the US Department of Agriculture's Foreign Agriculture Service, Ecuadorian cattle declined in number from 2010 to 2013, partly because of low beef prices (https://www.fas.usda. Gov/data/ecuador-ecuador-livestock). Economic returns can influence farmers to make changes in their production. Moreover, the presence of Foot-and-Mouth Disease (FMD) has contributed to the decrease in the number of cattle. In 2014, the number of cattle in Ecuador was estimated on the basis of the number of animals vaccinated against FMD. Based on the success of the vaccinations, the World Organization for Animal Health (OIE) has declared Ecuador free of FMD. This resulted in increased imports of live cattle, and set the goal of increasing national livestock to export beef, which is expected to begin in 2017.

f. Is the country self-sufficient in agriculture?

No. According to land use patterns, Ecuador is not self-sufficient in food (Fader, Gerten, Krause, Lucht and Cramer, 2013). Based on the model used in this study, by the year 2000, Ecuador lacked sufficient land to produce what is eaten in the country. The model predicts that by 2050, Ecuador would have to optimize crop management to achieve the highest possible yield in order to attain self-sufficiency. However, this would only apply with lower population-growth scenarios. This contrasts with the situation in other countries, which are either already self-

Figure 1. Ecuadorian products with the highest production in tons, 1995-2014



Source: FAO, 2017b (latest available data on March 6, 2017).

Table 1. Areas (in hectares) and tons produced from individual crops in Ecuador from 1995-2014, and changes in the past 20 and 5 years

Crop	1995	2010	2014	% change in 20 years	% change in 5 years
Sugar cane					
Ha harvested	106,210	106,928	96,892	-8.8%	-9.4%
Tons harvested	6,750,000	8,347,182	8,251,306	22.2%	-1.1%
Banana					
Ha harvested	227,910	215,647	182,158	-20.1%	-15.5%
Tons harvested	5,403,304	7,931,060	6,756,254	25.0%	-14.8%
Palm Oil-Fruit					
Ha harvested	91,010	193,502	272,011	198.9%	40.6%
Tons harvested	1,025,310	2,850,465	3,468,510	238.3%	21.7%
Rice					
Ha harvested	395,600	393,137	354,136	-10.5%	-9.9%
Tons harvested	1,290,518	1,706,193	1,379,954	6.9%	-19.1%
Maize					
Ha harvested	511,010	440,346	485,696	-5.0%	10,3%
Tons harvested	556,558	984,096	1,667,704	199.6%	69.5%
Potato					
Ha harvested	65,980	44,245	33,208	-49.7%	-24.9%
Tons harvested	473,204	386,798	421,061	-11.0%	8.9%
Green coffee					
Ha harvested	384,010	144,931	35,483	-90.8%	-75.5%
Tons harvested	148,205	31,347	4,225	-97.1%	-86.5%
Cacao					
Ha harvested	349,370	360,025	372,637	6.7%	3.5%
Tons harvested	85,505	132,100	156,216	82.7%	18.3%
Citrus fruits					
Ha harvested	4,500	6,463	7,327	62.8%	13.4%
Tons harvested	24,212	20,776	19,516	19.4%	-6.1%
Wheat*					
Ha harvested	28,430	8,533	6,082	-78.6%	-28.7%
Tons harvested	19,763	7,605	6,814	-65.5%	-10.4%
Barley					
Ha harvested	48,680	26,374	15,688	-67.8%	-40.5%
Tons harvested	31,683	18,733	14,490	-54.3%	-22.6%
Quinoa					
Ha harvested	800	2,034	4,122	415.3%	102.7%
Tons harvested	408	1,644	3,711	809.6%	125.7%

Source: FAO, 2017b.
* In 1969, there were 100,231 ha of wheat, whereas by 2014, only 6% of the area remained under wheat cultivation.

sufficient or may become self-sufficient, either by increasing productivity or by expanding land and water use, or may need to expand land and water use, or are unable to become self-sufficient (Fader et al., 2013).

g. Main export/import markets and products

Total export and import values for Ecuador were $27.4 billion USD each, with a slight positive trade balance of $23.8 million USD. Crude oil represents almost 50% of the country's total exports, while banana is the main export crop, accounting for 12% of Ecuador's total exports. Ecuador is the leading banana exporter, accounting for 26% of the world total, as mentioned previously, followed by the Philippines with 15% and Colombia with 7.8%. Based on the RCA (Revealed Comparative Advantage) value, Ecuador exports 167 times its equitable share in bananas (The Observatory of Economic Complexity [OEC], 2014). In terms of monetary value, Ecuador's banana exports stood at $ 2.8 billion USD in 2015, ranking first in the world, with Belgium occupying second place with $958.1 million USD (OEC, 2014). The largest importers of Ecuadorian products in 2014 were the US ($11.1 billion USD), Chile ($2.25 billion USD) and Peru ($1.68 billion USD) (OEC, revised March 2017).

Based on monetary value of 2014, after bananas, Ecuador's largest exports were crustaceans (9.3%), processed fish (4.7%), cut flowers (2.8%) and cacao (2.2%). In addition to bananas and cacao, Ecuador exports coffee/tea extracts, processed fruits and nuts, animal meal and pellets, and fruit juice. Sixty three percent of its banana exports are sent to Europe (19% to Russia), 15% to North America (13% to the US) and 12% to Asia (4.2% to China). Half the cacao exported goes to North America (39% to the US) and 33% to Europe (9.4% to the Netherlands) (OEC, 2014).

As mentioned earlier, the value of the country's imports equals that of its exports, resulting in an equitable trade balance. Based on their monetary value in 2014, Ecuador's main imports were refined petroleum and tar oil, accounting for 13% and 8.3% of the total value of imported goods, equivalent to $3.44 billion USD and $2.27 billion USD, respectively (OEC, Consulted March 2017). Regarding agricultural goods, highest expenses for imported animal products were unfilleted frozen fish (US $51 million), eggs ($23.5 million USD) and poultry ($16.6 million USD). Of the imported plant products, soybean meal has the highest costs per year at $368 million USD, but is used for animal feed, human consumption and oil-based products. After soybean meal, the next largest expense is wheat imports ($240 million USD), animal feed ($182 million USD), coffee ($92.6 million USD) and maize ($71.1 million USD). The main countries from which Ecuador imports are the US, from which it imports $7.56 billion USD, equivalent to 28% of all its imports, followed by China with $4.59 billion USD, Colombia with $1.8 billion USD and Peru with $901 million USD.

Import and export trends should be considered over relatively long periods. Economic factors such as taxes, tariffs, trade agreements, and natural factors such as pests, diseases, droughts or floods, can have significant effects on agricultural production in relatively short periods of time. Moreover, natural factors can influence regulations for the import/export of agricultural products and foodstuffs.

Table 2. Changes in livestock production (number of heads) from 1995-2014

Livestock	1995	2010	2014	% change in 20 years	% change in 5 years
Cattle	4,995,000	5,253,536	4,579,374	-8.3%	-12.8%
Pork	2,618,000	1,4897,961	1,910,319	-27.0%	-87.2%
Sheep	1,692,000	792,499	619,366	-63.4%	-21.8%
Goats	295,000	134,825	20,793	-93.0%	-84.6%
Hens	61,512	152,926	162,300	163.9%	6.1%

h. Potential sources of instability of food security

FAO reports a 10-year decline from 1998 onward in stunted growth and low weight in children under the age of five in Ecuador. Iron deficiency is the most prevalent problem of micronutrients in Ecuador, affecting more than 50% of the population in most age groups, together with moderate levels of vitamin A and zinc deficiencies (FAO, 2010). However, the indigenous population is disproportionately affected. For example, 42% of indigenous children under the age of five suffer from stunted growth.

Ecuador is relatively vulnerable to natural disasters such as volcanic eruptions, floods, droughts, earthquakes and climate change. The earthquake of April 16, 2016, with a magnitude of 7.8, claimed over 670 lives, leaving nearly 28,000 injured. The UN World Food Program distributed food to more than 105,000 people after the earthquake. Among the many active volcanoes in Ecuador, the Cotopaxi volcano – the world's second largest active volcano - erupted from August 2015 to January 2016. It is located only 50 km from Quito, the capital city with approximately 2 million habitants. Moreover, Ecuador receives the largest influx of refugees in Latin America (World Food Program [WFP], 2017). Climate change will affect water availability and temperature fluctuations/extremes, among other factors, and encourage the presence of invasive alien species that will influence the ability to grow and maintain certain crops rather than others (Early et al., 2016).

i. Major challenges in agriculture

As indicated earlier, the main challenges of agriculture are the management of water and land resources to increase productivity (Fader et al., 2013).

II. Institutional framework

a. National Agricultural Research System

The National Institute of Agricultural Research (INIAP) is Ecuador's government agricultural research institution. There are eight experimental stations distributed throughout the country with programs for rice, bananas and other Musaceae, cocoa, coffee, rubber, cereals, forestry, fruit farming, livestock and pasture, legumes and Andean grains, maize, oilseeds, potato, pineapple, yucca and sweet potato. Most warm-climate crops are grown on either side of the Andes mountain range, while cooler-climate and dry-land crops occur in the highlands. INIAP offers a wide range of services associated with the crops in the various programs. These range from extensive soil and water analysis, through the chemical analysis of the crops themselves, quantification and identification of microbes in soils, plants and seeds, to DNA analysis, including the sequencing and generation of microsatellite markers. The prices and location of the laboratories providing these services are available online. It is clear from the information on the website that INIAP focuses on services and research to improve the country's agricultural productivity. However, the INIAP website does not provide data on specific research activities or on the activities of its researchers. Although information on research publications, collaborations and interests can be found in public databases such as ResearchGate, details must be sought individually.

b. Is there a need to increase research skills?

Yes. In Ecuador there are two fundamental aspects affecting research development: the lack of financing and the difficulty of accessibility. Research is relatively expensive and new technologies even more so. Moreover, the lack of access to new technologies, and often even to common technology, reduces the opportunities to produce publishable research. The personnel's interest in research is gradually declining, as are infrastructure and research capacities. Ecuador invests barely 0.18% of its agricultural production (GDP-Ag) in research, the lowest percentage of GDP-Ag expenditure in Research and Development in South America. In 2013, the last year of available data, Ecuador had just 11.8 researchers per 100,000 farmers; only Peru had a smaller number (Agricultural Science and Technology Indicators [ASTI], 2013). The data used by the ASTI website are drawn from the World Bank, World Development Indicators. Lack of access to online literature also hinders the development of research, which in turn is due to lack of investment. In January 2017, the Ecuadorian government began to search for and evaluate options for accessing online literature services for its employees, such as SpringerLink. However, even with access to up-to-date literature, researchers still experience difficulty reading and understanding articles written in English, and/or a general lack of material translated into Spanish. Access alone will not significantly improve productivity and research activities.

c. Scientific collaboration networks inside and outside the country

Ecuador has a system for promoting collaborative research agreements among governmental, non-governmental and international institutions. The National Secretariat of Science and Technology has financed postgraduate studies for Ecuadorians abroad. Sometimes, the research for Ecuadorian students' theses is undertaken in Ecuador. As a result, these student theses establish international collaboration projects which, in turn, encourage other postgraduate studies and new collaborative projects.

d. Access to and maintenance of databases for monitoring farming systems

Although the INIAP provides databases on its website, they are not periodically updated and there are categories with no information, such as the list of publications. However, other government websites offer various forms of data. The Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) (2017a) offers comprehensive, up-to-date databases and training videos on product prices, censuses and surveys, production and various production costs such as agrochemicals, although only for Ecuador's main crops. The Ecuadorean Agency for Agricultural Quality Assurance (AGROCALIDAD, 2013) also provides search databases for information on health guidelines for the import, export and transit of agricultural products within the country. These databases also appear to be limited to the main crops and livestock. However, they are user-friendly and provide relevant information for farmers, companies or researchers needing to transport agricultural products.

e. Universities and Research Institutes

The Ecuadorian government recently launched a program to rate and certify the country's universities and colleges. The Council for the Evaluation, Accreditation and Quality Assurance of Higher Education (CEAACES, 2016) lists a total of 52 certified universities and polytechnic schools throughout the country. To ensure and improve the quality of education, CEAACES assessed all of the higher education institutions based on the standards established by the government and evaluated by external assessors. Subsequently, all universities and polytechnic schools were placed in four categories: A-D, with A the highest. There are six undergraduate universities with a categorization of A, 26 in category B, 16 in category C and four in category D. An independent website (altillo.com copyright 2016) listed 72 universities and colleges in Ecuador, organized by province and as private or public universities. The website mentions a total of 30 public universities and 42 private universities and colleges, with five public and 14 private institutions offering online or distance education. Most of the less populated provinces have only one public university. Seventy-five percent or more of the universities in the provinces of the large cities of Cuenca, Guayaquil and Quito are usually private institutions. However, the same government categorization system is maintained. QS Top Universities (topuniveristies.com 2017) also report more than 70 universities in Ecuador with an enrolment of over 61,000 students. These data refer to Ecuador's higher education centers in general.

Evaluations by CEAACES have pressured universities to increase their scientific output. If one regards the number of publications as a measure of the progress of Ecuador's research, there has been a steady increase in recent years. For example, the number of scientific publications registered in Scopus® for 2012 was 642, while 2,146 publications were registered in 2016. The largest number of publications, representing 25.5%, was in the area of agriculture and biological sciences, followed by medicine with 24.1%. If we compare these data with publications registered in 2016 by other countries in South America, Ecuador ranks fifth regarding the number of publications per capita, after Chile, Brazil, Argentina and Colombia. However, these figures are much lower than those recorded for Canada and the US. Although low investment in research, the high cost of inputs and equipment and the limited number of researchers with PhDs have limited Ecuador's scientific production, recent years have seen a steady rise in the latter.

III. Resource and ecosystem characteristics

a. Water resources and challenges for the next 50 years

Water is a globally threatened resource. It has been estimated that there are approximately 1.4 billion cubic kilometers of water on the planet, of which approximately 3% are freshwater. In Ecuador, average annual rainfall is 2,274 mm, corresponding to 583 km³/year throughout the mainland (FAO, 2016). The total amount of water available in all of its hydrographic systems is 432 km³/year. Ecuador has 31 hydrographic systems consisting of 24 in the Pacific slope, with a total area of 124,644 km² and seven on the Amazon slope, with an area of 131,726 km², corresponding to 49% and 51%, respectively. The hydrographic systems are divided into 79 watersheds, of which 72 belong to the Pacific Ocean slope - one part belongs to coastal areas with 123,216 km² (48%), and the other to the neighboring island territories, covering 1,428 km² (1%). These basins are home to 88% of the population. The other seven basins form part of the Amazon slope with 131,726 km² (51%) and 12% of the population. The country's overall water balance is positive, although there are basins with a water-supply shortfall in various parts of the country concentrated in the province of Manabí (hydrographic systems of Jama, Portoviejo and Jipijapa), and to the East and South of the Gulf of Guayaquil (Taura systems, Balao and Arenillas-Zarumilla).

One of the main problems in Ecuador is that agricultural drainage has been neglected, in both irrigated areas and wetlands, which has caused degradation and salinization effects on soils, severely limiting the use of potentially productive areas. The latter have produced a decline in crop yields and many farmers have had to expand the agricultural frontier to increase production. The greatest challenge for Ecuador is to create a combination of financial resources, capacity building and political will. Infrastructure for water supply, sanitation and wastewater treatment is expensive, for which public and private funding sources are insufficient. There is also an enormous lack of technical capacity in the operation and maintenance of water and sanitation systems, resulting in total or partial destruction in the short term. Moreover, the lack of proper management models focusing on small municipalities and rural areas leads to unsustainable systems requiring permanent subsidies.

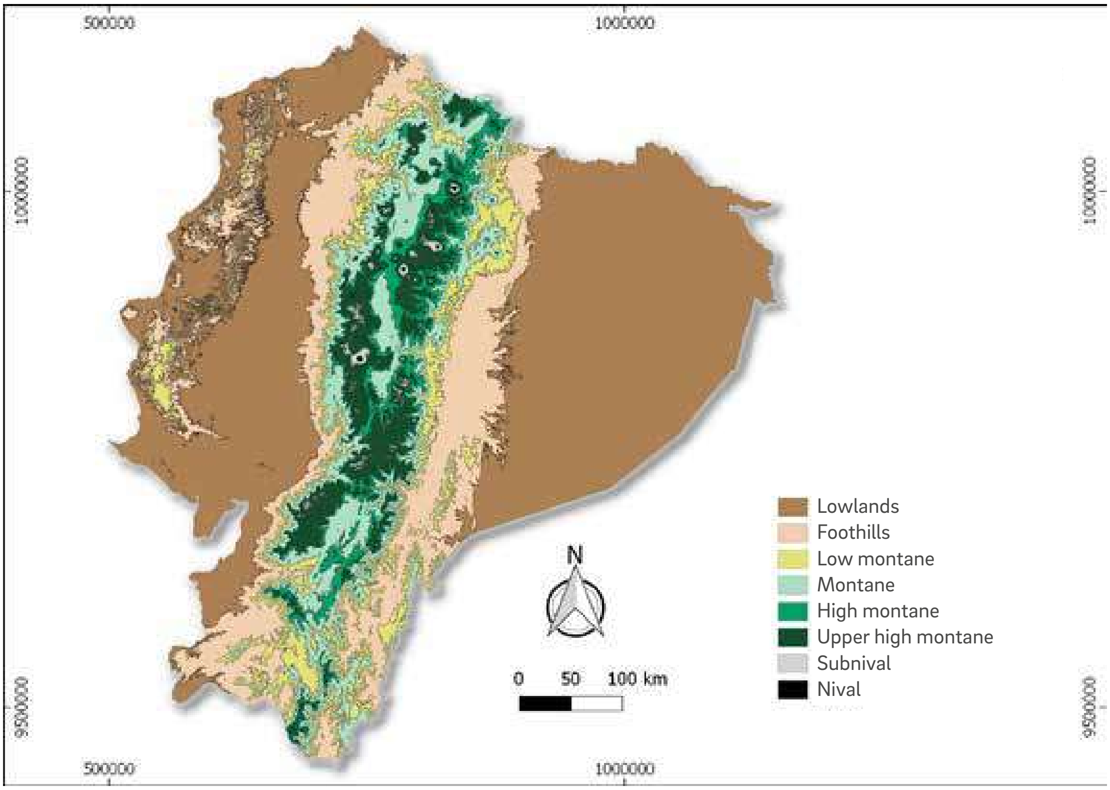
Agriculture will face complex challenges between now and 2050 to satisfy an estimated world population of 9 billion. One thing that is certain, however, is that more water will be needed to produce an estimated 60% of the additional food needed. Water issues to be addressed include: producing more food while using less water, creating resilience in farming communities to cope with floods and droughts, and using safe water technologies to protect the environment.

b. Land resources and challenges for the next 50 years

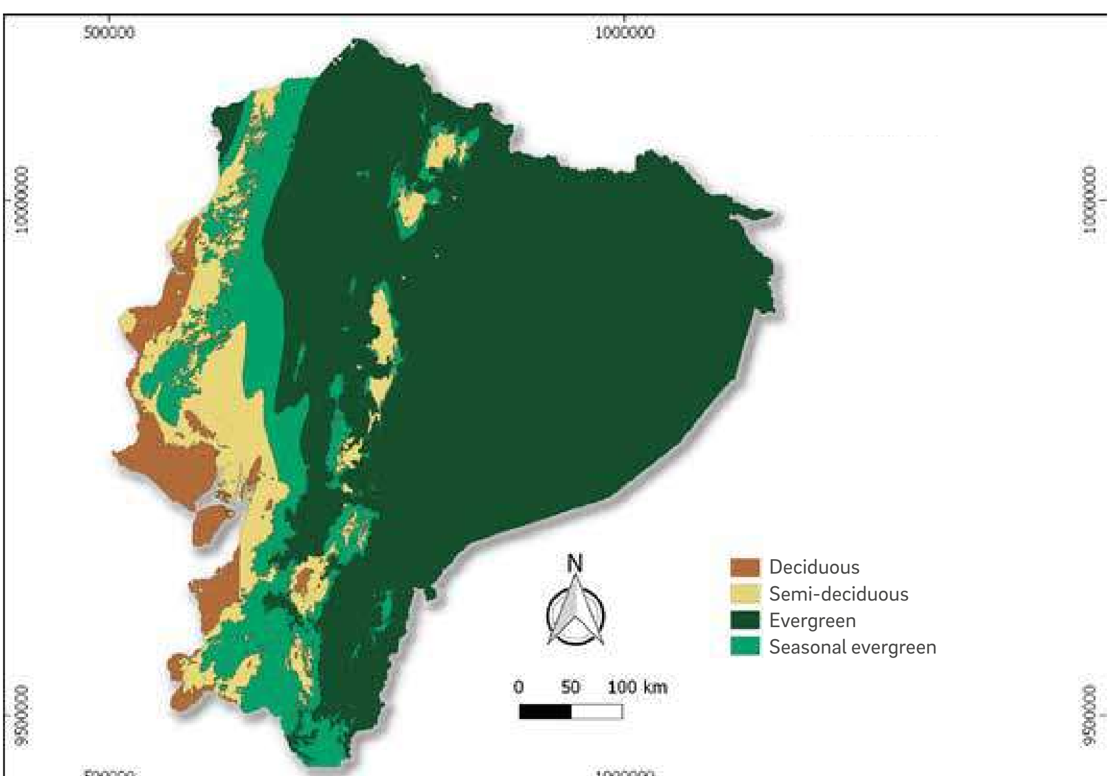
Ecuador is divided into three continental regions: Coastal, Andean and Amazonian, in addition to an island region: the Galapagos Islands. The coastal region, lying between the Pacific Ocean and the Andes Mountains, consists of lowlands and mountains. The greatest difficulties are undoubtedly faced by pastures in the high Andes, particularly in the drier parts of the mountain chain (FAO, 2016). In Ecuador, there is a significant degree of indigenous communal coordination. Rural development initiatives can therefore be effectively supported by these organizations, although one of the main challenges they face is the scarcity of economic options available at these altitudes.

The main limitation of animal pastures is availability, followed by the quality of fodder, in an environment where growth is severely limited by low temperatures and rain, hampering the process of restoring grassland. Whenever strategic

Map 1. Bioclimatic zonation of Ecuador



Map 2. Phenological patterns of Ecuador



irrigation is available, these limitations can be overcome through strategic supplementation of animal feed with planted pastures. The yield of *Lolium* and alfalfa species, as well as grasses with white clover, can achieve reasonably high levels through fertilization with nitrogen and potassium. However, a higher level constraint on the application of these solutions is the lack of policies and credit, coupled with limited consultancy services, as well as the inaccessibility to many of these services in many parts of the upper Andes.

It should be noted that native Andean grasslands, particularly in the moors, have been overexploited for decades. Given the severe climatic conditions, reversal of this situation is only possible in the long term and if suitable policies are available that take into account the assessment of their biodiversity and the ecosystem services they offer. These are challenges that have yet to be addressed by government agencies. This is unlikely due to more immediate concern with the promotion of high value export crops and other products mainly produced in the lowlands.

c. Energy Challenges

In Ecuador, the oil sector accounts for over half the country's export earnings and about two-fifths of public-sector revenues (CIA, 2017). A nationalistic approach to resources and debates over the economic, strategic and environmental implications of oil-sector development are prominent issues in Ecuador's policy and those of its government. Ecuador is the smallest producer in the Organization of Petroleum Exporting Countries (OPEC), yielding 556,000 barrels per day (bbl/d) of oil and other liquids in 2014, of which crude oil production accounted for 555,000 barrels a day (bbl/d). The lack of sufficient national refining capacity to meet local demand has forced Ecuador to import refined products, limiting net oil revenues (U.S. Energy Information Administration, 2011: 1-2).

The Ishpingo-Tambococha-Tiputini (ITT) fields in Yasuní National Park have an estimated 846 million barrels of reserves. The development of the ITT region could be challenging and costly. To minimize costs and environmental damage, ITT projects require foreign investment and experience in horizontal drilling. It is unlikely that the necessary investment and experience will be achieved, given the pro-nationalist position of the current Ecuadorian Government. The resistance to the development of indigenous groups also poses operational challenges.

Ecuador has relatively small natural gas reserves and a limited natural gas market (US Energy Information Administration, 2011: 6). In January 2015, Ecuador had an estimated 212 Billion cubic feet (Bcf) of natural gas reserves. The country's gross natural gas production was 54 Bcf in 2013, of which 37 Bcf were sold and the remainder flared and vented. Low natural gas-use rates in Ecuador are mainly due to the lack of infrastructure needed to collect and market natural gas (US Energy Information Administration, 2011: 6).

In 2014, hydroelectricity accounted for over 45% of the country's electricity. The other major source of electricity is a group of conventional, oil-fired power stations. Ecuador has over 200 power plants, 89 of which supply power to the national grid (US Energy Information Administration, 2011: 5). The other major source of electricity supply is the series of conventional thermal power plants in Ecuador, mainly designed to burn oil.

Of the renewable non-hydrogen fuels, bagasse - a fibrous residue from processed sugar cane - is used in industry, while traditional biomass is employed in rural households. However, traditional biomass consumption estimates are inaccurate because biomass sources (firewood, charcoal, manure and crop residues) are not normally marketed in markets. Ecuador also has limited wind and solar capacity, supported by feed-in tariffs (U.S. Energy Information Administration, 2011: 3).

d. Conflicts and challenges for biodiversity

Ecuador is one of the world's most biodiverse countries and has nearly 25,000 species of vascular plants, with high endemism distributed throughout its geographic regions (Tapia et al., 2008: 19), and the forests in the Western Amazon are characterized by high plant diversity. Over the past few years, a large part of these forests have undergone intense exploitation, experiencing large-scale genetic erosion in certain plant species such as Ecuadorian ivory palm (*Phytelephas aequatorialis*), Laurier (Ocotea spp.) and Royal palm (*Ynesa colenda*). Cloud forests (between 900 and 3,000 meters above sea level [masl]) are home to about half of Ecuador's plant species, although they occupy only 10% of the country's area. They are particularly rich in plants from the *Bromeliaceae* and *Orchidaceae* families. The various geographic regions are extremely rich in wild relatives related to cultivated species such as potato, bean, tomato and tropical and subtropical fruit trees. The country's natural forests are also home to the wild relatives of species such as avocado (Persea spp.) and papaya (Carica spp.). The high diversity of medicinal species is used on an everyday basis for the treatment of innumerable diseases, thanks to the traditional knowledge developed over thousands of years and advances in ethnobotany.

i. Problems associated with overexploitation

Overexploitation refers to the collection of a renewable resource to the point of diminishing yields. Sustained overexploitation can lead to the destruction of the resource. The term applies to natural resources such as wild medicinal plants, grasslands, game animals, fish stocks, forests and aquifers.

Ecuador has limited information on the distribution and current status of wild species and local cultivars, although habitat destruction, changes in dietary habits, logging, oil exploitation, shrimp farming, Industrial monocultures and highway construction are obviously among the factors that contribute to genetic erosion. Deforestation in Ecuador is considered to be most serious in the Amazon basin, affecting more than 137,000 ha a year. The Amazon region and the Galapagos Islands have been identified as the most important areas for conducting studies for drawing up inventories and ensuring the conservation of genetic resources, due to their high susceptibility to the dangers of genetic erosion caused by the expansion of agricultural areas and road infrastructure, urban settlements, the introduction of invasive plants and animals and oil drilling (Tapia et al., 2008: 20).

The second place is the Sierra region, which faces threats of deforestation and soil erosion causing a great loss of Andean biodiversity. Although the natural vegetation has been almost entirely replaced by crops and urban settlements, indigenous communities still continue to plant and conserve multiple traditional varieties of various crops. The most important ones are maize (*Zea mays*), potato (*Solanum tuberosum*), sweet potato (*Ipomoea batata*), melloco (*Ullucus tuberosus*), oca (*Oxalis tuberosa*), white carrot (*Arracacia xanthorrhiza*), quinoa (*Chenopodium quinoa*), Andean lupin (*Lupinus mutabilis*), beans (*Phaseolus vulgaris*) and other Andean grains, tubers and roots. The coastal region is the country's most exploited area, where the damage caused by timber and shrimp companies and extensive farming systems has destroyed nearly all dry forests and coastal mangroves.

ii. Exhaustion of genetic diversity

The diversity of genetic resources for food and agriculture (in other words, plants/crops, animals, aquatic resources, forests, micro-organisms and invertebrates) plays a crucial role in meeting basic food and human nutrition needs (FAO, 2017). It is essential to maintain and improve the efficiency and resilience of production systems, as well as to contribute to sustainable food supply and the provision of ecosystem services, such as pests and disease control.

Genetic resources are the raw materials that local communities and researchers rely on to improve the quality and yield of food production (FAO, 2017). When these resources are eroded, humanity loses the potential means of adapting agriculture to new socioeconomic and environmental conditions. Because of their genetic variability, plants, animals, microorganisms and invertebrates are able to adapt and survive when their environments change. Maintaining and using a broad range of diversity - both interspecific diversity and intraspecific genetic diversity - involves maintaining the capacity to meet future challenges. For example, plants and animals that are genetically tolerant to high temperatures or droughts, or resistant to pests and diseases, are of great importance in adapting to climate change.

The diagnosis of genetic erosion in Ecuador is limited and the government has experienced enormous difficulty in combating the gradual loss of genetic diversity. Although Ecuador recognizes the importance of assessing genetic erosion and vulnerability, the methodologies for conducting these types of studies have only just been established. The FAO Early Warning System (WIEWS) is an important tool for assessing genetic erosion in Ecuador. External support is therefore crucial to having the equipment and personnel needed to meet the WIEWS goal. The creation of a National Commission on Genetic Resources and the reactivation of the National Working Group on Biodiversity (GNTB) are the appropriate spaces for developing and using appropriate monitoring and alert systems (Tapia et al., 2008). It is also necessary to provide external support to develop efficient systems with administrative, technical and financial structures that will allow immediate decisions to be made when the system warns of a situation of genetic erosion (Tapia et al., 2008: 32).

e. Implications of forest trends

In early 2013, Ecuador was one of the 12 countries involved in an Interpol operation to combat the illegal timber trade in Central and South America (Forest Legality Initiative, 2014). Ecuador has also prioritized the reduction of its deforestation rate through a number of national policies and is the first country to grant inalienable rights to nature in its Constitution. It also launched the Forest Partner Program in 2008 to encourage the protection of forests. Finally, the government developed the Good Living Plan in 2009, and established a national target to reduce deforestation by 30% by 2013.

In 2008, the Ecuadorian people approved a Constitution that was the first in the world to recognize the rights of nature (Forest Legality Initiative, 2014). Forests were declared fragile ecosystems, therefore, special protection was given to moors, wetlands and mangroves. The Ecuadorian Constitution recognizes the inalienable right of ecosystems to exist and thrive.

The Forest Partner Program is an incentive based policy for forest conservation, developed by the Ecuadorian Ministry of the Environment. Plans have been developed for a two-pronged forest conservation and poverty-alleviation strategy. The program seeks to achieve its two-fold objectives by offering direct monetary incentives per hectare to local landowners and indigenous communities that preserve native forests. Since its inception, the program has been expanded to include areas with higher altitude prairies (moors) and forest restoration. Since October 2012, the Socio Bosque program has protected more than 1.1 million ha of native ecosystems and has over 123,000 beneficiaries.

f. Potential impacts of climate change

Global Climate Change is regarded as the most serious, critical environmental problem facing mankind this century. The term refers to the increase in the Earth's surface temperature due to the rapid increase in the concentration of greenhouse gases in the atmosphere. These variations will have a direct impact on certain climate parameters (National Aeronautics and Space Administration [NASA], 2017).

Climate change is expected to increase pressure on water resources, with a wide range of impacts on humans and the environment. By modifying the water cycle, including rainfall, soil moisture, runoff, evaporation, atmospheric vapor and water temperature, climate change will result in more extreme conditions. The increasing variability of traditional climate patterns, in both time and space, compounded by other global changes such as urbanization, change in food consumption and migration, has exacerbated existing pressures on water resources in the Americas, including Ecuador.

Ecuador is a relatively small developing country, thus making only a marginal contribution to greenhouse gases (Tapia et al., 2008: 15). However, climate change is a global problem that affects all countries, particularly developing ones, such as Ecuador. Accordingly, it signed the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, which establishes the need to address the mitigation of these gases. Given that the vulnerability to climate change of developing countries is higher than that of developed countries, climate change adaptation strategies and actions identified in Ecuador will have high priority, although national sustainable development policies must also be prioritized.

g. Resilience to extreme events

Ecuador's geographical location and its rugged topography make it particularly vulnerable to the impacts of climate change. Wet and dry seasons have shifted or become longer and more intense, moors have been degraded, glaciers have receded (losing 30% of their mass in the past 30 years) and the ability of ecosystems to regulate the water supply has declined (Hines, Alvarado and Chiriboga, 2013: 1). Variability and climate change threaten livelihoods, food and nutritional security and communities' food sovereignty. The challenges of extreme weather events are expected to become more frequent. In the past decade, Ecuador has lost more than $4 billion USD as a result of droughts, together with $70 million USD due to floods in 2012.

Climate-related disasters affect key sectors such as agriculture, water resources, fisheries, infrastructure and tourism, and are particularly damaging to rural areas with large indigenous and Afro-Ecuadorian populations. Climate variability, including the increasingly frequent and intense El Niño and La Niña phenomena, together with pockets of food insecurity and poverty, have led Ecuador to prioritize sound planning and replicable implementation models to address these threats.

Ecuador has launched a project to build resistance to climate change and improve food security in four provinces (Pichincha, Azuay, Loja and El Oro) (Hines et al., 2013). The government launched the project in cooperation with the United Nations World Food Program (WFA), supported by the Adaptation Fund (UNFCCC), to restore community and ecosystems and reduce climate vulnerability. The project brings together communities and local authorities, several branches of national government and the United Nations World Food Program. Its two pronged approach involves developing community awareness and concrete plans for adaptation actions, within an ecosystem-based approach.

h. Future prospects

With its diverse range of natural environments - from the coastal plain, high mountains to the Amazon jungle - Ecuador is expected to experience a number of impacts due to climate change (Nachmany et al., 2015: 3). As a relatively small, middle-income country, Ecuador does not support emission targets for developing countries that do not cause large anthropogenic emissions. However, the government has now made climate change adaptation and mitigation one of its objectives. The Constitution establishes that Ecuador will "adopt policies to mitigate climate change" and promote the development and adoption of clean technology (Nachmany et al., 2015: 4).

The ambitious, wide-ranging national climate-change strategy fits into a broader development strategy. Its aim is to protect the country's biodiversity, a fundamental resource for health and well-being. The strategy is closely linked to other policy areas: the sectors prioritized in the National Plan for Good Living also receive priority in the national strategy for climate change in order to provide policy coherence. These priority areas are: agriculture and livestock security, development of fisheries and aquaculture, maintenance of water supply and natural ecosystems, tourism development, infrastructure improvement and strengthening human settlements. The strategy is part of a broader set of measures under the new constitution being put in place to promote more sustainable development in Ecuador.

IV. Technology and Innovation

a. Role of biotechnology in agriculture and livestock

According to the Convention on Biological Diversity (UN, 1992), 'biotechnology' is defined as "any technological application that uses biological systems and living organisms or their derivatives for the creation or modification of products or processes for specific uses". According to this definition, agriculture and traditional breeding techniques for plants and animals could be regarded as biotechnology. A broader, more modern approach to biotechnology includes the use of genetic manipulation techniques, tissue culture, molecular markers, among others, to obtain organisms or products with desirable qualities. The use of certain biotechnologies, such as Genetically Modified Organisms (GMO), has been controversial and in Ecuador their adoption has been limited for reasons that will be discussed later. However, there is evidence that the adoption of GMO has resulted in increased crop productivity, lower use of agrochemicals, increased nutritional quality of food and greater tolerance to biotic and abiotic stress (Adenle, 2011; Hellmich and Hellmich, 2012; Klümper and Qaim, 2015; Pérez-Massot et al., 2013; Zhang, Wohlhueter and Zhang, 2016). They are unquestionably a useful tool in the search for food and nutritional security in Ecuador.

The use of GMO is not a panacea, however, and other technologies must be adopted to meet the demand for food in future decades. Table 3 shows the yield changes for maize, wheat and rice, according to the technology adopted, considering scenarios of both higher and lower temperature and rainfall, modeled by Rosegrant et al. (2014). These environmental conditions would be possible scenarios in a changing climate, as expected in the future. According to this model, wheat in Ecuador would benefit most from the use of technology to raise yield, while maize and rice would also experience significant increases. Ecuador imports almost all of the country's wheat demand, estimated at 800,000 metric tons in 2016 (US Department of Agriculture [USDA], 2016a). Achieving an increase in the yield and production of wheat and other cereals would contribute significantly to the country's food security through the adoption of simple technologies such as non-tillage. Wheat cultivation in Ecuador and its production have declined enormously since the 1970s. Several factors have contributed to this reduction, including low yield and the susceptibility of varieties to diseases such as rust, low wheat prices, the higher quality of imported wheat and marketing systems that mainly benefit intermediaries. Wheat now has a substantial government subsidy for its importation, which places the few domestic producers at a disadvantage.

The use of other more advanced technologies, such as precision agriculture, could also significantly increase the yields of several products, according to the Rosegrant et al. Model (2014). However, their adoption would be limited by costs and the use of complex technology. Methods such as precision farming are not practical for small landholders in Ecuador, at least in the near future. Small farmers, those most in need of solutions to ensure their food and escape from poverty and malnutrition, need simple, effective, low-cost technologies.

As for the use of modern biotechnology for cattle breeding, although Ecuador does not develop or commercialize genetically modified

Table 3. Increase (%) in yield of maize, wheat and rice in Ecuador by 2050, by use of technology, under higher and lower temperature and rainfall climate conditions and without irrigation

Technology	Higher temperature and rainfall			Lower temperature and rainfall		
	Maize	Wheat	Rice	Maize	Wheat	Rice
Without tillage	43.3	124.2	NA	37.7	123.4	NA
Drought tolerance	7.0	17.1	1.8	11.8	15.1	3.4
Heat tolerance	7.2	42.8	1.2	12.4	29.2	4.6
Integrated soil fertility management	14.6	55.4	22.2	16.7	34.5	17.8
More efficient nitrogen use	27.5	9.2	26.3	24.1	9.5	32.5
Precision farming	1.1	78.4	16.6	0.7	42.9	10.9
Rainwater collection system	0.2	35.3	NA	0.5	24.2	NA
Crop protection from disease	12.1	12	17	12.7	14.4	17.2
Crop protection from insects	9.1	4.4	13.1	8.8	4.3	14.0
Crop protection from weeds	11.8	8.2	10.6	12.2	8.2	10.5

Sources: Agritech Toolbox, 2017; Rosegrant et al., 2014. *NA = Data Not Available.

animals, there are no laws or regulations prohibiting or limiting their use (USDA, 2015). The use of technologies in animal husbandry, particularly in the area of disease diagnosis and vaccine production, is an incipient area in Ecuador, which, if implemented, could result in a more productive activity and economic benefits for farmers and the population in general (Madan, 2005). Biotechnologies aimed at improving reproductive physiology, animal health and nutrition should be adopted and developed.

b. Prospects for novel agricultural products

Like the rest of the world, Ecuador will be affected by climate change, and technology must provide novel solutions to produce more food under conditions of drought and high salinity, in addition to ensuring high yield and pest and disease resistance. Innovation must be able to offer agricultural products that are also environmentally friendly, in other words, that will help reduce greenhouse gas emission and guarantee more efficient use of soil nutrients to reduce the use of nitrogen fertilizers (Global Food Security Index, 2015).

Ecuador is one of the few countries regarded as mega-diverse (Myers, Mittermeier, Mittermeier, da Fonseca and Kent, 2000). It has a rich genetic stock from which genes could be obtained through the use of biotechnologies and used to improve crops with greater resistance to the changing populations of pests and diseases, or adverse environmental conditions that reduce food productivity. Likewise, genetic diversity can be used to develop products with better nutritional value. It is the responsibility of the government and Ecuadorians to ensure the conservation and proper use of these resources.

c. Opportunities and obstacles for the management of new technologies

In order for a technology to be successful, it must first be accepted and adopted. In Article 401, the Ecuadorian Constitution of 2008 declared the country free of GMO. There is therefore a legal impediment to the use of technologies that could help make Ecuador self-sufficient in food and with a well-nourished population. However, Article 281 of the same Constitution also stipulates that it is the state's responsibility to ensure adequate scientific and technological development to achieve food sovereignty and regulate biotechnology use and development. In fact, Ecuador has already developed methodologies to modify bananas, for example, to deal with black sigatoka disease (Santos et al., 2016). INIAP has begun trials with genetically modified maize to evaluate its usefulness in Ecuador, which would be permitted under Ecuadorian laws (USDA, 2016b). Ecuador therefore has the capacity to develop research on new biotechnological products. With clearer legislation and uncomplicated procedures for the use and development of biotechnological products, with investment capital, infrastructure and training, Ecuador could achieve food security through biotechnology.

The use and development of new technologies must go hand in hand with public education campaigns to prevent a negative perception of the use of biotechnologies in human and animal feeding, which could affect the extent of their use. There are examples in the Americas, such as the US, Canada, Brazil or Argentina, where new biotechnologies have been adopted that increased yields of agricultural products to the point that they produce more than these countries consume (Clapp, 2017). With the appropriate use of new biotechnologies, Ecuador could also achieve that level of productivity.

d. Development of marine/aquatic resources

Fishing and aquaculture are an important economic activity in Ecuador. Fish and seafood exports account for 12% of the country's total exports, second only to oil and equal to banana. The main fishing product is tuna, Ecuador's tuna industry being the largest in the South Pacific (FAO, 2011). There is an important artisanal fishing activity which, according to the latest available data from 2013, created a local market of approximately $200 million USD per year (Martinez-Ortiz et al., 2015).

Ecuador has enormous potential for aquaculture development, a sector that has experienced significant growth in the past 30 years in developing countries (FAO, 2011b). The Ecuadorian government is seeking to diversify aquaculture for marine and freshwater products, which have mostly been based on shrimp and tilapia cultivation, to contribute to achieving food sovereignty (MAGAP, 2017b). Moreover, the government, through public entities related to aquaculture, is attempting to make this sector sustainable. This not only requires the adoption of relevant technologies, but also appropriate dissemination and training in the use of technology for the population engaged in this activity (MAGAP, 2017b).

Among the technologies applied to the development of aquaculture, the most important ones are related to the reproduction and genetic improvement of livestock, an activity that has yet to be fully exploited in agriculture. Other techologies include disease diagnosis techniques, vaccine development, the use of bioremediation techniques to reduce the environmental impact of commercial activity and methods based on molecular techniques for the early detection of toxic algae (FAO, 2011b).

With regard to the challenges for industrial and artisanal fisheries, adequate management plans should be developed to avoid overexploitation of resources. However, further studies are needed on the composition of the species being exploited and their population dynamics are needed in order to make better recommendations. There is a need for educating large and small fishing communities about the importance of the integrated and sustainable management of fishery resources, and for support to boost fishing activity so that it is competitive and productive as well as a contributor to the social and economic development of the population engaged in this activity.

V. Increased efficiency of food systems

a. Outlook for increased technology-based agricultural production

Modern technologies, including biotechnology, such as propagation and artificial insemination, could be used to boost agricultural and livestock production. In order to develop suitable varieties for the market or a food product, proteomics and meta-genomics would be useful for increasing production. The use of meteorological information and Geographic Information Systems (GIS) for the production and monitoring of production would help expand production.

b. Infrastructure needs

Although Ecuador has research laboratories at its universities and research centers, they are insufficient and lack the resources to be able to undertake studies, particularly consumables that are required even when the necessary equipment is available. Basic scientific studies require internal funding. However, external funds are required for nearly all research projects, and tend to be limited extent to large research teams.

There is a need for an ongoing upgrade of equipment and technologies at research centers and universities, but this implies resources that must be provided through research projects.

c. Aspects related to food use and waste minimization

The country's poor performance in food production and manufacturing means that joint cooperation between industry and research centers must be encouraged and financed.

Post-harvest losses can be reduced through the application of cooling treatments and the use of coatings and storage in modified or controlled atmospheres or containers, as required.

Manufacturing processes, unit operations and the application of technological alternatives must be optimized to reduce waste and increase their value. Joint work between industry, academia and research centers in general is therefore important.

d. Conflicts, if any, between food production and energy and fiber production

Many industries have failed to optimize energy use and, in order to reduce consumption, most require the implementation of new facilities or the modification of existing ones, which requires investment. The relatively low cost of energy in Ecuador obviates the need to optimize its use, which is compounded by the lack of ecological awareness. Production units are relatively small and require technical-economic analysis prior to the implementation of energy generation systems from the by-products of agroindustrial industries.

At the same time, biofuel has begun to be produced from non-traditional plant species, but requires the use of land intended for food production. There are currently initiatives with mediocre results, although in the future, conflicts may arise as a result of this activity.

The cultivation of plants for fiber production is relatively low, with abaca and cabuya being the species cultivated specifically for this purpose.

VI. Health Considerations

a. Foodborne diseases

Through the National Directorate of Food Safety, Ecuador carries out actions to prevent foodborne diseases, its mission being: "To guarantee the quality of food in its primary phase of production, through the implementation of good production practices and the control of contaminants in agricultural products to ensure the country's food sovereignty" (AGROCALIDAD, 2017).

The Management Program for the Certification of Primary Production and Good Practices has published Good Agricultural Practices (BPA) Guides and Manuals, as well as Manuals for Good Livestock Practices (BPP). There is also a national program for the Monitoring and Control of Pollutants in Primary Production (ResolutionDAJ-20133EC-0201-0096), which defines the control and monitoring of pollutants, maximum permitted levels and areas of use for products consumed at the national level, produced in the country, imported or for export.

The Ministry of Health, through the Under Secretary of Public Health Surveillance and National Epidemiological Surveillance Directorate, has reported salmonella infections among waterborne and foodborne diseases. A decline in cases was observed in 2014 and 2015, although unfortunately, at the end of 2016, an upsurge was reported in the last four months, registering 120 new cases (Ministry of Public Health [MSP], 2016: 12). It is important to note that the Ministry of Health monitors cases at the national and province level. In the case of food poisoning, monitoring is conducted at the national level by age, gender and zone. At the national level, the most vulnerable group reported in 2016 is the male and female population aged 20-40 years (MSP, 2016: 13).

The number of cases of Shigellosis did not vary significantly from 2014 to 2016, with 25 cases being reported in 2015 (MSP, 2016: 14).

b. Overconsumption

Article 1 of the Ecuadorian Constitution stipulates that, "Persons and communities have the right to safe, permanent access to healthy, sufficient and nutritious food; permanently produced locally and in accordance with their cultural identities and traditions. The Ecuadorian state will promote food sovereignty". Regulations for processed food labeling have increased in recent years, for both imported and domestically produced food.

Ecuador is largely an agricultural country and food is available year-round due to its microclimates in the three natural regions. Nevertheless, prices may vary depending on the production of a particular item.

In the past two years, imports of fruits from both Colombia and Peru has been observed in months where national production has been low or non-existent. The price of these goods is obviously much higher than that of domestically produced fruit.

The National Health and Nutrition Survey (ENSANUT, 2012), undertaken by the Ministry of Public Health, conducts a study of maternal and child health, sexual and reproductive health, nutritional status, risk factors for the most prevalent chronic diseases and physical activity and sedentary lifestyles.

The prevalence of inadequate protein intake at the national level for 2016 is 6.4%. However, among individual groups the indigenous population had the highest rate at 10.4%, and the Rural Andean Region categoryhad a rate of 10.9%.

Rice is an important feature of the diet and the main source of energy (33%), carbohydrates (48%), and even protein (19%). There is excess consumption of carbohydrates and fat nationwide, particularly among the indigenous population and on the rural coast. Consumption of fruits and vegetables at the national level is 183 g/day, which is a very low value, and consequently there are programs to increase fruit and vegetable consumption. The most widely consumed processed food is sodas, whose national prevalence value for 2016 was 81.5% (INEC, 2014b: 299 and 312).

c. Expected changes in consumption patterns (and implications for food imports)

The prevalence of consumption of processed foods (soft drinks and other beverages, fast food and snacks) in the population ages 10-19 years reaches 81% for soft drinks, while the consumption of snacks stands is 64% (INEC, 2013: 31). Obesity and overweight levels have increased among the population. As a result, the prevalence of diabetes in the population aged 10-59 years at the national level (blood glucose >126 mg/dL) is the same for the population aged 50-59 years at 10.3%.

In relation to the prevalence of hypercholesterolemia (>200 mg/dL), hypertriglyceridemia (>150 mg/dL), and LDL (5) 59, according to the 2013 survey, this increases with the respondents' age, reaching values of 51.1, 43.1, 40.5, and 39.4, respectively. In order to improve this nutritional situation, the sale of junk-food products in the vicinity of schools and schools has been regulated to reduce the consumption of these products.

Ecuador is the first Latin-American country to adopt the traffic light system in its food products to alert consumers to the amount of fats, sugars and salts they contain. The guide for food labeling is available in the Food Labeling Regulations for Human Consumption, prepared by the National Agency for Health Regulation and Control (ARCSA). The traffic light system is based on the use of colors to indicate the level of products: Red is the maximal alert for excess of salt, sugar or fats in a food, yellow is a warning, and green has zero risk. Thus, the entire Ecuadorian population receives clear, simple information about what it eats.

This new system is an innovative method that will help prevent cases of obesity and diabetes from continuing to increase. It is also a way to inform the population of the products they are consuming and ingesting, so that they can make a conscious decision about their health (MSP, 2013: 2).

d. Understand and encourage behavior change, emergency personalized nutrition

According to the 1986 Ottawa Declaration (WHO, 1986), health promotion is the process that enables people to increase control over their health in order to improve it. It not only covers actions aimed directly at increasing people's skills and abilities, but also those designed to change the social, environmental and economic conditions that impact health determinants. The process of training (empowerment) people and communities can be used to determine whether or not an intervention promotes health (World Health Organization [WHO], 1986; Davies and MacDonald, 1989).

Nutritional education at the national level is limited. There is information from commercial firms about recommendations for changes in eating habits to improve health or prevent disease. Functional foods are marketed in Ecuador and regulations are issued by the INEN so that producers can declare that their products are functional foods (Instituto Ecuatoriano de Normalización [INEN], 2011: 1). Compliance with the labeling of functional foods is limited due, among other factors, to lack of information on the target population, dose, active ingredient and the particular disease it may prevent.

However, there has been a gradual increase in the culture of health and keeping fit through exercise and encouragement to eat healthy foods, depending on consumer conditions, such as age, physical activity, physiological condition, and so on.

e. Malnutrition, vitamin A and iron deficiency

According to the nutritional surveys conducted in Ecuador in DANS 1986 (MSP, 1986) and the 2012 ENSANUT-EC (INEC, 2014b) in relation to values of Hb <11 g/dL, there were no significant changes in the population under 5, despite having programs to fortify wheat flour with iron. In Ecuador, the great problem of iodine deficiency has been overcome by fortifying table salt with iodine. The prevalence of anemia due to iron, zinc and vitamin A deficiency of 25.7, 28.8 and 17.1, respectively, is higher among children ages 6-11. The Ministry of Public Health, through the Integrated Program of Micronutrients (IMP), has presented the following strategy to combat micronutrient deficiencies: supplements (iron and folic acid tablets for pregnant women; iron syrups for children under one and vitamin A capsules for children aged 6-36 months) and fortification and diversification of the diet, all supported by the Ministry's Information Education and Communication programs (IEC). The main weakness of the IMP has been the lack of resources for the continuous implementation of the program (INEC, 2014b).

VII. Political considerations

Ecuador has several public policy strategies to guarantee food security and nutrition. These regulations are structured at different levels (from the Constitution to guidelines and regulations) to cover multiple sectors linked to the country's food production, marketing and consumption. These political considerations have permitted the proposal of various processes and projects for the promotion of food security and nutrition activities. According to the FAO, 10.9% of the population in Ecuador is undernourished. Accordingly, the country has made a major effort to meet the hunger goal of the Millennium Development Objectives (CELAC), 2017.

a. Distortions created by subsidies and other agricultural-policy models

In Ecuador the agricultural production is a purely private activity, which is why public policy guidelines require the participation of producers. Accordingly, developing the mechanisms and incentives for producers to see their interests reflected and to be encouraged to assume production guidelines is a priority (MAGAP, 2016: 364).

The state has failed to provide the incentives to meet the needs of small producers. Public efforts in this field have been partial and concentrated solely in union organizations (Chiriboga, North, Flores and Vaca, 1999: 19).

Some of the challenges that have not been achieved through the use of subsidy or incentive policies include the following: the creation of conditions for farmers and their offspring to remain in the countryside, for those who left to return and for those living in cities to be encouraged to move to the countryside; the adequate inclusion of women farmers in the various agricultural programs that exclude them today (agricultural incentives, employment, etc.) (MAGAP, 2016: 112, 191 and 365), and for subsidies to provide advantages not only for large agricultural producers, but also for medium and small farmers.

b. Promotion of nutrition-sensitive agriculture to provide healthy, sustainable diets through issues associated with resource use and food prices

Ecuador's Political Constitution establishes food as an independent right for all members of society. Article 13 stipulates that persons and communities have the right to safe, permanent access to healthy, sufficient and nutritious food; permanently produced locally and in accordance with their cultural identities and traditions. This has allowed various strategies to be promoted in order to obtain better productive results, in a more environmentally friendly way, but also to encourage the consumption of healthier foods and to combat malnutrition throughout the country (Ayaviri, Quispe, Romero and Fierro, 2016: 217 and 219).

The main strategies include: (A) promotion of more profitable, responsible production; (B) promotion of healthier, more nutritious diets - the latter with the Ecuadorian Food Program created and implemented to improve food practices and access to food in the Ecuadorian population through specific projects, and (C) the Nutrition Action Program, led by the Coordinating Ministry of Social Development, which seeks to enhance the health and nutrition of children under five through the design and implementation of public policy mechanisms and inter-institutional coordination at the national and local level.

c. Policies that encourage technological innovation

As part of the national strategy for the change of the productive matrix, the Ecuadorian State is based on a set of public policies and strategies that promote technological innovation in food production. These include:

- 2008 Ecuadorian Constitution,
- Organic Law of Rural Lands and Ancestral Territories,
- Organic Law of the Regime of Food Sovereignty,
- Organic Law of Higher Education,
- Organic Code of Production, Trade and Investment,
- Ecuadorian Agricultural Policy: Toward sustainable rural territorial development 2015-2025.

d. Policies that create human resources (education, gender, equity)

Over the past decade Ecuador has seen the improvement of human capacities, especially related to the training of human talent to strengthen the education system through third- and fourth-level education. One of the fields that have received the greatest emphasis is the renewable natural resources sector, which is covered by related national policies where people's rights and priority groups are promoted in keeping with the regime of good living.

e. Policies that seek to redesign agricultural ecology (land use, bioeconomics, etc.)

Since traditional agricultural production is directly related to environmental deterioration and alterations in these activities that have been observed in the last decades, it is essential to propose alternative policy mechanisms to solve these problems. In Ecuador, some of the proposed strategies only address the need to increase productivity, and appear to contradict some of the principles put forward as rights of nature (recognized in the Constitution). However, there are other strategies that promote the redesign of agricultural ecology in the country. These alternative policies, which seek cleaner, more sustainable production, are based on the legal bases mentioned in section C, designed to improve the contribution of agriculture to guaranteeing the Ecuadorian population's food security and sovereignty.

f. Policies to promote the consumption of healthy foods

Although the benefits of healthy food consumption have been known for several decades, one of the challenges faced by producers of this type of food is scarcity of demand. Therefore, an essential feature in achieving a healthier food culture is the promotion of the consumption of healthy products. The starting point for the implementation of strategies to encourage a healthier diet is the creation and implementation of public policies in this area.

g. The country's comparative advantages in agriculture

Ecuador is a country that relies heavily on agricultural production. In recent decades, the country's income from these activities has been its second source of income, surpassed only by oil exports.

The data presented below are a summary of the results of the analyses conducted by MAGAP in its book *The Ecuadorian agricultural policy: Towards sustainable rural development* (*La política agropecuaria ecuatoriana: Hacia el desarrollo rural sostenible 2015–2025)* (MAGAP, 2016: 71-72 and 78).

During the 1960s and 1970s, sectoral government policies, applied within a global development policy to modify the current productive model, failed to achieve their objectives. Instead, they became agrarian reforms that affected the structure of land ownership, efforts to achieve technological innovation and agricultural health and subsidized direct financing.

Between 1980 and 1992, implicit agricultural policies dominated, within the framework of macroeconomic stabilization schemes, with a direct impact on the agricultural sector. In 1992, the agricultural sector modernization strategy was implemented, introducing significant reforms that reduced state intervention in the agricultural sector. In the wake of the passage of the Agricultural Development Law in 1994, emphasis was placed on the self-regulation of markets, land and productive factor markets, and producer and consumer prices were liberalized. In addition, the subdivision of communal lands was authorized, among other key changes. All this led to a systematic increase in the contribution of the agricultural sector to GDP, yet reduced farmers' income.

The outstanding features of this policy that failed to benefit the most vulnerable producers (medium and small) were maintained until 2006. Since then, MAGAP has strived to draw up medium- and long-term agricultural policies. From 2007 onward, attempts were made to restore the state's stewardship, and its role as market regulator and a key player in politics. The last decade has seen significant progress in these policies, whose efforts have been accompanied by successes and failures. Although some progress has been made, much remains to be done to achieve more profitable, inclusive and environmentally responsible production.

h. International trade matters

The Ecuadorian agricultural sector is characterized by its marked dualism. On the one hand, there is a very dynamic export sector, which produces traditional export crops and new agroindustrial crops. On the other, there are the majority of agricultural producers, basically small and medium peasant farmers, whose production focuses mainly on the domestic market (and partly the external market). These two sectors are linked to the foreign market in very different ways.

Exports

The agricultural sector has made an enormous contribution to the country's economy, responsible for 41% of the foreign currency entering the country annually from exports surpassed only by oil exports.

Between 2000 and 2013, agriculture accounted for an average of 79% of total exports. The relative importance of agricultural exports in relation to total exports (excluding oil) was 81% between 2000 and 2013, with some positive and negative changes during this period.

Of the $11.4 billion USD in agricultural exports, primary products account for 54% and agroindustrial exports for 27%. This performance has remained constant throughout this century with some variations in 2002 and 2008. In 2013, agricultural trade with a positive balance accounted for 8% of total GDP ($7.326 billion USD), 64% of expanded agricultural GDP and 30% of the total exported that year (MAGAP, 2016: 124-127).

Imports

The high demand for imports of raw materials and capital goods that characterizes most sectors in Ecuador is not reflected in the agricultural sector. The imported component of national agricultural production accounts for 8% of agricultural GDP, reflecting this sector's self-sufficiency. Agricultural activity saves foreign exchange and pressure on the country's economy and generates foreign exchange with a favorable balance in trade with the rest of the world.

An analysis of the structure and evolution of agricultural imports by use and economic destination since 2000 shows that only 7.2% of total imports have corresponded to the agricultural sector. Major imports of raw materials and intermediate products for agriculture include cereals, soybean paste, fertilizers, fungicides, herbicides and insecticides (MAGAP, 2016: 127-130).

In conclusion, Ecuador's agricultural trade balance, despite the crisis at the beginning of the century and that of 2009, has maintained positive, increasing balances since the beginning of the 21st century.

i. Market challenges

Ecuador is a small country with an economy open to the world, whose evolution has been linked to the external sector. Its economic integration into the hegemonic centers in the contemporary era began in the 19th century as the result of a primary export model. These economic links with the rest of the world have constituted a source of wealth and growth for the country, although they have also been a source of vulnerability and instability, since they are subject to variations in the prices of export products on the international market (MAGAP, 2016: 35).

Leveraging this agricultural potential, combined with the generation of added value and its competitive advantages vis-à-vis markets (national and international), would constitute a solid basis for reducing poverty and promoting sustainable rural development. Although the effective volume of production has increased in the country, and international demand for agricultural goods has risen and will continue to grow (ECLAC, FAO, Inter-American Institute for Cooperation on Agriculture [IICA] 2012: 3), but there are market challenges the country will have to address given the external economic dynamics of the current hegemonic centers.

VIII. Abstract

a. Some potential national agricultural scenarios for agricultural production in the next fifty years

- Optimize food access for the entire population with respect to quantity and quality.
- Through the opening of international markets - especially with the signing of agreements with the European Union and China – Ecuador has the opportunity to expand its markets. At the same time, its biggest challenge will be to increase production with competitive product costs.
- The use of rapid, modern processes for genetic propagation will help lower costs and develop varieties that are resistant or tolerant to fungi, diseases, etc.
- Implement post-harvest treatments to increase the shelf life of fresh produce.
- Preservation techniques for food of plant, fish, and animal origin must be improved and added value must be given to materials.
- Use of food-safe containers.
- The use of co-products of the agricultural industry for their use in the extraction of active ingredients for human, animal and industrial consumption.
- Maintain water quality and manage the optimization of its use.
- Optimize the use of alternative or traditional energy sources.

b. High-priority actions to achieve agricultural sustainability

- Create a germplasm bank of Ecuadorian materials.
- Incorporate biotechnology as a transversal science and expand its applications.
- Study biodiversity to characterize it and guide its application in food, pharmaceuticals and industrial products.
- Transform raw materials into innovative products.
- Develop systems to generate relatively low cost energy.
- Conduct water management, availability and quality studies.
- Make high-technology equipment available to study product characterization and safety.
- Train technical specialists.

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