Food and Nutrition Security in Colombia

Popular market in the Department of Huila, Colombia. Photography of Neil Palmer

Colombia

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Its abundance of agricultural and natural resources, water, biodiversity and human talent means that **Colombia has the potential to supply food for humanity, as long as it preserves its ecosystems.**

Summary

As a result of its position and physiography, Colombia has an enormous diversity of climate zones, together with abundant agricultural and fresh water resources, an exceptional biodiversity and a wealth of natural resources. Its agriculture is characterized by technified monocultures by region (such as sugar cane, coffee, flowers, cotton, banana, banana, sorghum, maize, rice, African palm, potato and cassava). There are crops for domestic consumption, while high-value crops such as coffee, sugar cane and African palm are exported. Agriculture in Colombia will be seriously affected by climate change, both in terms of food security and agricultural socioeconomics.

In relation to food and nutritional security (SAN), Colombia ranks 10th in the Food Sustainability Index and the ninth in sustainable agriculture (2016 Food Sustainability Index), and although the percentages of malnutrition have decreased, they still persist in low-income as well as indigenous populations. A total of 12,5% of the population is undernourished. The country reflects the nutritional transition of its population, and has problems of both underweight and overweight in all the population groups.

Climate change mitigation and adaptation activities have been undertaken to address the challenges of sustainable agricultural production. Despite the current budget reduction for Science and Technology, colombian scientific and technological capacities are solid, with a long history, and there have been developments in alternative solutions to boost agricultural productivity in the diverse farming systems with territorial considerations. The aim is to boost the agricultural supply to guarantee food security and promote agricultural exports and farmers' welfare. The many initiatives implemented include: The Colombia Plants Strategy; the Mission for the Transformation of the Colombian Countryside and the Green Growth strategy.

I. National characteristics

Colombia is located in the NW region of South America (**Figure 1**), with an area of 2.129.748 km^2, 1.141.748 km^2 of which correspond to its continental territory and 988.000 km^2 to its maritime area. Of the latter, 658.000 km^2 are located in the the Caribbean Sea, and 330.000 km^2 in the Pacific. It is the fourth largest country in South America. It is organized in 32 decentralized departments and the Bogota Capital District, seat of the National Government. It is divided into six natural regions based on their ecosystems, relief and climate: Amazonian: Andean; Caribbean: Orinoco; Pacific; and islands (Archipelago of San Andrés and Providencia in the Caribbean Sea, Malpelo and Gorgona

Islands in the Pacific) (IGAC, 2012). Due to this diversity, it has abundant agricultural and freshwater resources, exceptional biodiversity and a wealth of natural resources such as nickel, copper, iron, coal, natural gas, oil, gold, silver, platinum and emeralds (OECD, 2015).

Approximately 82,5% of the country's total area is below 1,000 meters above sea level (masl), with average temperatures above 24°C. In the highlands, the climate is cold, with temperatures ranging from 12° to 17°C. Above the cold lands in the Andes are the high Andean forests and moors. Above 4.000 masl, where temperatures are very low, some glacial zones still exist. The country has approximately 42,3 million hectares (ha) suitable for agricultural production (DANE, 2015; DNP, 2015a). Agricultural potential amounts to 26,5 million ha, of which nearly 11 million are suitable for agriculture, 6 million for livestock raising, 4 million for agroforestry, 3 million for forestry production and 2 million are in bodies of water (MADR, 2016). The agricultural sector has been crucial to the Colombian economy, because of its contribution to the Gross Domestic Product (GDP), employment and exports (OECD, 2015). According to figures from the third National Agricultural Census (CNA), in 2015, Colombia had 7,1 million ha in crops. Agricultural development has been achieved despite major social and productive lags (DANE, 2015). A total of 74,8% of the area (5,3 million ha) is used for permanent crops, and 16% for transitional crops (1,2 million ha). Of the total rural area, 56,9% (62,8 million ha) corresponds to natural forests, while 38,3% (42,3 million ha) is used for agriculture.

Demographic characteristics

The population is largely the result of miscegenation among Europeans, Indians and Africans, with indigenous and Afro-descendant minorities. The Colombian Caribbean is home to a significant number of people of Middle Eastern ancestry (DANE, 2005). According to the National Administrative Department of Statistics (DANE), on June 30, 2015, the country had a population of 48.747.708. Most of the population is located in the Center (Andean region) and North (Caribbean region) of the country, whereas in the East (Llanos Orientales) and South (Amazonia), there are large areas with very few inhabitants. There has been significant movement by the rural population to urban areas coupled with emigration to other countries. The most highly developed area in Colombia corresponds to the Andean region in cities such as Bogotá, Medellín and Cali. Although over 99,2% of Colombians speak Spanish, a hundred Amerindian languages are also spoken in the country. Life expectancy is 74,79 years, infant mortality is 15,92 per thousand, coinciding with Inter-American Development Bank (IADB) figures for Latin America and the Caribbean. The driving elements of the demographics of the region are lower fertility and increased longevity. In 2015, the fertility rate was 2,15 children per woman (Marczak & Engelke, 2016).

Agriculture

Agriculture is characterized by technological monocultures by region: sugar cane; coffee; flowers; cotton; banana; banana; sorghum; maize; rice; African palm; potato and cassava. Colombia is the world's largest producer of soft

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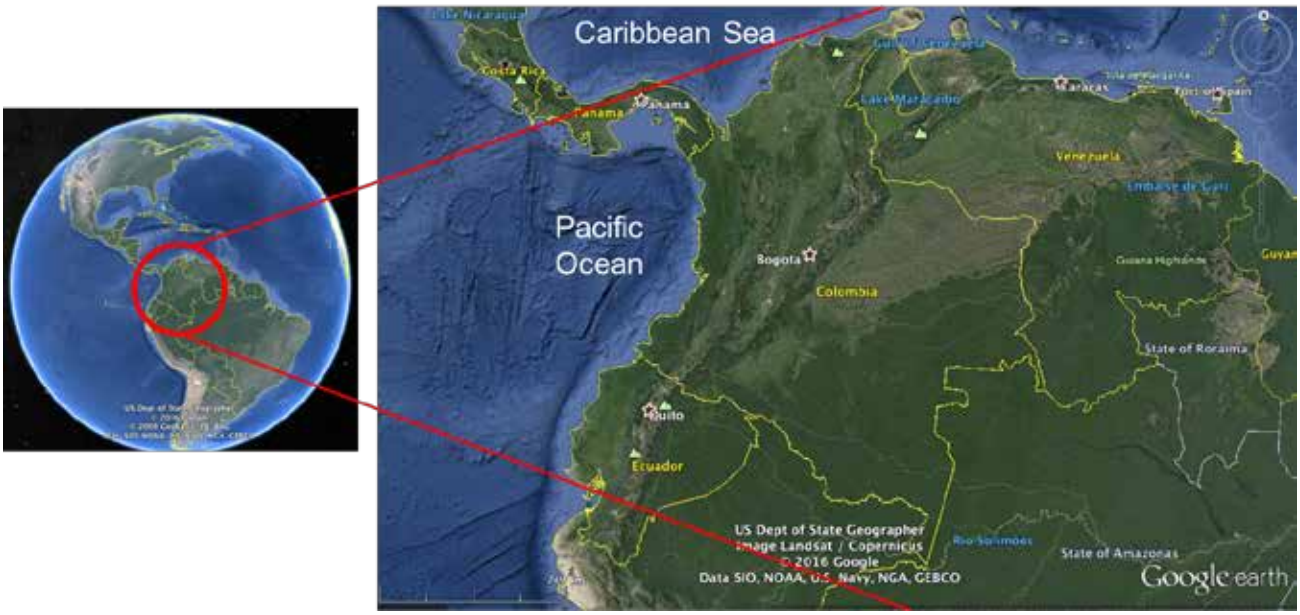
Figure 1. Location of Colombia in America



coffee. "Colombian Coffee" is a designation-of-origin protected by the European Union since September 27, 2007. This denomination is given to 100% Arabic coffee (*Coffea arabica L.*) produced in Colombia's coffee regions, located between Latitude N 1° to 11°15, longitude W72° to 78° and specific ranges of altitude that may exceed 2,000 masl (Valencia, 2012). The country has 21.4 million head of cattle, the largest number in Latin America after Brazil. A total of 66,2% of producers own fewer than 100 ha, while 53,8% own fewer than 50 ha (DANE, 2015).

To a large extent, food and nutritional security depends on the production of cereals in small plots (smallholdings) that allows them to be supplied and traded in local markets. The most important cereals are rice and corn. Perennial crops for domestic consumption and export account for 41% of agroindustrial employment. High-value export crops include coffee, sugar cane and African palm. Cacao production has mainly been implemented by small producers; Colombia has a very high potential to be a major cacao producer worldwide, and there are programs to promote its planting (Ramírez-Villegas et al., 2012). Cacao and fruit trees are chains with significant participation by small and medium producers, whereas maize, soy, rice, palm, rubber and forestry are mainly the province of large producers since they require large cultivated areas for profitable and sustainable project development (MADR, 2016).

Agriculture in Colombia will be seriously affected by climate change, both in terms of food security and agricultural socioeconomics. The country has undertaken activities to mitigate and adapt to this threat and is promoting links among research centers (national, sectoral and international), in search of alternatives for the various crop systems and their territorial characteristics. The aim is to evaluate germplasm in various regions and to study their behavior in response to a variety of conditions (both biotic and abiotic) in order to select the materials with the best agronomic behavior (Ramírez-Villegas et al., 2012). In order to support programs for the evaluation and selection of new germplasm, the International Center for Tropical Agriculture (CIAT) in Colombia and other research centers are using drones. Thematic networks for research and experimentation have been established that should be further strengthened in various regions, especially in the country's current

circumstances (after the signing of the peace agreement with the FARC guerrillas), which seek to strengthen territorial development by offering suitable alternatives to different social sectors and, additionally, to increase the area under cultivation in Colombia (MADR, 2016).

Food and nutrition security

Colombia ranks 10th in the 2016 Food Sustainability Index and ninth in sustainable agriculture according to the report prepared by The Economist Intelligence Unit and the BCFN Foundation (https://www.eiuperspectives.economist.com/sustainability/food-sustainability-index-2016).

Approximately 13,2% of children under 5 in Colombia suffer from chronic malnutrition. A total of 42,7% of the country's indigenous population live under conditions of food insecurity (FAO, 2015a). In 2013, Colombia's Intersectoral Food and Nutrition Security Commission (CISAN) officially launched the 2012-2019 National Food and Nutrition Security Plan, with the aim of ensuring that the entire Colombian population has access to and consumes food in permanent, timely fashion, in sufficient quantity, variety, quality and safety (OSAN, undated). There are several factors that affect the situation in the Colombian countryside and represent a huge challenge: the incidence of armed conflict; limited access to goods and services such as drinking water, aqueduct, sewerage and sanitary solutions; energy; health and food security. A total of 57,5% of rural households are food-insecure, compared to 38,4% of urban households (MADR, 2016).

Foreign trade

Colombia's main export product is oil. Other key activities include the textile, food, automotive and petrochemical industries, food processing, coffee production, oil, beverages, cement, gold, coal, emeralds, nickel, cut flowers and bananas (DANE, 2016).

Although Colombia only accounts for a low share of the world's agricultural market, several studies have demonstrated its potential to become a key player in the increase of the world food supply; "*It is one of the five most important countries to be a global food pantry because of its location and availability of land*" (FAO & Earthscan, 2011; MADR, 2016). In 2015, the GDP of the Colombian agricultural sector was 32,9 trillion Colombian pesos (equivalent to $11,75 billion USD), accounting for approximately 6,1% of the Gross Domestic Product (GDP). As for the labor market, the population employed in rural areas is equivalent to 16,1% of the national total (MADR, 2016). Agricultural products currently account for approximately 11% of Colombia's total exports, with a predominance of traditional products such as coffee, flowers, bananas and plantains, and sugar (OECD, 2015). Exports from the agricultural and agroindustrial sector (2010-2015 averages) show a total average of 4,2 million tons (t) for a total average value of $6.734 million USD, distributed as follows: coffee 34%, flowers and buds 19%, bananas and plantains 12%, sugar cane 6%, confectionery without cacao 4%, coffee extracts and essences 4%, palm oil 3%, livestock 2%, baked products 1% and other products 15% (MADR, 2016). Forty percent of agricultural imports are led by domestic products for which there is a high demand, such as corn, wheat and soybeans. The average amount of imports between 2010 and 2015 was 10.1 million t with an average value of $5.934 billion USD. The country has a positive trade balance mainly because of traditional products such as coffee, bananas and flowers, which are exported and whose external prices produce a trade surplus (MADR, 2016).

Challenges of Colombian agriculture

Annual agricultural output growth rates have fluctuated over the past two decades with a relatively low growth rate of 1,6% since 1990 (OECD, 2015). The main economic obstacles are the low productivity of the production units, the lag in transport infrastructure and the production, transformation and aggregation of agricultural value, low use (due to inaccessibility or low interest in the instruments available for the sector) of productive planning instruments and the incipient mitigation of agroclimate risks and access to productive land (MADR, 2016).

According to the Third National Agricultural Census (DANE, 2015), 69,9% of Agricultural Production Units (APU) have less than 5 ha and accounted for less than 5% of the area surveyed. On the other hand, 0,4% of APU have 500 ha or more and occupy 41,1% of the area surveyed. The main problem lies in the concentration of land ownership. **Figure 2** shows municipal agricultural production presented by the Agricultural Rural Planning Unit (UPRA) for 2012, highlighting the country's most productive regions. After 50 years of armed conflict, which has limited the development of the country's agricultural sector, and since the signing of the peace agreement at the end of 2016, the agricultural area is expected to expand, with significant prospects for rural development in areas previously occupied by guerrillas, while agribusinesses have an enormous potential to promote rapid growth and the restructuring of agriculture. The main challenges of the agricultural sector, essential to its growth, are: reducing energy prices to meet production; levering the agricultural and agroindustrial potential of its lands (it only uses 24% of its 22 million hectares suitable for agriculture); development opportunities by improving socioeconomic conditions in rural areas; access to financial services; and sensible management of the devaluation of the Colombian peso (ASOBANCARIA, 2016).

Many of the problems associated with agriculture and food production in Colombia stem from a set of factors recently summarized by the "MTCC" (DNP, 2015b) Mission for the Transformation of the Colombian Countryside- (DNP, 2015b). A summary of this Mission is available in **Box 2** of Section VII of this chapter, "Food and Nutrition Security Policies". The diagnosis indicates that in Colombia: i. Conflicts over land use remain; ii. There is a high concentration of informal property ownership; iii. In many areas, land use does not reflect its ideal use; iv. There is a lack of protection and poor regulation of natural resources; v. There has been asymmetrical development between the countryside and the city; vi. There are major inequalities within the rural sector; vii. Over the past 15 years, poverty has been reduced but urban-rural gaps have increased; viii. There has been some progress in social inclusion, but not in productive inclusion; ix. The scattered population in the rural sector is poorer than in

Figure 2. Municipal Agricultural Production in Colombia (UPRA, 2014)

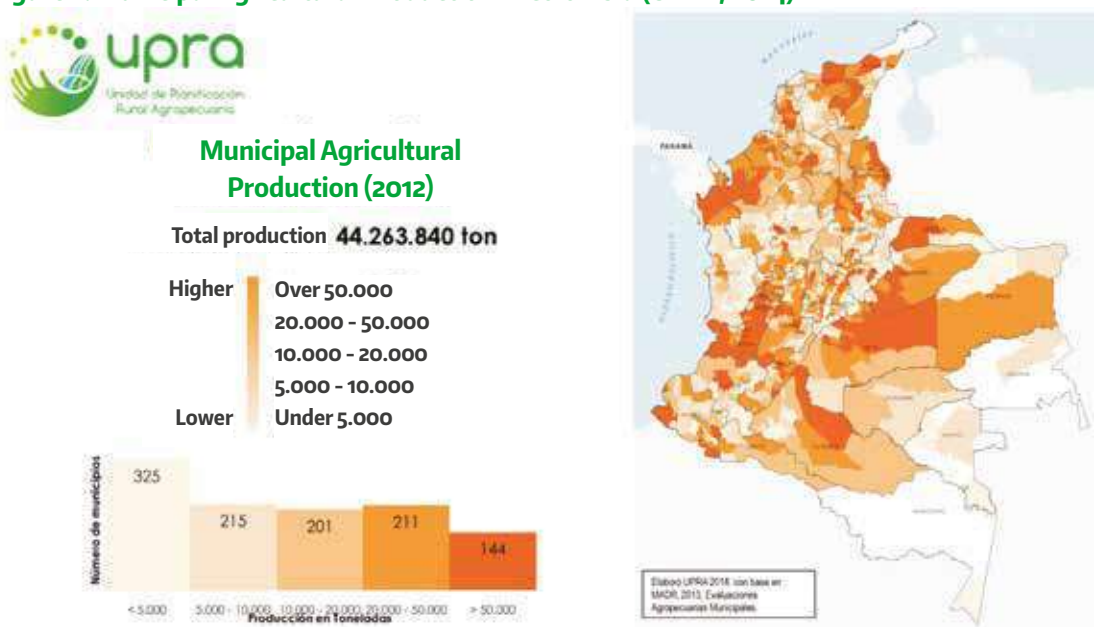


Table 1: Research Institutes in the National Environmental System, Colombia

Institute	Mission / Objectives
Alexander von Humboldt Biological Resources Research Institute (IAvH)	Promote, coordinate and undertake research that contributes to the knowledge, conservation and sustainable use of biodiversity as a factor for the development and well-being of the Colombian population.
José Benito Vives de Andreis (INVEMAR) Institute of Marine and Coastal Research	Develop research on renewable natural resources and the environment in marine and coastal ecosystems.
Amazonian Institute of Scientific Research (SINCHI)	Advance biological and social research in the Amazon region, with sustainable use of its resources. Promote business plans to adopt productive systems with good environmental and social practices in the Amazon Region and encourage the strengthening of production chains and the marketing of local products
Pacific Environmental Research Institute (IAP)	Undertake research on the Pacific Coast environment (knowledge, innovations and traditional practices, related to the natural, social and ethnocultural reality of the Biogeographical Chocó).
Institute of Hydrology, Meteorology and Environmental Studies (IDEAM)	Obtain, analyze, study, process and disseminate information on the physical environment.

the municipal headwaters, and x. The gap is higher in large cities. There are serious problems regarding the provision of social services in the fields of education and health, as well as a social security system that is almost non-existent for the rural population. It is thought that the lack of dynamism of the agricultural sector in Colombia is linked to the disarray of its institutions, as well as weak policy instruments and the Ministry of Agriculture and Rural Development's unstable budget. The section on Food and Nutrition Security Policies summarizes the main recommendations of the MTCC in relation to public policies and public investment decision-making instruments for rural and agricultural development for the next 20 years, which will help transform the Colombian countryside.

II. Institutional Context

National Agricultural Research Systems

Numerous research centers attached to the Ministries of Agriculture and Environment or trade unions, as well as groups in universities and the private sector, are formulating and implementing research and development projects focused on improving productive efficiency in the agroindustrial sector. They also seek resilient productive systems, with environmental, social and economic sustainability, and adaptation to climate change, which involve environmental, social and economic considerations. There have been significant advances in a number of sectors and, with the support of government policies, links between the academic and research sectors are being strengthened as described below.

The Ministry of Agriculture and Rural Development (MADR), which is responsible for agricultural policy and rural development, attempts to promote rural development through a territorial approach and by strengthening the productivity and competitiveness of agricultural products, as well as promoting links between institutional actions in the rural environment in a focused and systematic way, under the principles of competitiveness, equity, sustainability, multisectoriality and decentralization, for the country's socioeconomic development (MADR, 2016). To this end, it has seven organizations: The Rural Development Agency; National Land Agency; Territorial Renewal Agency; Colombian Agricultural Institute (ICA); Rural Planning Unit (UPRA); National Aquaculture and Fisheries Authority (AUNAP), and the Land Restitution Unit. It also has five associated bodies: Agrarian Bank of Colombia; Finagro; Corabastos; Vecol and the Mercantile Exchange of Colombia; and two Mixed Participation Corporations: The Colombian Corporation for Agricultural Research (CORPOICA) and the Colombia International Corporation.

Agricultural research in Colombia by government institutions is channeled through CORPOICA (http://www.corpoica.org.co/menu/qhc/), whose goal is to undertake research and technological development to transfer innovation processes to the agricultural sector in order to improve productivity and competitiveness. It has 13 regional research centers distributed throughout the country and offers extensive technological advice on permanent crops and on transitional and agroindustrial crops in diverse species, as well as on livestock and small animal species.

National Environmental System Institutes

The main players in sustainable development and applications based on biodiversity in Colombia are the research institutes attached to and linked to the Ministry of Environment and Sustainable Development (MADS), whose function is to propose sustainable technological developments in order to create products that incorporate knowledge and added value based on renewable natural resources (**Table 1**).

Research Centers and Universities

In 1938, agricultural production unions began to create their own Agricultural Research Centers known as CENI, financed by the private sector and focused on commercial crops: Ceniacua (cultivated shrimp and others); Cenibanano (banana and plantain); Cenicafé (coffee); Cenicaña (sugar cane); Cenicel (cereals and legumes); Ceniflores (floriculture); Cenipalma (oil palm) and

Box 1. National Water Study 2014 (IDEAM, 2015a)

The study undertakes a diagnosis of the status of water as both a resource and a threat in Colombia. It identifies the hydrographic subzones and watersheds that should be prioritized, to improve water resource management in terms of vulnerabilities, pressures for use and impacts on quality. It also evaluates the country's Water Footprint in relation to the amount of water used for goods and service production. The main conclusions of the study are:

- Colombia has a water yield 6 times the world average and 3 times that of Latin America. Its groundwater reserves triple this supply and are distributed throughout 74% of the country.
- Water distribution varies between the different hydrographic areas. The Magdalena-Cauca and Caribbean regions, which are home to 80% of the population and produce 80% of national GDP, produce just 21% of the total surface water supply.
- The most critical water conditions, such as pressure due to use, pollution, vulnerability to shortages and climatic variability and regulatory conditions are concentrated in the Magdalena-Cauca and Caribbean areas, comprising 110 municipalities with a population of 18 million inhabitants.
- Various water quality indicators (biodegradable and non-biodegradable pollutants, nutrients, heavy metals and mercury) are severely affected in nearly 150 cities and municipalities, including Bogotá, Medellín, Cali, Barranquilla, Cartagena, Cúcuta, Villavicencio, Manizales and Bucaramanga.
- The amount of biodegradable organic matter discharged into water systems in 2012 was estimated at 756.945 t/year, whereas non-biodegradable organic matter (chemical substances) was estimated at 918.670 t/year, with Bogotá, Cali, Medellín and Cartagena being the main contributors. At the same time, 205 tons of mercury are discharged into the soil and rivers.
- Over 300 million tonnes/year of sediment are transported by rivers, the largest contributor being the Magdalena River at the Calamar station with 140 million t/year.
- 318 municipalities with 12 million inhabitants could experience shortages during the dry season.
- A high dependency on green water was observed in agricultural and livestock sectors, which makes these economic sectors vulnerable to climate change.
- Sixteen Hydrogeological Provinces with 61 aquifer systems and a potential water supply of 5.848 km³ of groundwater were identified, mainly located in regions under high pressure due to use, pollution, vulnerability to shortages, variability and climate change.
- The total water demand in different sectors at the national level is 35.987 Mm³. The sectors with the greatest demand are: agricultural (46,6%), energy (21,5%), livestock (8,5%) and domestic (8,2%).
- The water concessioned annually amounts to 1.032 million m³. Of these, 498 million m³ (48%) correspond to the agricultural sector (450 million m³ are extracted in Valle del Cauca for the sugar industry), 25% to industrial consumption and 17% to household consumption.

CONIF (agroforestry products). CENI are linked to productive sectors, which together employ 4.684.000 Colombians, whose work in 1.414 million ha generates annual global production that meets the national demand for the various products and allows annual exports for a value of $4.448 millions USD. Production of the various goods is distributed throughout the country. They are grouped together in a network (CENIRED), to promote the scientific and technological development of the agricultural sector, the use of sustainable technologies through participatory research, and to manage, finance and monitor research and technological development plans, programs and projects through agreements, contracts and other modalities based on strategic alliances (http://www.cenired.org.co/index.php/corporativo-cenired).

A key complement to the strengthening of research capacity in the agricultural sector in Colombia is Palmira, home to the International Center for Tropical Agriculture (CIAT), which is part of the CGIAR Consortium, an international organization composed of 15 member centers committed to research for a future with food security. Several institutions have technical and scientific cooperation activities and receive advice or training and technical training from CIAT.

There are also associations - Research Centers/Consortia - most of which work with emerging and leading-edge technologies such as molecular techniques, some for the genetic transformation of material-of-agricultural-interest, as well as phytochemistry/bioproducts, in biological control and development of biofertilizers. Their main objective is the strengthening of business, the development of productive processes and supply services and the efficient scaling and commercialization of products developed by research groups.

For strengthening of capacities, especially in relation to human resources training and training in state-of-the-art technologies such as meta-genomics, proteomics, molecular markers and bioinformatics, the National Agency for Science and Technology - Administrative Department of Science, Technology and Innovation (COLCIENCIAS) - has attempted to rationalize the use of scientific, technical, infrastructure and financial resources by promoting the establishment of Centers of Excellence, which bring together various institutions and research groups from universities throughout the country around an issue-of-interest with defined objectives. The following institutions promote research, development and innovation: Colombian Center for Genomics and Bioinformatics of Extreme Environments (GEBIX); Center for Bioinformatics and Computational Biology of Colombia (CBBC); Center for Basic and Applied Interdisciplinary Studies (CEIBA); Center for Research and Studies on Biodiversity and Genetic Resources (CIEBREG), and the National Research Center for Agro-industrialization of Tropical Medicinal Aromatic Plant Species (CENIVAM).

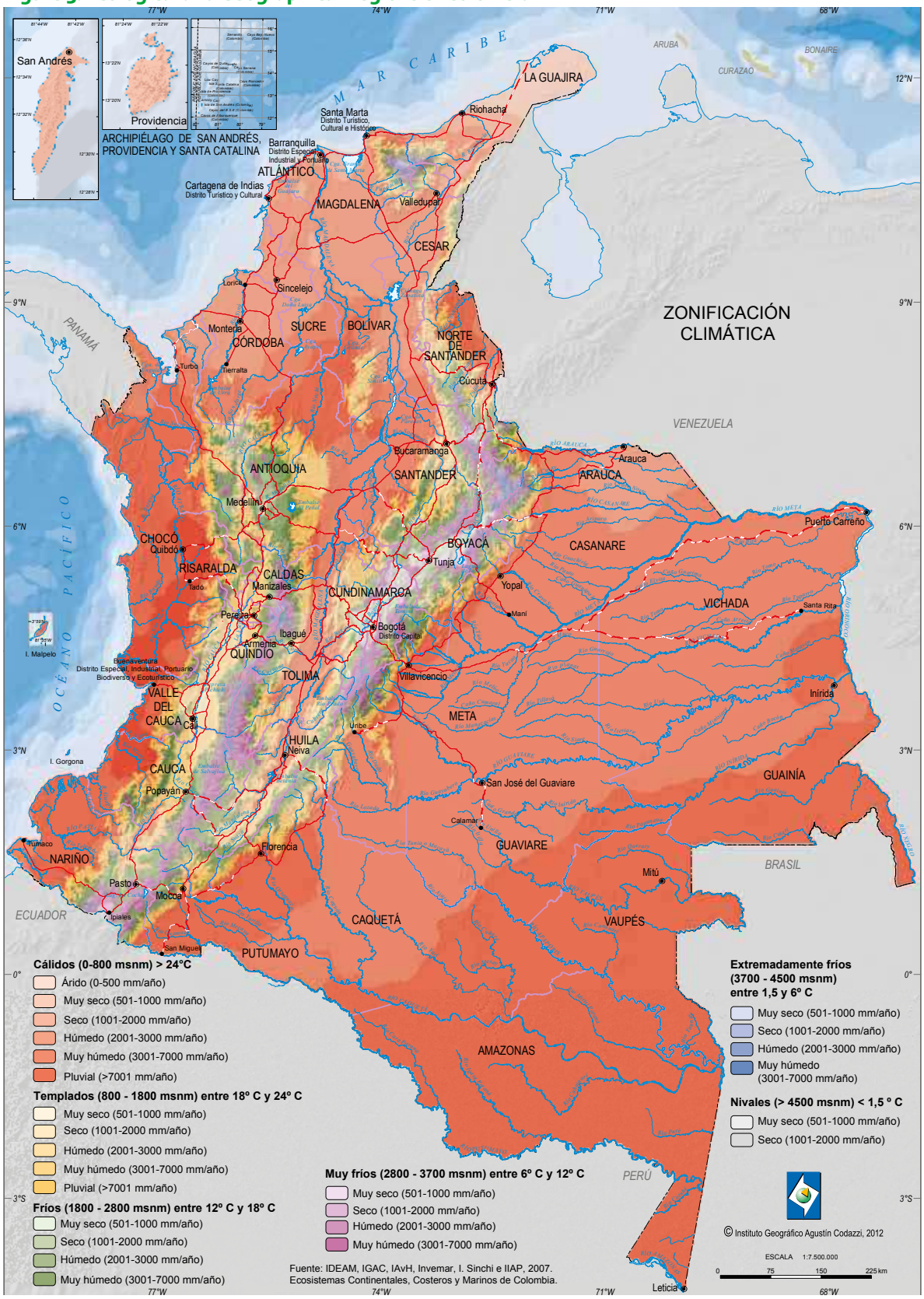
The country has solid research capacity at its universities. Most of these public and private universities have various research groups associated with agricultural production and food-security activities in fields such as conventional genetics, phytopathology, soil microbiology, environmental microbiology, functional foods, natural products, agricultural and environmental biotechnologies, molecular biology, genomics, proteomics and metabolomics, genetic transformation of organisms by recombinant DNA, gene editing, bioprospecting and bioprocesses.

III. Characteristics of Natural Resources and Ecosystems

Water resources and future challenges

Colombia's location in the NW corner of South America accounts for its abundance of waters, due to: (1) the oscillation of the Intertropical Convergence Zone; (2) the transport of moisture by several wind currents over the Caribbean Sea, the Pacific Ocean and the Eastern Plains; (3) orographic rainfall in the three Andes mountain ranges that cross the country from the SW to the NE; (4) its portion of the watersheds of the Amazon and Orinoco Rivers, and (5) strong soil-atmosphere interactions (Poveda et al., 2011). The natural supply of water varies significantly in the country's five geographic regions: (I) Caribbean; (ii) Andean; (iii) Pacific; (iv) Orinoco, and (v) Amazonia (**Figure 3**). Moreover, the country's water supply and availability is conditioned by the

Figure 3. Ecological and Geographical Regions of Colombia



hydroclimatic variability over a wide range of time scales, from the interannual scale to the diurnal scale, and the effects of climate change and deforestation (Poveda, 2004).

Evidence of climate change in Colombia

The effects of climate change in Colombia include an increase in average and minimal temperatures in a large number of stations and mixed precipitation trends without a clear regional pattern, except on the Pacific plain, where an upward trend has been observed (Carmona & Poveda, 2014). The study by Mayorga et al. (2011) finds that of 310 stations with records of monthly precipitation, 71% demonstrate upward and 22%, downward trends. Mean and extreme flows exhibit negative trends in nearly all of Colombia (Poveda et al., 2011; Carmona & Poveda, 2014). The study by Hurtado & Mesa (2015) finds positive trends in Colombia's precipitation series for the 1975-2006 period, mainly in the Pacific, Orinoco and Amazon basin regions. Climate change is also causing the disappearance and rapid retreat of Colombia's tropical glaciers (Rabatel et al., 2013).

Water resources and future challenges

Several factors have prevented the proper management of Colombian land, such as the social and political situation, inequality, poverty, armed confrontations and drug trafficking, and the weaknesses of its education, research and technological development systems, leading to the degradation and alteration of the country's fragile soils (MADS, 2013a). Twenty-nine percent of Colombian soils are infertile (ultisols and oxisols), while suitable agricultural soils (andisols and molisols) constitute an area of 8.5 million ha (7,5%). Of the country's 114 million ha, 32 million (28,7%) are unsuitable due to overuse (15%) or underuse (13%) and 87 million ha should be declared Protected and Conservation Areas (IGAC, 2012). Degradation processes include erosion (48% of the territory), sealing, contamination, loss of organic matter, salinization (5%), compaction and desertification (0,7%), mainly in the Caribbean, Andean and Orinoquia regions, and incipiently in the Amazon and on the Pacific Coast (MADS, 2013a). The degraded areas are home to the main urban centers (IDEAM-MADS, 2014).

Energy challenges

The main and cheapest source of energy in Colombia is hydroelectric, followed by thermoelectric power (gas, diesel and coal). The country has an effective, installed capacity of 14.478 MW, of which 9.836 MW (67,9%) are hydro, 4.566 MW thermal (31,5%); 57,8 MW cogeneration and 18 MW wind power plants (**Table 2**). Seventeen new hydroelectric projects with a capacity of 3.961 MW are currently being built, at a cost of over $10 billion USD. With this new energy, Colombia will achieve a generation capacity of 18.385 MW to supply the demand forecast for 2018 (ACOLGEN; http://www.acolgen.org.co).

Biodiversity, conflicts and challenges

Colombia has the world's largest number of species-per-unit area, making it the second most mega-diverse country after Brazil. Occupying 0.7% of the planet's area, it is home to approximately 10% of the world's fauna and flora (FAO, 2015). This biodiversity is a source of numerous ecosystems and human livelihood and welfare systems, including the provision of services such as food, timber and non-timber forest products (skins, meat and ornamental fauna), genetic resources, natural ingredients, medicinal plants, pharmaceuticals and cosmetics, and water. The V National Report to the Convention on Biological Diversity (MADS-UNDP, 2014) identifies the following five factors associated with loss of biodiversity and ecosystem services: (i). changes in land use (livestock, illegal crops and infrastructure); (ii). reduction, loss or degradation of native ecosystems and agroecosystems (agribusiness, mining, hydroelectric generation, urbanization and fishing overexploitation); (iii). biological invasions; (iv). water contamination and toxicity, and (v) climate change.

Effects of forest trends

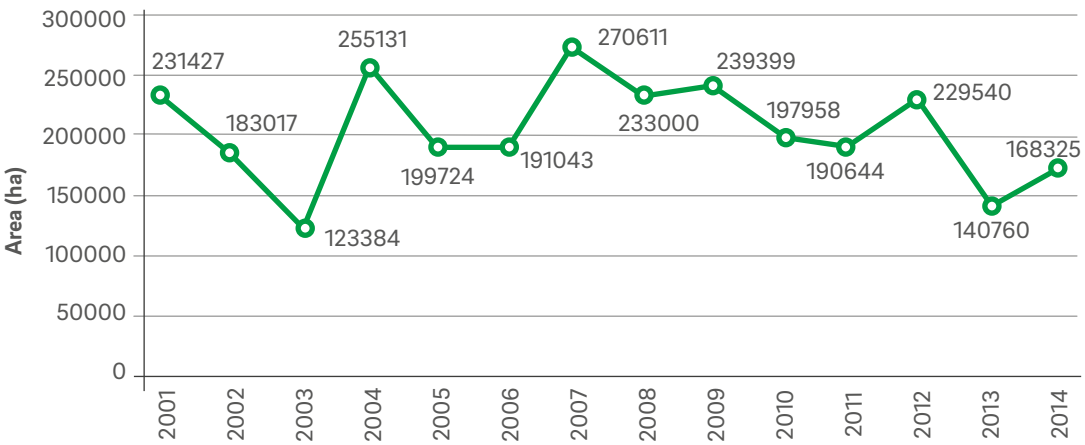
Deforestation and changes in land use are some of the greatest threats to Colombia's sustainable, economic development. In 2014, the country had 8.867 metric t of carbon stored in its living forest biomass (Hansen et al., 2013) after losing 2.822.693 ha of forest in the 2001-2014 period (**Figure 4**).

Table 2. Energy Generation capacity (GWh) forecast for various scenarios and energy sources, during the 2017-2022 period. Taken from UPME, 2016

Scenarios	Hydroelectric	Minor+ Liquids	Liquids	Gas	Coal	Wind	Solar Photovoltaic	Geothermal + Biomass
ESC 0.0	980.828	64.997	23	52.398	120.502	62.683	2.221	22.857
ESC 1.0	990.453	64.997	80	74.528	121.655	32.811	795	21.188
ESC 2.0	992.164	64.997	49	75.159	89.584	62.684	685	21.188
ESC 3.0	997.464	64.997	82	86.812	100.198	32.811	1.547	22.589
ESC 4.0	988.101	65.347	35	60.588	107.701	62.683	867	21.188

Source of table: UPME

Figure 4. Annual series of forest loss in Colombia during the period 2001-2014



Source: Compiled by the authors based on data from Global Forest Watch http://www.globalforestwatch.org/

Factors such as the expansion of agricultural and livestock borders and mining have led to deforestation in Colombia, destroying ecosystem services in forests such as the regulation of hydrological extremes, erosion control, protection against global warming by carbon sequestration and evapotranspiration, protecting biodiversity, and nutrient storage and recycling.

Impacts of climate variability on agriculture

Effects of El Niño

According to the Ministry of Agriculture, the occurrence of the El Niño phenomenon reduces Colombia's agricultural yield. Historically, the most severely affected crops have been manioc, cassava, African palm, barley, rice, coffee and potato, as well as milk production, which is declining. During 2015-2016, El Niño was responsible for a 20% decrease in Colombia's agricultural output, doubling mortality in the livestock sector. Short-cycle crops saw the greatest decline in production (3,4%), although long-cycle crops increased their yield by 2,5%. Cereals and fruits were affected by frost, which increased production costs, as were potato, milk and rice. Over 600,000 ha of coffee plantations were affected by the intense heat wave. El Niño also causes a high impact on agricultural pests and diseases (IICA, 2015; OIRSA, 2014).

Effects of La Niña on the agricultural sector

The intense rainfall that occurs in Colombia during La Niña causes flooding, landslides and erosion. The La Niña event in 2010-2011 caused economic losses of 11.2 billion pesos through

damages to infrastructure, agricultural crops and livestock, transportation, mining and tourism. The effects of climate variability and climate change on rural communities engaged in coffee cultivation in Colombia are reported in Poveda et al. (2017).

Potential impacts of climate change

Several studies indicate that climate change will negatively impact the Colombian economy. The study by Burke et al. (2015) predicts for Colombia a 77% decrease in GDP per capita between 2015 and 2100 due to climate change. The DNP-IDB study (2014), albeit with various limitations, uses the results of various climate-change models and scenarios and finds that the agricultural sector would suffer the greatest losses due to reductions in yields per hectare, caused, among other factors, by the decrease in climatic range, summarized in **Table 3**.

The study by Ramírez-Villegas et al. (2012) explores the possible impacts of climate change on Colombian agriculture, mentioning the challenges that would affect the main crops and regions and suggesting adaptation actions. It estimates that by 2050, climate change in Colombia will impact approximately 3.5 million people, affecting 14% of GDP in agriculture, employment, agroindustries, supply chains, and food and nutrition security. Most crops and cultivated regions will experience negative impacts unless adaptation measures are adopted, these impacts including increased flood frequency and changes in the prevalence and presence of pests and diseases, increasing the vulnerability of small farmers (Ramírez-Villegas et al., 2012).

Building resilience to extreme events

The National Planning Department of Colombia with the support of the Ministry of Environment and Sustainable Development (MADS) coordinates the National Plan for Adaptation to Climate Change (PNACC), designed to reduce the risk and socioeconomic impacts associated with climate variability and change in Colombia by: i) increasing knowledge about the potential risks and opportunities and incorporating climate risk management into sectoral and territorial development planning, and ii) reducing the vulnerability of socioeconomic and ecological systems to climatic events. Due to limited scientific research on climate change and variability in Colombia, it is suggested that in Latin America, public discussion be conducted with society and governments on the severity of the various social, environmental, ecological and economic threats and the effects of climate change. It is suggested that the discussion focus on the following key issues:

- What are the main scientific questions posed by climate change and deforestation on ecosystems? What will be the most likely effects on the occurrence of extreme hydrometeorological events (droughts and floods) in the various regions in Latin America? How will they impact society and the various sectors?
- How much carbon is stored by the various ecosystems in Latin America, from deserts to wetlands, through dry forests, humid mountain forests, tropical humid forests, savannas in the inter-Andean valleys, the Amazon and the other regions, and ecosystems in the subcontinent?
- What are the evapotranspiration rates of these ecosystems? Evapotranspiration provides a hitherto overlooked ecosystem service (cooling and refrigeration, counteracting the effects of global warming). This ecosystem service must be measured and valued separately from carbon storage.
- What are the most likely impacts of climate change on human health, water availability and food production, electricity generation and other sectors?
- What kind of decisions (economic, financial, social and environmental) must the region take to address the consequences of climate change and deforestation? What types of investments in science and technology are required to address this problem? How will this disparity be addressed?
- What is the budget of the organizations responsible for financing scientific research in the countries in the region (COLCIENCIAS), and of the ministries and regional and municipal governments to support basic and

applied scientific research on the subjects of climate change and deforestation, and all of their consequences in Latin America?

IV. Technology and Innovation

Role of biotechnologies

Biotechnology is one of the areas with greatest potential for the Colombian economy. It is clear that numerous biotechnological advances in various sectors of the economy, in addition to their multiple applications for human and animal health, offer several alternatives to meet the requirements of food and nutritional security and the sustainable intensification of agricultural production, as well as addressing the challenges of crop adaptation to climate change. Complementary issues include the production of bioinputs (biofertilizers and biopesticides) and biodegradation systems for agri-food waste and bioremediation. Properly integrated with other technologies as well as with agricultural and food production, biotechnologies offer a powerful set of tools for crop improvement and production, and has the potential to deliver significant benefits to both the consumer and the environment. It can also revolutionize the strategies needed to conserve biodiversity.

In agrobiotechnologies, Colombia, in addition to its own developments - in bioinputs, crop improvement by molecular techniques and environmental biotechnology - has been an important player in the adoption of Genetically Modified (GM) biotech crops. It began growing

Table 3. Percentage changes in Colombian agricultural productivity for different times and climate-change scenarios, compared to the 2000-2010

	2040*	2070**	2100***	Averange
National				
A2	-6,7	-5,8	-4,4	-5,6
B2	-5,2	-5,5	-5,2	-5,3
A1B	-10,2	-11,4	-12,4	-11,3
Average	-7,4	-7,6	-7,3	-7,4
Technified Maize				
A2	-22,9	-21,8	-22,8	
B2	-21,9	-22,2	-22,8	
A1B	-24,1	-21,9	-19,3	
Average	-23,0	-22,0	-21,6	
Potato				
A2	-15,7	-14,1	-9,1	
B2	-12,3	-12,8	-10,7	
A1B	-19,4	-20,0	-19,3	
Average	-15,8	-15,6	13,0	
Irrigated Rice				
A2	2,3	2,7	2,1	
B2	2,6	2,4	1,8	
A1B	-1,6	-3,9	-6,6	
Average	1,1	0,4	-0,9	

Source: DNP-BID (2014). * Averange 2011-2040; ** Averange 2041-2070; *** Averange 2071-2100

GM carnations in 2002 and is currently one of the 28 countries in the world that plant more than 100,000 ha of GM crops per year (James, 2015). By 2015, a total of 101.131 ha were cultivated in the country, including maize (85.251 ha), cotton (15.868 ha) and ornamental flowers (12 ha) grown in 22 of the country's 32 departments (Data from the Instituto Colombiano Agropecuario -ICA-). By 2015, 24% of the country's maize and 77% of its cotton crops were transgenic (FENALCE, http://fenalce.org/nueva/index.php CONALGODON, http:// Conalgodon.com/). The advantages of adopting GM crops include beneficial environmental effects, due to the reduction in the use of pesticides, yields and incomes from better-quality harvests due to pest reduction (James, 2015).

In the development of its functions, CORPOICA has obtained results in research and technological solutions for plants and livestock. It conducts research in biotechnology and genetic engineering, integrated water and soil management, natural nutrient fixation, pest and disease management and has developments in clean agriculture, through the reduction of pesticides and chemical fertilizers. In agricultural and livestock research, CORPOICA's work focuses on the use of the country's own genetic resources, which are kept in custody in germplasm banks. Among other crops, it stores the Colombian collection of musaceae (bananas) and boasts the world's second largest potato seed collection after the International Potato Center (CIP) in Peru. Making use of the genetic material stored (22,700 seeds of different types), and through conventional breeding techniques, 50 new varieties of maize, soybean, cotton, potato, bean, cassava, lulo and papaya have been comercialized. CORPOICA provides farmers with selected or improved materials in crops such as sugar cane, cacao, maize, eggplant, sorghum and soybeans. It has developed six biological products (bioinputs) including biofertilizers (Rhizobiol for soybean, Monibac for cotton), biopesticides (Baculovirus to control the Guatemalan moth, *Tecia solanivor*, in potato and *Lecanicillium (Verticillium) lecanii* to prevent and control whitefly attack). It also provides services for the analysis of soil, food, nutritional content and the quality control of inputs. Using a climate-smart agriculture approach, it works with Agroclimatic Adaptation and Prevention Models (MAPA) to develop climate change adaptation capacities (http://www.corpoica.org/). The animal germplasm bank (semen) stores 19,000 straws of the seven Colombian Creole cattle breeds, from which some genes-of-interest for breeding have been identified, such as those conferring tolerance to brucellosis in cattle of the Blanco orejinegro Creole breed.

The International Center for Tropical Agriculture (CIAT), based in Colombia, is renowned for its research on rice, cassava, beans, tropical forages and genetic resources and promotes ecoefficient agriculture (https://ciat.cgiar. Org/). Thus, over 90 improved varieties of four basic crops (rice, cassava, beans and fodder) have contributed to boosting food security in Colombia and improving small farmers families' incomes. As a technological innovation for its breeding programs, CIAT is using drones to monitor rice and cassava crops in order to detect efficiency patterns in nitrogen-use and water-use efficiency (drought tolerance). Drones have also shown to be useful to scientists in the evaluation of behavior in the field of specific traits. They reduce the time taken by researchers to develop varieties that tolerate biotic or abiotic stress environments (FAO, 2016b; Global Harvest Initiative, 2016). To provide alternatives to current challenges, a partnership between CIAT and the International Fund for Agricultural Development (IFAD) promises to boost resilience to climate change and improve the livelihoods of thousands of small farmers around the world. Small-scale agriculture, especially in tropical areas, must become more robust, resilient, efficient and sustainable, so that it can meet the increasing demand for food and resources, while offering profitable means for emerging from poverty. CIAT leads research on genome editing in rice in Latin America to remove selection markers of transgenic lines with increased iron and zinc in grains, to validate genes that are candidates for resistance to white leaf virus (RHBV) and hybrid seed production or to validate genes that determine the number of flowers in the panicle and number of grains per plant (Li et al., 2016). This effort is being made

in collaboration with foreign institutions (e.g., NIAS in Japan, and the University of Adelaide in Australia), and is supported by collaboration with private enterprise, local universities and National Research Centers. Following the example of what has been achieved with Waxy corn, edited with CRISPR/Cas9, which would not be regulated in the USA (Waltz 2016), work is being conducted on cassava to convert common starch to Waxy-type starch with a high commercial value in Colombian and Asian varieties, and in the development of non-transgenic tolerance to herbicides. In beans, genetic transformation methodologies are being developed to deactivate anti-nutritional genes in the grain using CRISPR/Cas9.

CENI focus on the search for technical solutions and innovation to provide greater competitiveness, efficiency, yield and resilience to the crops of their interest in activities such as the selection and propagation of selected material, plant breeding by various systems including transgenesis (for greater yield, adaptability to climate change, tolerance to pests and diseases), the development of biofertilizers (biofertilizers, biopesticides), supplemented by the evaluation of competitive and sustainable agribusiness models, as well as training in specific techniques. CENI have close contact and cooperate in several projects with organizations in a number of countries: CENICAÑA is one of the first members of the International Sugar cane Biotechnology Consortium. CENIACUA works with Akvaforsk in Norway, the world leader in breeding aquatic species. CENICAFÉ maintains close ties with the University of Cornell, with which it collaborates on Molecular Biology, the University of Maryland and the IRD of France, among others.

Outlook for obtaining new products

Colombia has over 150 biotechnology-based firms distributed among various sectors: 38% in agriculture; 33% in food and alcohol; 8% in biofuels, which is steadily increasing; 5% in pharmaceuticals, and 16% in universities and research centers that have set up companies (Narváez, 2015).

Examples of developments include those of the Biotechnology Institute of the National University of Colombia, with the production of bioinsecticides formulated with native species of *Bacillus thuringiensis* (Bt) for the biological control of pests that attack cotton, rice, maize, sorghum and potato. Within the crop breeding program, six varieties of virus-free potatoes and healthy yam and rubber seeds are available to farmers. Transgenic R12 potato plants, widely accepted in agribusiness, are under development. An additional example is the BIOTEC Corporation, which focuses its research on the production of propagating material (clones) from Isabela grapes and sour sop. BIOTEC also developed a biofungicide, made from the *Trichoderma harzianum* Rifa fungus, for the control of *Botrytis* spp. P. Mich. ex. Pers., which attacks the vine (http://corporacionbiotec.org/index.html).

In biotechnology, there are diverse fields of application with good development and a high scientific and technological capacity, as is the case of the cosmetics and toiletries sector and absorbents, phytotherapeutic and nutritional supplements, as well as the bioinputs sector. Concerning the latter, over 191 products have been registered with the ICA – mostly biopesticides (biological control agents) or biofertilizers (N-fixing inoculants) - and 122 companies are registered as producers or importers of bioinputs for the agricultural sector.

New breeding technologies for genome editing an example of an alternative to improve rice yield and nutritional quality

The National Federation of Rice Farmers (FEDEARROZ) estimated that in 2015, every Colombian in the urban area consumed 36.4 kilos of rice, whereas in the rural area, consumption amounted to 44.2 kilos (http://www.fedearroz.com). Comparatively, in 2014, per capita potato consumption was 63 kilos, indicating that rice is an important item in the Colombian diet. In 2015, over 280,000 tons of white rice were imported into Colombia to meet national demand, indicating a deficit in national production. Genome editing is one of the New Breeding Techniques (NBT) that offers the possibility of significantly increasing rice yield through the editing of genes that influence the number of grains, the type of clusters

(vegetative or sexual), grain size and panicle size (Li et al., 2016). In the case of the number of grains, a gene called Gn1a increases the number of flowers (Ashikari et al., 2005), resulting in twice the number of grains in the panicle. The technology is easily transferable to Colombian varieties of rainfed or irrigated rice. The system for editing rice genes is used at CIAT and produces mutant lines that could be considered conventional varieties for regulation, distribution and consumption purposes.

Rice is the world's most widely consumed cereal. Cadmium (Cd) contamination of rice in China was made public in 2013 (https://rendezvous.blogs.nytimes.com/2013/05/20/cadmium-rice-is-chinas-latest-food- Scandal/), especially in Hunan province, where rice crops coexist with artisanal mining operations that contaminate paddy fields with Cd and other heavy metals. However, the main contributor to Cd contamination in agricultural soils around the world are phosphate fertilizers contaminated with Cd (Järup & Akesson, 2009; Polle & Schutzendubel, 2003). Despite the lack of solid data related the level of Cd contamination in Colombian rice fields, there is, however, evidence that this carcinogenic heavy metal may accumulate at undesirable levels in rice, beans and lentils (Méndez-Fajardo et al., 2005). Accordingly, guaranteeing food security in Colombia not only implies maintaining crop yields (and other foods) at levels that satisfy the demand of a growing population, but also entails maintaining the nutritional quality of those foods. Fortunately, there is evidence that the mutation of a single gene (OsNRAMP5) in rice results in undetectable levels of Cd in the plant and grain (Ishikawa et al., 2012). Here again, NBT would play a decisive role in the production of genetically edited Colombian rice varieties, with zero accumulation of Cd. This technology is being used to improve several crops (Khatodia et al., 2016), and could obviously be used in beans, lentils and cacao to reduce the accumulation of Cd provided that at least three conditions are met: The Cd absorption system is similar to that of rice, the number of genes involved is minimal (1 or 2), and there is an *in vitro* system to edit and regenerate cells.

Development of marine resources

In its coastal, marine and island areas, Colombia has strategic ecosystems such as mangrove areas (378.938 ha) and coral reefs (300.000 ha), as well as resources that provide environmental goods and services that can be used as the basis for developing key economic activities. Maritime territory is underused and has not been properly integrated into the country's development. In order to address this situation, activities are being undertaken, such as participation in the South Pacific Information and Data Network to support Integrated Coastal Area Management (SPINCAM), a project promoted by the Permanent Commission of the South Pacific (CPPS). The objective is to establish Indicators for Integrated Management of Coastal Areas (ICZM) in each country of the Southeast Pacific region (Chile, Colombia, Ecuador, Panama and Peru), focusing on environmental, socioeconomic and governance conditions within the context of sustainable development and integrated coastal area management (INVEMAR, MADS and DIMAR-CCCP, 2011). In its turn, the Marine Research Institute (INVEMAR) implements an R&D Program on Assessment and Exploitation of Living Marine Resources (http://www.invemar.org.co/web/guest/descripcion-var), through the formulation of proposals for the sustainable use of living resources as well as marine and coastal ecosystems, and the adoption of clean production technologies, seeking to contribute to decision making and policy formulation and enhancing the sustainable economic development of biodiversity.

The ecosystems that support Colombia's fishery resources in Colombia are scattered and poorly characterized, although mangroves, coral reefs and wetlands have been identified as important ecosystems for this activity. In terms of fishing, in 2012, Colombia ranked 81st in catches and 72th in aquaculture among the 229 countries reported by FAO. This means low production, which is only 1% of that of countries such as Peru. The contribution of fishing to GDP showed a downward trend for the 2004-2012 period. Whereas in 2004 it represented 0,22%, by 2012 its contribution had fallen to 0,17%. Exports, which in 2011 exceeded the Free On

Board (FOB) value, were reached by imports in 2012 and largely surpassed by them in 2013. The main export is tilapia. Colombia is a global leader in the export of ornamental fish (FAO-MADR, 2015).

V. Increased Efficiency of Food Systems

Outlook for increases in agricultural production based on technology

In 2010, the Global Harvest Initiative estimated that agricultural productivity would need to increase by at least 1,75% a year to meet global food requirements by 2050. The development and implementation of appropriate policies, practices and technologies lead to improved food and nutritional security at the global level, accelerate productivity, reduce losses and waste, facilitate the conservation of natural resources and contribute to climate-change mitigation. Emphasis is placed on higher yields, access to nutritious food, increased income for producers and strengthening productivity, competitiveness and resilience for producers (Global Harvest Initiative, 2016). The increase in the Total Factor Productivity (TFP) of crops is achieved through the incorporation of knowledge and appropriate cultural practices, by adopting seed varieties with technological innovations such as higher yield, tolerance/resistance to biotic factors such as pests and diseases or abiotic factors such as drought or flood or the use of bio-inputs. CORPOICA and the CENI have been incorporating practices and technologies into various crops, as mentioned earlier. The growing bio-innovation sector in Colombia includes precision agriculture, the targeted, specific use of microorganisms (fungi and bacteria) that allow higher yields to be generated either as biofertilizers, or by protecting plants from diseases or extreme humidity conditions (Hodson & Díaz, 2013).

In relation to the potential of gene-editing technologies for plant breeding, the greatest impact is likely to be on the nutritional quality of the products. Simple examples include: the suppression of genes responsible for antinutritional compounds or allergens; the increase of cereal yield through the deactivation of negative regulators of the number of grains in the panicles, and the creation of tolerance or resistance to pathogens by modifying the target site of the infective bacterial proteins. For the examples mentioned, prototypes or proofs-of-concept have already been published (such as for rice, Li et al., 2012). Colombian researchers are advancing work in this direction, as yet at the development phase. It is important to reflect on the regulation of the use and release of crops obtained from gene editing. In the US, some are not considered GMO, and are therefore unregulated, which facilitates and lowers the cost of their development and adoption in developing countries. Let us hope, then, that this is the way forward in Latin America and the Caribbean (LAC). These concerns must be addressed because, in many developing countries, excessive legislation or the lack thereof has delayed and hampered the access of small farmers to technological developments that could benefit them.

Efficiency and competitiveness

The country must strive to become increasingly competitive in markets - both local and international – in order to be able to compete with products of different origins and, in the case of Colombia, with high volumes from the US (MADR, 2016). "This situation can only be reversed through a policy that increases the exportable supply and makes it possible to competitively replace part of the large imports of agricultural products that have accumulated over the last quarter of a century. *In both cases, producers must compete with producers from all over the world, since globalized markets are an irreversible reality.* There have been increases in the international demand for promising products in which the country has gained preferential access under its trade agreements. However, the size of the agricultural export supply is the most important structural weakness of the sector and the main obstacle for Colombia to position itself as one of the world's main food suppliers."

In 2015, agricultural GDP grew by 3,1% over the same period in 2014 (an increase of 0,3% above the level reported in 2014 of 2,8%). This is attributed to the positive performance of coffee production, which increased by 11,5% from January to September, and of livestock sectors such as pork (11,8%) and poultry production (6,0%). However, if one excludes coffee, then the agricultural sector grew by a mere 1,1%. The negative performance of some mostly short-cycle crops is associated with the reduction of areas-under-cultivation due to low prices at the time of planting and unfavorable climate conditions caused by the intense El Niño event. This gave rise to crop losses, decreased yields per hectare and poor-quality harvested products (Mejía-López, 2015).

Infrastructure needs

Globalization and trade liberalization have given a special connotation to the concept of infrastructure, making it a central feature of the national agenda. Agricultural infrastructure includes both irrigation and drainage districts, as well as conditions such as roads, collection points for commercialization and rural energy. The yield of a third of the crops in Colombia has been favorably affected by irrigation and drainage districts. This infrastructure is crucial to the well-being of the sector and its productivity, as well as access to land, the proper functioning of markets, the quality of institutions and appropriate access to technology and credit. Agricultural infrastructure is considered part of the public goods of collective use. Accordingly, its deficiencies not only detract from crop productivity and yield, but also hamper the functioning of markets, limiting their spatial and temporal integration. The Colombian State has increased resources to strengthen and improve the provision of public goods for the countryside and has provided funds for land and wasteland allocation programs to the most vulnerable communities, the construction of rural, social-interest housing (with basic sanitation, particularly potable water) and the provision of health services through subsidies (Lozano & Restrepo, 2015). Due to their particularities and specific circumstances, innovation and development activities in seed improvement and variety, fertilizer management, innovation in equipment and machinery, as well as the development of more efficient production processes compatible with sustainable development, these are regarded as a public goods, since the successful application of these developments is associated with the sector's infrastructure assets. Efforts have been made to purchase and assign land and wasteland, subsidize rural housing and support technical assistance. However, further efforts are required to maintain and set up irrigation and drainage districts, the road network, retail and wholesale centers and rural electrification.

Food use and loss minimization. National policy for sustainable food production and consumption

As a response to the desire for a sustainable economic growth model, in search of cyclical production, with environmental criteria throughout the life cycle of the product, in 2010, the Ministry of Environment proposed a Sustainable Production and Consumption Policy to respond to the commitments made by the country at several international forums derived from the Earth Summit (MAVDT, 2010). The policy is designed to change unsustainable patterns of production and consumption by the different actors in society, which will contribute to reducing pollution, conserving resources, promoting the environmental integrity of goods and services and encouraging the sustainable use of biodiversity, as sources of business competitiveness and quality of life.

In the same context, within the framework of the Community of Latin American and Caribbean States (CELAC), in January 2015, the CELAC Action Plan for Food Security, Nutrition and Hunger Eradication 2025 was approved. It was requested by the FAO Community, with the collaboration of the Latin American Integration Association (ALADI) and the Economic Commission for Latin America and the Caribbean (ECLAC) (FAO, 2015c).

Food banks

Food banks are a response to the world's problem of food waste, since the phenomenon focuses not only on access, but also on the use of what is produced and commercialized. Alliances are essential for this: Companies donate products that can no longer be marketed because their useful life has ended; they are unsightly or over-ripe, and former producers deliver crops of which they have an abundance or which are non-tradable because of their shape and size; and food banks recover and redistribute them to vulnerable populations. In Colombia, various activities have been designed to recover food in industry, commerce, power plants and directly from the countryside through the Program for the Recovery of Agricultural Surplus (REAGRO). In 2014, through the Association of Food Banks (ABACO) (http://www.abaco.org.co/home), 18.000 tons of food were rescued from 703 donor companies, making it possible to feed over 400,000 people. Through REAGRO, 2.468 t of fruits and vegetables were recovered from 409 associated producers, benefitting 35.764 people (FAO, 2015c). As an example of the impact on the child population, in 2014, the alliance between Alpina S.A., a food and dairy product company and ABACO benefitted the nutrition of more than 280,000 children, expectant and breastfeeding mothers. Older adults in 11 cities in the country benefitted from the recovery and donation of more than 500 t of products. For Alpina S.A., working on the recovery of products for the donation was the gateway to a higher commitment: contributing to the reduction of Food Loss and Waste (PDA). Thus, in January 2015 the company launched the Bon Appétit Program, which seeks to contribute to the fight against hunger through projects and alliances that work to reduce PDA. The program adopts a three-pronged approach: i) internal improvements to reduce operating losses; ii) working with suppliers, distributors and others to reduce loss and waste throughout the value chain, and iii) sharing the experience with other industries, academic institutions, cooperation and the public sector, in order to create a greater impact on food security in Colombia (FAO, 2015c).

VI. Health Considerations

Malnutrition

According to the 2012 FAO Report, for the 2010-2012 period, 12,5% of the Colombian population was undernourished. According to the latest Colombian Nutrition Situation Survey (ENSIN) in 2010 (ICBF, 2011), the population was experiencing a nutritional transition, since it had problems of underweight and overweight at the same time. Although rates have declined, malnutrition persists in low-income and indigenous populations. The study showed that 3,4% of children under 5 suffered from global malnutrition, 13,2% from chronic malnutrition and 0,9% from acute malnutrition, which exposes them to death from malnutrition or associated diseases, mainly of infectious origin, such as acute diarrheal disease and acute respiratory infections (Mazo-Echeverry, 2014).

According to Colombia's National Institute of Health (INS), in 2016, 101 children under five died in Colombia due to probable cases of malnutrition, with 54,5% of the cases involving infants under the age of 1. The most serious situation is in the Department of La Guajira, where these cases are frequent. 57,5% of rural households are food insecure, compared with 38,4% of urban households (MADR, 2016). It is striking that, between 2005 and 2010, the date of the last ENSIN study (ICBF, 2011), chronic malnutrition in Colombia fell by 17% to 5 percentage points away from the target for 2015. The percentage of stunted growth in children was 13,2%, regarded as low prevalence at the international level. The study found that although Colombians have made progress in the fight against malnutrition (anemia and hunger in the Colombian child population), there have been increases in overweight and obesity in all population groups. As a response to these challenges, a number of activities are underway in connection with the "National Plan for Food and Nutrition Security (NSPAN) 2012-2019" and the Food Guidelines for the Colombian Population, which seek to guide the population on food consumption, in order to promote complete nutritional well-being (OSAN, 2016, National Government, 2013).

Obesity

Colombia is undergoing a process of epidemiological transition reflected in the simultaneous existence of problems of malnutrition, both deficit and excess, with a disturbing degree of obesity and overweight. According to ENSIN 2010, 51,1% of people between the ages of 18 and 64 were overweight or obese, the rate being approximately 10% higher in women (55,1%) than in men (45,6%); the survey showed that the prevalence of excess weight increases with age, reaching 66,3% in the group aged 50-64 years (ICBF, 2011). ENSIN 2005 had found that 48% of the population were obese. By 2010, this percentage had risen to 52%. It was found that 62% of women and 39,8% of men have abdominal obesity, while 24,8% of pregnant women are overweight. This is attributed to Colombian sedentarism, which increased from 43% in 2005 to 47% in 2010, the Creole diet - which includes a high intake of sugar and fats - as well as the increase in processed foods in the diet (**Table 4**). According to MPS-FAO-OSAN (2014) studies, approximately 5% of households have at least one child under 5 years of age with stunted growth and an overweight mother. Among school age children, 0,1% are classified as having stunted growth and obesity while 1,4% are anemic and overweight. Of the women between 13 and 49 years of age, 3,4% are anemic and overweight. Obesity is associated with chronic noncommunicable diseases such as cardiovascular diseases, cancer, respiratory diseases and diabetes. For example, obesity caused the deaths of 2.085 men and 1.906 women in 2013 (Silva-Sarmiento, 2016; Sarmiento et al., 2014).

Expected changes in eating patterns

Food and Nutrition Security (SAN) is a state commitment framed within a rights, intersectoral, interdisciplinary and risk management approach (National Government, 2013). Since 2008, the National Policy on Food and Nutritional Security (PNSAN) has been established, in which the objective is to "Ensure that all Colombians have access to and consume food in a permanent, timely manner, in sufficient quantity, variety, quality and safety" (MPS-FAO-OSAN, 2014). The overall objective is to contribute to the improvement of the FNS of the entire Colombian population, especially the poorest and most vulnerable sectors, by: i) protect the population from hunger and inadequate food; ii) ensure access to timely, sufficient and quality food; and iii) Integrate and coordinate intersectoral and inter-agency interventions.

One of the sensitive issues in food security in the country is insufficient income to purchase food. The concept of food and nutritional security (SAN) in Colombia organically includes all the components in the agro-food chain linked to the main axes of availability, access, consumption, biological use, quality and safety of the food required (Silva-Sarmiento, 2016). One of the activities undertaken to address food security

Table 4. Average eating patterns in the Colombian population

Average Consumption of certain foods in Colombia	
39%	(ages 5 to 64) do not consume dairy products daily
33%	do not eat fruit every day
71%	do not eat vegetables every day
14%	do not eat meat or eggs every day
24%	eat fast food every week
22%	drink sodas every day
33%	have a sweet a day and 20% twice a day
72%	eat products purchased in the street, on a daily or weekly basis
56%	of children and young people (ages 9 and 18 years) eat cold cuts (charcuterie) every day

Source: ICBF Data, 2011.

is the Nutrition Recovery Strategy, a set of actions in health and nutrition designed for the population with a high prevalence of malnutrition in previously targeted areas, whose objective is to contribute to improving and/or restoring the nutritional status of children under 5, expectant and breastfeeding mothers, through actions to ensure the care and promotion of good health and nutrition practices with the co-responsibility of the family and the community, as well as the institutions in the National Family Welfare System (National Government, 2013).

Among the most important measures to improve Colombians' diet is the effort to promote healthy habits such as sports in children, changing eating habits for more balanced systems and promoting the awareness of the entire population through conferences, posters and the mass media. According to the Colombian Institute of Family Welfare (ICBF), one of the most important measures is the production of "*Food guides for the Colombian population, which seeks to establish which foods are suitable for each age and the daily portions a Colombian should eat*". In this respect, (2016), the Ministry of Health and Social Protection recently issued Resolution No. 003803, which establishes the Recommendations for the Ingestion of Energy and Nutrients (RIEN), for the Colombian population (http:/www.leyex.info/leyes/Resolucionmsps3803de2016.pdf). Some of the regional programs currently being implemented include "Bogotá without hunger", Antioquia with its program entitled "Food and Nutrition Improvement for Antioquia (MANA)" and recently in Cauca, the "Cauca without Hunger" program, which have focused on an analysis of the social and economic impact of malnutrition in infants (https://helpx.adobe.com/en/reader.html).

VII. Policies linked to Food and Nutrition Security

The climate is changing as are agriculture and food. There is an urgent need to adapt agriculture to climate change to meet the challenges and achieve the sustainable development goals (SDG). The Sustainable Development Objective 2 commits the global community to "*ending hunger, achieving food and nutrition security and promoting sustainable agriculture*" (United Nations, 2015). Colombia has welcomed these commitments and incorporated them into its development plans. As regards Food and Nutrition Security (SAN), Colombia ranks 10th in the Food Sustainability Index and the 9th in sustainable agriculture (2016 Food Sustainability Index), reflecting the commitment to and advances in these issues in the country, although efforts related to the prevention of food loss and waste, in which the country ranks 16th in the study, should be strengthened.

To achieve sustainable rural development in Colombia, it is essential to boost agricultural activities that strengthen economic activity in the regions, thus generating a better supply of goods and services for the rural population. In the past two decades, the agricultural sector has reduced its share of GDP in the local economy from above 7.5%, to approximately 6.1%, with an average of 7% for the past 15 years (DANE, 2015). Nevertheless, in the Latin American and Caribbean regional context, Colombia is one of the countries in which the agricultural sector has the greatest importance in the national GDP, above the average of 5.1%. In 2016, in order to increase the agricultural supply to guarantee food security in the country and promote agricultural exports with added value, the Ministry of Agriculture and Rural Development of Colombia (MADR) established the strategy "Colombia Siembra" (Colombia plants or sows) (http://colombiasiembra.minagricultura.gov.co). This program attempts to leverage the country's enormous potential for agricultural development and is the result of a process of research, planning and consultation, with the help of producers, industrialists, guilds and public sector organized, which has been proposed to increase the number of hectares planted in the country by one million by 2018, as well as to increase productivity. "Colombia Siembra" will create a favorable environment to boost the investments required in new areas, technological packages, and solutions for water, infrastructure, machinery, research and technology transfer (MADR, 2016).

Within the framework of the first objective entrusted to the Ministry of Agriculture and Rural Development (MADR), "*To promote rural development with a territorial approach and to strengthen the productivity and competitiveness of agricultural products, through comprehensive actions that improve the living conditions of rural people, allow the sustainable use of natural resources, create jobs and achieve the sustained, balanced growth of the regions*". In order to promote the coordination of institutional actions in the rural environment in a focused, systematic way, with the principles of competitiveness, equity, sustainability, multisectoriality and decentralization, for the country's socioeconomic development", and taking into account the country's potential to strengthen food production, through "Colombia Siembra", this ministry will coordinate the efforts of the various actors of the agricultural sector to promote the planting of a million hectares, i.e. increase the total area planted from 7.1 to 8.1 million ha (DANE, 2015). The "Colombia Siembra" Strategy has set itself the goal of establishing the social and economic conditions to promote the planting of a million more hectares of crops to achieve the inclusive, sustainable and competitive development of the Colombian countryside. Part of this undertaking involves developing various types of incentives to foster the increase in the supply of agricultural products in a sustained manner to meet Colombia's domestic demand, and to promote exports to strengthen the positioning of Colombian agricultural products in the international market (MADR, 2016).

The national government has several initiatives to transform the Colombian countryside, which are interlinked and complement each other. The goal of the 2014-2018 National Development Plan, "Everyone for a New Country" is to analyze the country's situation on the basis of the particularities and specificities of the regions and territories in order to address its three development objectives: peace, equity and education, for which there are five transversal strategies and a sixth overarching strategy known as Green Growth (DNP, 2015a). The Development Plans provide the strategic guidelines for the public policies formulated by the Government.

The concept of Green Growth means, "*Fostering economic growth and development, ensuring that ecosystems continue to provide the services that guarantee social well-being. With this focus, it is essential to catalyze investment and innovation, which will be the basis for sustained growth by creating new economic opportunities*" (OECD, 2015). This strategy is linked to the Organization for Economic Cooperation and Development (OECD) guidelines and proposes the efficient use of land and natural resources. It is designed to achieve sustainable, low carbon development; ensure the sustainable use of natural capital and improve environmental quality; promote resilience and reduce vulnerability to disaster risks and climate change. Among other activities, it proposes the design and implementation of an Early Agroclimatic Alert System (SAAT) and the formulation of climate change adaptation and mitigation plans for production systems and priority areas. Due to Colombia's technological backwardness, its National Plan for the Development of Sustainable Aquaculture should be implemented, with strategies to boost the levels of productivity and competitiveness of the national aquaculture in order to become a key productive area in the agricultural sector. It seeks to boost rural competitiveness through the provision of sectoral goods and services to make agricultural activities a source of wealth for rural producers (DNP, 2015a). The implementation of this strategy involves several agencies within the Ministries of Agriculture and Environment with their affiliated institutes, as well as the private sector. Thus, the goal of the Private Competitiveness Council regarding the Green Growth Strategy, is to be an economy that exports goods and services with a high added value and innovation, to achieve a business environment that encourages local and foreign investment, raising the quality of life and substantially reducing poverty levels. Competitiveness must be a national commitment in which entrepreneurs, government, academia and civil society work together (CPN, 2016). An

Box 2. Mission for the Transformation of the Colombian Countryside (DNP, 2015b)

The recent "Mission for the Transformation of the Colombian Countryside" (MTCC) report has proposed a program to settle the country's historical debt with the rural sector and contribute to the construction of peace (DNP, 2015b). According to MTCC, it is essential to: (i) place equity at the center of rural development policies and reduce the enormous inequalities between rural and urban dwellers, among rural inhabitants themselves, between men and women, and between different ethnic groups and between regions; (ii) adopt a participatory territorial approach, consistent with the country's regional heterogeneity, and with the need to promote social participation in all its forms; (iii) create an enabling environment for small, medium and large enterprises; and (iv) ensure the protection of the environment, particularly water, soils and forests. Proposals include: (1) State public policies and explicit goals for the countryside in all ministries, with guaranteed public resources to invest over the next 15 years. (2) More and better social investment in the countryside to narrow rural-urban welfare gaps. (3) Greater investment in public goods for productive development and less direct support in response to temporary situations. (4) Greater involvement of regions and local social organizations in the planning and prioritization of investments, project implementation and social control. This should be supported on six strategies:

1. Social inclusion in the rural sector with a rights focus, prioritizing the elimination of malnutrition in the countryside and a Zero Illiteracy campaign. The goal is to create permanent, specialized directorates within the Education and Health Ministries to design rural policies adapted to the particularities of the countryside. In education, investments should be made in flexible models with relevant content and quality that facilitate productive inclusion and encourage creativity and innovation. In health, the aim is to migrate to models with an emphasis on promotion and prevention, eliminating access barriers and bringing health services closer to families, especially in the most widely scattered municipalities.
2. Productive inclusion and family farming in agricultural, fishery and fishing activities, and non-agricultural activities (new rurality).
3. Increase agricultural competitiveness, invest more in services and public goods for productive development and less in short-term subsidies, improving the adequate public goods provision and establishing macroeconomic policies, foreign trade, financial services and internal marketing.
4. Advance environmental sustainability, recovering and protecting ecosystemic water and soil services, addressing climatic variability, and leveraging natural capital for rural prosperity in a sustainable way. Increase water use rates to encourage its proper use and create sufficient resources for watershed conservation. Some resources would be used in a payment program to conserve water sources and others for payments for environmental services, especially for family farmers established in protected areas. Establish a goal of zero deforestation by 2030 and definitively closing the agricultural frontier, through Forest Reserve Zones (ZRF). Establish an Early Agroclimatic Alert System and contingency plans to address the threats faced by the agricultural, livestock, fishery and forestry systems.
5. Territorial planning and development including environmental, social and productive aspects; regional convergence and narrowing rural-urban gaps; rural development with a territorial approach; and consolidation of territorial associativity. Creation of a Land Fund for redistributive purposes as a tool to reduce the concentration of rural land ownership and allocate land suitable for rural families in conjunction with income generation projects. Create Business Development Zones (ZDE), where schemes such as concession, lease or land rights are used rather than the delivery of land ownership. Gradually implement Integral Rural Development Programs with a Territorial Approach (PDRIET) in regions with a high density of family farmers, high poverty levels and high productive potential. Improve the territorial planning system, with an emphasis on building the capacities of departments, provide separate investment budgets for municipal and rural areas, and support the formation of planning and management provinces and regions as a means of territorial integration.
6. Various recommendations to adjustment the institutional framework and implement a program to promote and strengthen producer organizations and social organizations, adjust participatory forums, empower them and provide them with instruments to respond to the principles of transparency, democracy and participatory planning.

essential complement is the project to improve the National System for the Control and Safety of Food for national consumption and export under a risk approach by the National Institute of Food and Drug Surveillance (INVIMA), in order to support the export of beef and poultry to prioritized countries. One of the objectives is to develop the productive and commercial capacities of rural communities and to draw up a plan for commercial exploitation to ensure agricultural products' access to markets. Several Colombian products have unmet international demand and/or growth projections in the short, medium and long term. Accordingly, this objective seeks to

leverage the opportunities for greater access to international markets for products such as cacao, fruit trees, beef, trout and tilapia. It is therefore essential to guarantee a constant supply of products with the quality demanded in the international market (DNP, 2015a).

Another initiative linked to the government's approach to the innovation required in the Colombian countryside, through which public policy guidelines will be defined to have a broad portfolio of policies and instruments that will allow public investment decisions for rural and agricultural development over the next 20 years, is the Mission for the Transformation of the Colombian Countryside (MTCC; see **Box 2**). It seeks to guarantee economic opportunities and economic, social and cultural rights for the rural inhabitants so that they have the option of living the decent lives they want and value (DNP, 2015b). The Mission diligently and conscientiously undertook diagnoses in various sectors and situations and proposes a series of strategies, both general and specific, to implement this transformation of the countryside that the country requires. **Box 2** summarizes the six strategies proposed by the Mission for the Transformation of the Colombian Countryside.

VIII. Conclusions

Agriculture has been a fundamental component of the Colombian economy and will continue to be a priority for economic growth, a source of employment, a factor of rural development to alleviate poverty, and in the country's current conditions, essential to the reintegration processes for the post-conflict process (Lozano & Restrepo, 2015). The main objectives of Colombian agricultural and socio-economic development are the promotion of sustainable rural development with a territorial approach and the strengthening of the productivity and competitiveness of agricultural products. The aim is also to promote the coordination of institutional actions within the principles of competitiveness, equity, sustainability, multi sectorality and decentralization.

In order to promote food and nutrition security in rural areas, actions must be taken to achieve "smart agricultural production" to focus efforts on enhancing the resilience of production systems, and to promote innovations for climate change adaptation that are affordable and suitable for all producers, including small farmers. Science and the addition of knowledge to conventional systems are the most valuable tool in the agricultural productive sector to meet current challenges and achieve some of the millennium goals. It is essential to use all currently available technologies and link them with conventional systems, according to the conditions and particularities of each region and crop: no system should exclude others (whether conventional, technified, biotechnological, organic or family agriculture).

Among the many applications of agrobiotechnologies - the most useful ones for the future in order to develop crops that are better adapted to climate change and environmental and social sustainability (ecologically friendly and with lower production costs) - are the production of bioinputs, both biofertilizers (mycorrhizas and nitrogen fixers), biopesticides for biological control and plant growth promoting bacteria (PGPBs). Colombia has had a successful experience in this field and, in fact, some of these bio-inputs are being exported (Hodson & Díaz, 2013). Other applications include the early detection of diseases through molecular diagnostic systems, the adoption of transgenic crops (GM or biotech) provided they respond to specific production constraints, and the use of recent technologies using molecular advances. One of the most promising of these technologies is one that makes it possible to obtain "Genome-Edited Crops" (GEP), because of its possibilities of addressing several constraints on production as in the case of the use of the gene edition system (such as CRISPR/Cas9 technology) to obtain resistance or tolerances to pests and diseases, improve the nutritional quality of products or seek mechanisms to tolerate abiotic factors (drought, flood, salinity) related to climate change. This technology has several advantages compared with other molecular improvement systems due to its relative simplicity, and the fact that it is

highly specific and reliable for gene editing in plant, animal and microbial cells (Li et al., 2012).

In production chains, in which Colombia has experience in production, the potential for improving productivity and increasing the area under cultivation, there is an opportunity for national production to increase its participation in the national and international market. The positioning of Colombian products abroad has advanced and the negotiation of various sanitary and phytosanitary measures has been achieved with 80 countries for over 2.500 traditional and non-traditional agricultural products. Negotiations are currently underway with 225 products to encourage exports by Colombian producers. Among the main markets are the countries with the largest population, such as the Hong Kong region, Canada, the USA and countries in the European Union (MADR, 2016).

In order to achieve a comprehensive approach to the scientific and technological developments available for the strengthening of agricultural productivity, as well as its competitiveness with social, ecological and economic sustainability, it is worth considering the Bioeconomy model, which proposes a system that is less dependent on fossil resources, based on the production and intensive use of knowledge of the biological resources, processes and principles, for the sustainable provision of goods and services in all sectors of the economy. The point is to add knowledge to the sustainable productive use of renewable natural resources. The bioeconomy cascading approach implies that processes are circular and sustainable. It minimizes production of waste or residues, and instead generates new products and services in multiple sectors, since the by-products of one process are used as the raw material of new process. The Bioeconomy development model enables the harnessing of the country's enormous natural wealth and the particularities of each territory, and facilitates its insertion into the world economy through new sustainable products and services, based on the value added by scientific and technological knowledge.

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Box 2

The Water Footprint in the Agricultural Sector

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The concept of the "water footprint" was developed by A. Hoekstra and A. Chapagain in 2003, based on the earlier concepts of virtual water (Allan, 1993) and green water (Falkenmark, 1995).

The concept of VIRTUAL WATER was presented by Tony Allan when he studied the possibility of importing virtual water as a partial solution to the problems of water scarcity in the Middle East and is defined as the quantity of water used directly and indirectly for the realization of a good, product or service. Every object that surrounds us needs thousands of liters of water to be produced, we call this water "virtual" because we do not see it; however, it is present in the food, goods and services we consume on a daily basis. This refers to the water that is contained in the products and does not return to the territory from which it was extracted for its production. In this sense, when importing or exporting products, we import or export water.

The concept of Green Water originally meant soil moisture and was first included by Professor Malin Falkenmark in order to draw attention to the water available for biomass growth and its participation in evapotranspiration. The FAO updated the definition of GREEN WATER, considering it as the vertical flow of water, ie water stored in the soil that supports rainfed vegetation and does not recharge surface or underground water sources. In this way, a definition of BLUE WATER was implicitly generated, which came to mean horizontal water flow, ie, surface water sources, rivers and lakes, and groundwater sources, aquifers. (FAO, 2000).

This new concept takes into consideration the use of hidden water employed along the chain of production of goods or services for consumption. Hidden water is the indirect use of water in producing food and products for consumption. The water footprint has three components:

1. **The green water footprint:** Refers to the consumption of groundwater stored from rainfall that maintains vegetation without irrigation. It meets a need without requiring human intervention.
2. **The blue water footprint:** Refers to the consumption of water extracted from surface or underground to meet the needs of a process. It measures the loss of available water (evaporation, change of watershed, product incorporation) due to specific consumption. It requires human intervention.
3. **The grey water footprint:** Is defined as the amount of fresh water required to absorb the amount of pollution in a body of water, taking into account the environmental quality norms and limits established for quality for both the environment and people.

Many countries, economic sectors and companies have begun to incorporate the concept as a complementary indicator of Integral Water Resource Management (IWRM). In 2010 Colombia began an initiative for the estimation of the water footprint in the agricultural sector. Studies were developed at the basin scale using the methodology of the IWFN with a Multisectoral Assessment of the Water Footprint in the Porce river basin. This study was an essential first step to allow the incorporation of the Water Footprint concept into a major document and consultation on water issues in Colombia to be used as a basis for decision making (the National Water Study - ENA 2014).

Specifically, the agricultural sector is recognized as one of the main water consumers, concentrating 85% of the world's freshwater consumption (Mekonnen & Hoekstra, 2011; Zeng et al., 2012). Irrigated agriculture accounts for 19% of the total area cultivated worldwide (ECLAC & DNP, 2014). At the

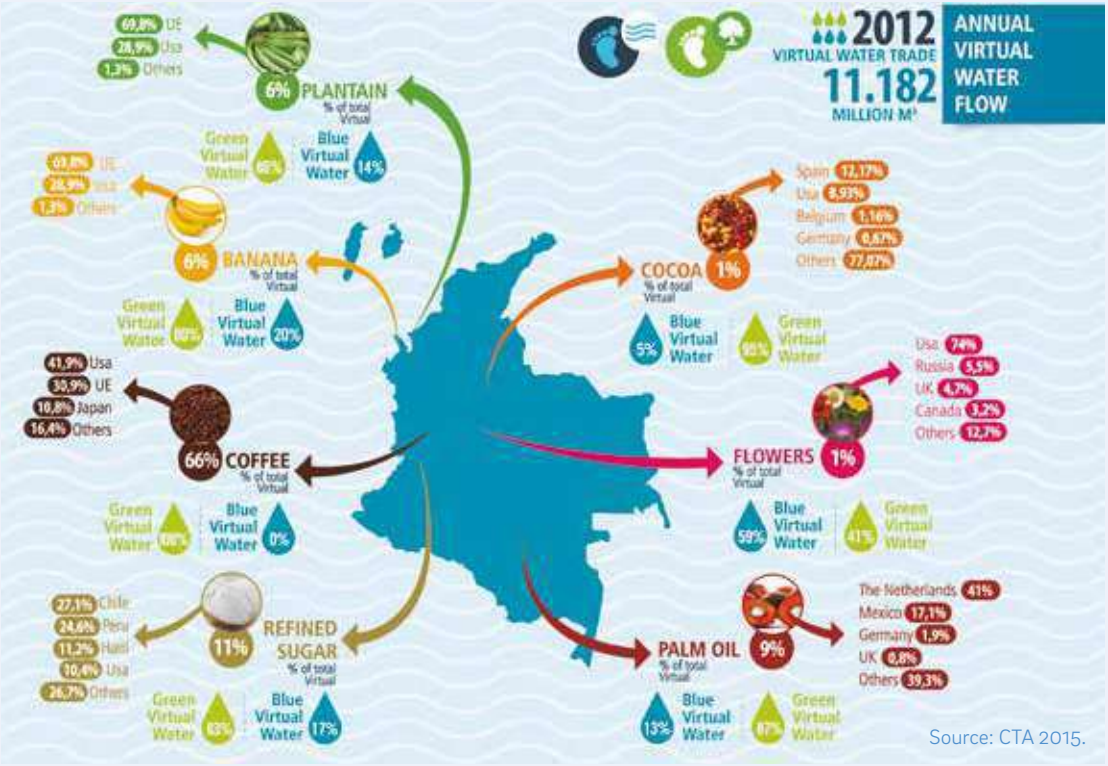
Table 1. Our Water Footprint. How Much Water does it take to Produce...

1 litre tap water > **1 litre**	1 kg corn > **900 litres**	1 whole orange > **50 litres**	1 dozen eggs > **2,400 litres**
1 litre bottled water > **5 litres**	1 kg wheat > **1,300 litres**	1 glass orange juice > **170 litres**	1 kg chicken meat > **3,900 litres**
1 cup tea > **30 litres**	1 kg soybeans > **1,800 litres**	1 whole apple > **70 litres**	1 kg pork > **4,800 litres**
1 cup coffee > **140 litres**	1 loaf bread > **960 litres**	1 glass apple juice > **190 litres**	1 kg beef > **15,500 litres**

Source: www.waterfootprint.org

international level, the organization that has led the standardization of the concept is the Water Footprint Network (WFN). The WFN has already carried out global analyzes of the water footprint of many products, which can be consulted on the WFN website; in **Table 1** are some examples.

In Colombia, 70% of the water use is attributed to the agricultural sector, corresponding to irrigation water (blue water). Even though the use of irrigation water in Colombia is marginal, compared to the use of green water (IDEAM, 2015), which corresponds to 89% of agricultural water use, we evaluate the virtual water flow of our export products, as follows:



In Colombia, developments based on the concept of water footprint are needed to integrate the agricultural sector and the environmental sector. This concept is valuable in supporting decision making regarding the productive zoning of the country and the identification of the fitness of the territory for establishing highly demanding irrigated water crops, without endangering the ecosystems and the goods and services they offer.

The water footprint has proven to be a robust tool to communicate understandable results for all sectors and actors present in a watershed. The results and conclusions aim to become a tool that supports other indicators designed for the integral management of water resources, in the local and national contexts, as well as in a tool to better manage our consumption habits.

It is important to remember when interpreting the water footprint that it is not a measure of relative scarcity. That is there are resources other than water such as labor, energy and capital that are also scarce and whose level of use is not captured by the concept.