MAIZE FOR COLOMBIA

2030 Vision

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International Center for Tropical Agriculture
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CIMMYT
International Maize and Wheat Improvement Center

The inspiration for this effort originated in the work of Knowledge Systems for Sustainability (KSS), a global alliance of organizations focused on building and testing new knowledge systems for sustainability. In addition, this work takes up methodological elements of the Australian National Forecast —which was published by the Commonwealth Scientific and Industrial Research Organization (CSIRO)—, design thinking, and transformative scenario planning methods integrated into a new CIMMYT methodology called Integrated Crop Country Initiatives that affects the generation of productive, inclusive and resilient agrifood systems to contribute to improving the quality of life of farmers and consumers. We thank Martin Kropff, Director-General, and Marianne Bänziger, Deputy Director General for Research and Partnership of CIMMYT for their support in the realization of this strategic planning. Special thanks to Molly Jahn for her innovative and inspiring vision.

CIMMYT expresses its recognition and gratitude to all those people and institutions whose contributions made possible the elaboration of this strategic plan, which aims to facilitate decision making and tactical planning in the sector. The Maize for Colombia strategic plan was made possible thanks to the support of the Government of Mexico and the vision of the Government of Colombia, the membership of the Innovation Fund for the Private Sector (Kellogg's, Grupo Bimbo, GRUMA, Nestlé, Syngenta and Pioneer now Corteva Agriscience), Rabobank, and the CGIAR Research Program on Maize (MAIZE), made possible by the generous support of W1 and W2 donors, including the governments of Australia, Belgium, Canada, China, France, India, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, the United States of America; and the World Bank.

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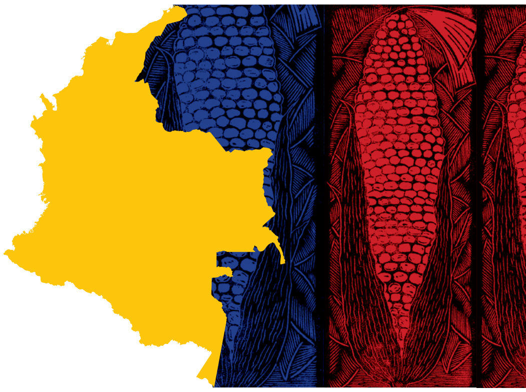

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MAIZE FOR COLOMBIA 2030 Vision

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1. Introduction

In Colombia, maize is the third crop with the largest cultivation area after coffee and rice. In spite of this, it is the country with the highest volume of imports in South America, and the seventh in the world[1].

Maize is one of the most important crops in the agrifood sector in Colombia. Maize production increased 76% between 1961 and 2016, whereas the demand for it grew at a faster rate. In 2012, a historical production peak of 1.8 Mt (million tonnes) was reached. According to the most recent data, production fell to 1.6 Mt (2016)[2]. In the same year, 74% of the national demand[3] was imported, that is, 4.6 Mt of the 6.2 Mt required in the country. If this trend continues, production is expected to grow by around 6% and demand by 9% between 2018 and 2030[4].

Maize has an important social dimension in the diet of millions of Colombians, providing 9% of the daily energy supply of their diet through the consumption of foods such as *arepas* and *mazamorra*, among others. On average, a Colombian consumes 30 kg of maize a year. However, the growing demand for this grain responds, to a greater extent, to the consumption of animal protein, which requires maize for animal feed. Therefore, this demand is explained by the significant increase in the consumption of animal products, which has soared dramatically in recent years[5]. Consumption patterns in the diet of Colombians respond to changes in income —hence in their consumption habits— as well as to the spending on animal products among the global population.

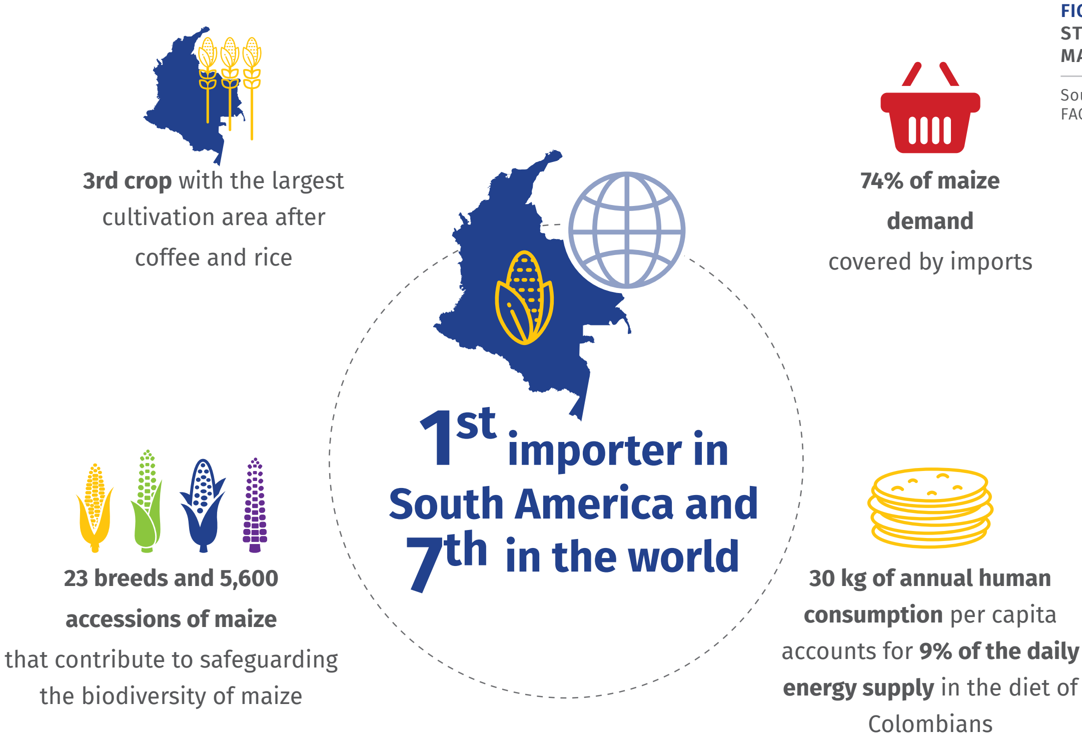


FIGURE 1.1 COLOMBIA: KEY STAKEHOLDER IN THE MAIZE MARKET

Source: Own elaboration with data from FAO and DIAN.

1 Food and Agriculture Organization of the United Nations (FAO).
2 Data simplified for editorial purposes; total production is 1,643,908 tons with data from FENALCE, 2016.
3 Directorate of National Taxes and Customs (DIAN).
4 CIAT projection, 2018.
5 FAO

In turn, production is also part of an important social and economic dimension. Two systems of maize production co-exist in the country: technified and traditional. The technified maize production system is characterized by monocultures of more than 5 hectares (ha) with water availability for irrigation in some cases, and the use of technologies based on mechanization for soil preparation, use of improved seeds, fertilizers, and chemical pesticides[6]. In Colombia, this system represents 48% of the area destined for maize, with a production of 1.2 Mt[7] and an average yield of 5.4 t/ha (tonnes per hectare), given its main characteristics of cultivation[8]. In turn, the traditional production system is characterized by planting areas smaller than 5 ha, where the crop is based on the use of a wide diversity of native varieties without the use of hybrids due to the economic difficulties to access them. Also, the technologies for sowing are based on the plough with hoe and dibble bar[9]. In this sense, in spite of having 52% of the area destined for maize production, less is produced than under the technified system, reaching a production of 0.5 Mt, and an average yield of only 2 t/ha[10].

1.1 The challenge of maize productivity in Colombia

Despite its relevance, Colombia has low average rates of maize productivity compared to the main producing countries. In 2016, the average yield for maize in Colombia was 3.6 t/ha, while in the United States it was 11 t/ha, and the world's average yield 5.4 t/ha (Table 1.1).

Since Colombia opened to trade, the demand for maize increased significantly. Between 1991 and 2016 demand grew by 515%. In the same period, however, according to data from the

TABLE 1.1 AVERAGE YIELD OF MAIZE PRODUCTION IN DIFFERENT COUNTRIES/ REGIONS

Source: Own elaboration based on information from USDA, World Agricultural Production Report, 2018.

Country/Region	2016/2017		
	Production (Mt)	Yield (t/ha)	Higher proportion in comparison with Colombia's yield
United States	384.8	11.0	3 X
Canada	13.9	9.8	2.7 X
Turkey	5.5	9.7	2.7 X
Argentina	29.5	8.0	2.2 X
Egypt	6	8.0	2.2 X
European Union	61.9	7.2	2 X
Ukraine	28.0	6.6	1.8 X
China	263.6	6.0	1.7 X
South Africa	17.6	5.9	1.6 X
Worldwide	1,122.5	5.8	1.6 X
Brazil	98.5	5.6	1.6 X
Russia	15.3	5.5	1.5 X
Vietnam	5.1	4.6	1.3 X
Pakistan	6.13	4.6	1.3 X
Thailand	5.2	4.5	1.2 X
Mexico	27.6	3.7	1 X
Colombia	1.6	3.6	

6 Quintero, L., 1999. The production and commercialization of grains and cotton in Colombia. National Agricultural Exchange. Le'Print Club Express. Bogotá, Colombia.
7 Simplified data for editorial purposes; the total average production data of the technified system is 1,165,943 t, and 477,965 t for the traditional system, according to data from FENALCE, 2016.
8 Data FENALCE, 2016.
9 Quintero, 1999.
10 Data FENALCE, 2016.

National Federation of Grain and Legume Growers (FENALCE), production increased by 27% with significant fluctuations over 25 years. In other words: *Colombia consumes maize at a faster rate than it produces it, depending more and more on imports, mainly from the United States.*

This increase in demand, characterized in recent years by a growth in yellow maize consumption, explained by the high demand for poultry products in the diet of Colombians, which means an increase of 34% in imports of yellow maize alone. Increasing the productivity of the sector is necessary to provide national farmers with the opportunity to participate competitively in the national market, improving their income, the welfare of their families and that of the Colombian population by granting access to animal products at lower prices.

The current vulnerability and risks that threaten the stability and growth of national maize production require changes in the strategies used to date. With the entry into force of the Free Trade Agreement, the imports of cereals such as maize at lower costs from the United States has represented losses for the maize sector in terms of competitiveness among national cereals. These effects have sought to be mitigated by the Government through the offer of credits for investment in machinery, incentives per ton harvested, among other kinds of support for Colombian farmers. An example is the *Plan País Maíz* 2010, implemented by FENALCE, geared to boost the supply of yellow maize; also, the *Plan Colombia Siembra 2015-2018* of the Ministry of Agriculture and Rural Development (MADR), aimed at generating more and better income by expanding the country's planted areas by 1 Mha[11].

However, the country's efforts to encourage national maize production and become competitive have not been sufficient. Global trends of increased animal protein consumption and its consequent demand for maize, as well as the effects of climate change on the crop continue to rise. The problem could worsen in the future if the gap between demand and national production grows. The challenge, therefore, is to increase the productivity and competitiveness of maize in Colombia —mainly yellow maize —in a sustainable manner, and to increase the productivity in traditional systems, without negatively affecting the environment or the living conditions of the rural population.

11 Tróchez González, J., Valencia, M., & Salazar Uribe, J. (2018). Los efectos del Tratado de Libre Comercio con Estados Unidos y los precios del maíz colombiano. *Apuntes del CENES*, 37(65), 151-172. Available at: https://doi.org/10.19053/01203053.v37.n65.2018.5988

1.2 What is Maize for Colombia?

Maize for Colombia (MpCo, its acronym in Spanish) is a strategic plan led by the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Tropical Agriculture (CIAT), which involves different levels of government, national and international research centers, civil society, farmers' associations, and private sector to design a better future for maize in the country based on a common objective: *to increase the productivity and profitability of maize in a sustainable manner, while preserving its biodiversity and improving the use of resources.*

Maize for Colombia (MpCo) proposes a space for institutional and participatory debate around three core questions: *(1) Where are we?*– Identifying current challenges and trends affecting maize cultivation in Colombia; *(2) Where are we heading?*– Projecting the *status quo* scenario based on current trends towards 2030 and analyzing more pessimistic and optimistic scenarios; and *(3) How to achieve a better future?*– Defining the conditions and drivers for achieving positive change and, therefore, a desirable scenario, moving from vision to practice through a participatory consultation process.

The result of this participatory process is reflected in this report **"Maize for Colombia: 2030 Vision"**, which consists of two parts. The first one, presents the current situation and trends in consumption, production, self-sufficiency, and imports, and their projection to 2030, assuming that these trends will be maintained; that is, if the *status quo* remains unchanged, with a focus on climate variability. It is important to highlight that the 2030 Scenarios do not represent desirable ones, but are a consequence of not modifying current production processes or consumption trends. The IMPACT[12] model was used, which includes a system of integrated models around a multi-market economic model for the production, trade, demand, and establishment of global prices of agricultural commodities. This exercise makes it possible to compare a highly probable future —if no action is taken to influence or even reverse current trends— with other more positive, but no less attainable, scenarios, which require coordinated action in favor of change. The result of this analysis lays the foundation for developing strategies with a view to transforming the maize market in Colombia in the long term.

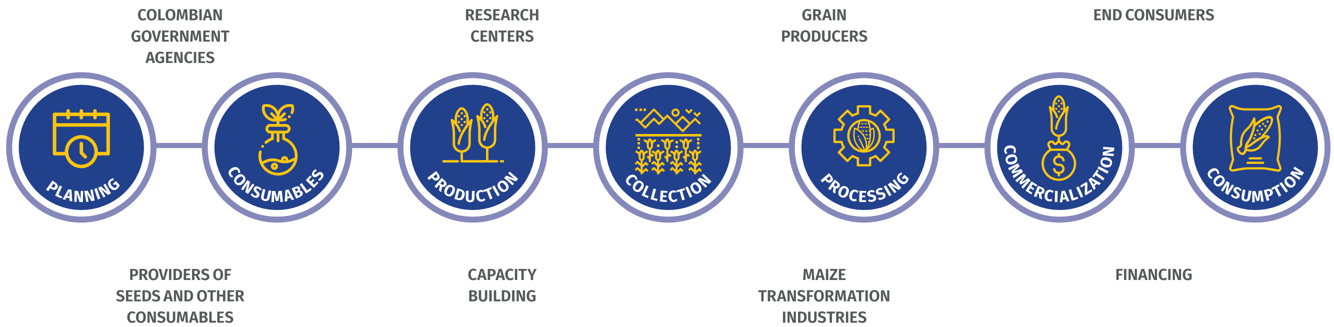
The second part introduces the strategies of the **Maize for Colombia** strategic plan, which are the result of a consensus process among stakeholders in the sector. This section focuses on setting objectives and aligning strategies to increase the supply of national maize and strengthen Colombia's resilience and food security. As will be developed later, this component is comprised of 5 drivers of change, endowed with 15 actions for implementation, developed with the participation of experts and representatives of the sector. These drivers focus on access to improved seed, nutritional security, climate-smart agriculture, farm advisors innovation networks, and the linkage of competitive farmers to the market.

The main objective of the **Maize for Colombia** strategic plan is to sensitize stakeholders and decision-makers to the need for national public-private strategic planning of the maize chain production. In this way, it will be possible to establish objectives and align strategies to increase the supply of national maize and support Colombia's food security. The current situation and trends of maize cultivation in Colombia require as much alignment as possible of stakeholders that are part of this system's production chain, as well as of those who make up the Colombian agrifood sector.

12 *International Model for Policy Analysis of Agricultural Commodities and Trade.*

The scope of **Maize for Colombia** comprises the maize value chain (Figure 1.2) represented by key players such as seed and other inputs, suppliers, farmers, collectors, processing industries —in particular the feed industry—, traders, and final consumers. In addition, the participation of Colombian Government agencies, research and training centers, service providers —such as financing, logistics—, storage, agricultural insurance and technical assistance, among others, is considered.

FIGURE 1.2. SCOPE OF THE STRATEGIC PLAN MAIZE FOR COLOMBIA



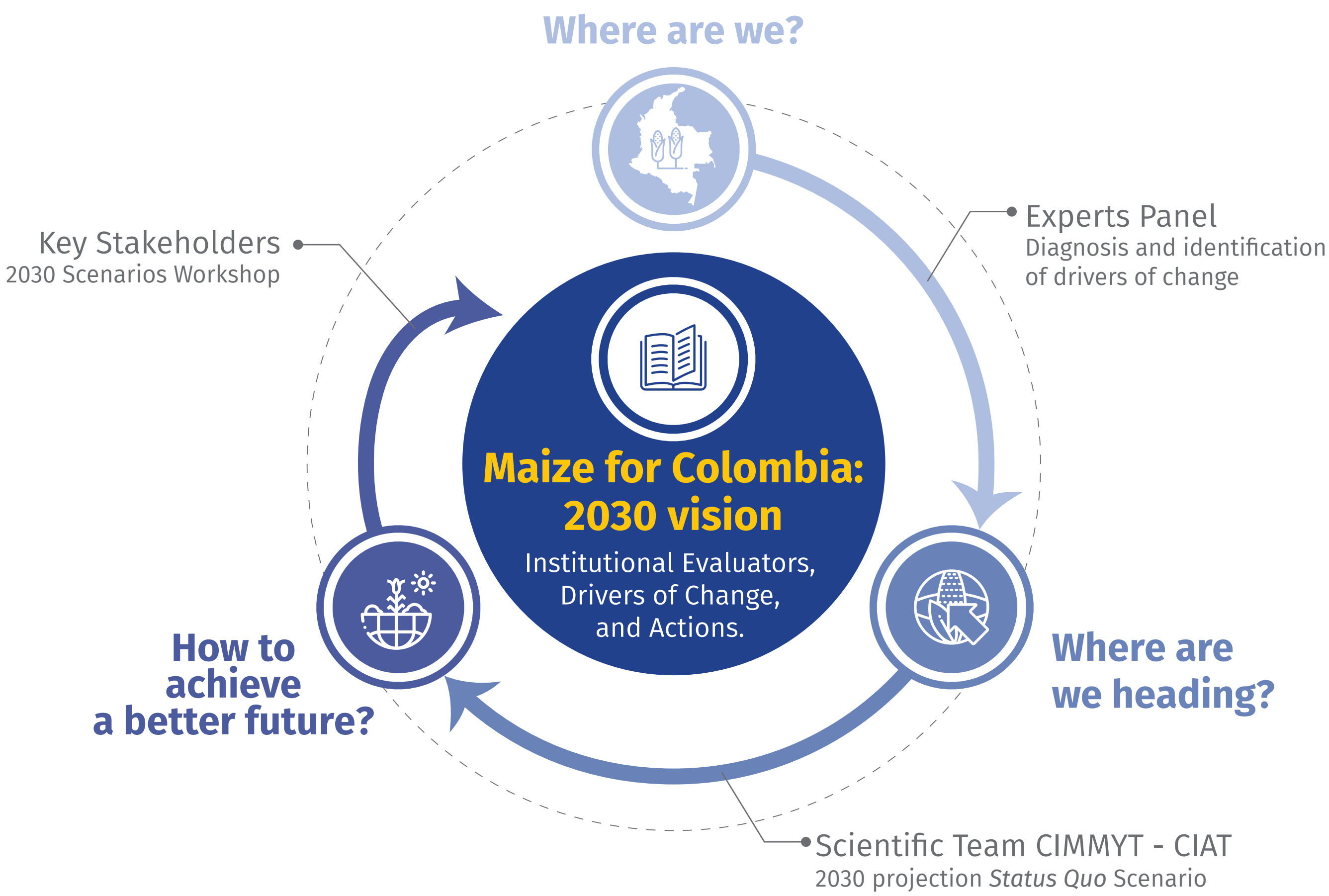
1.3 Methodology

CIMMYT, together with CIAT, as independent international centers and leaders in research and development of maize production systems, propose with this initiative a space for reflection and institutional debate to *generate a strategy to transform the maize field and sector in Colombia*. The basis of this strategic plan is research, consultation, analysis, and validation, in which actors decide how to respond to potential future scenarios and jointly develop a common vision, with recommendations for the design and implementation of public policies. There are numerous studies on the conditions of maize cultivation and its growing areas of opportunity and threats. Despite this, it is known that recommendations from studies and research projects often remain on paper. **Maize for Colombia (MpCo)** *seeks to move from paper to action, encouraging debate and participation among stakeholders and*, based on this, generate a strategic plan making use of available data and information. **Maize for Colombia** follows the methodological scheme below:

FIGURE 1.3 MAIZE METHODOLOGY FOR COLOMBIA

QUESTIONS	PROCESS	FOCUS GROUPS	OUTPUT
I. Where are we?	Analysis	Experts Panel	Diagnosis and identification of drivers of change
II. Where are we heading?	Research	CIMMYT-CIAT Scientific Team	2030 Projection, *Status quo* Scenario
III. How can we achieve a better future?	Participatory Consultation	Key stakeholders	2030 Scenarios Workshop
	Validation	Institutional Evaluators	Strategic Drivers and Actions

FIGURE 1.4. DIAGRAM OF THE MAIZE PROCESS FOR COLOMBIA



1.4 Participatory consultation: Outcomes

Every successful project is based on a clear and shared vision. Hence, analysis and research should be complemented by a participatory consultation process —in this case a 2030 Scenarios Workshop based on 6 drivers of change identified by internal and external experts, of which 5 were validated. The objective behind the call and conduct of this exercise was to involve stakeholders from the outset and facilitate the implementation and continuity of the strategic plan. The participatory process used was designed to:

- Generate a vision of the desired final outcome.
- Establish the values that will guide the group's decisions in the long term.
- Establish a starting point for effective change and its continuity.
- Gather the initiatives already underway under a single reference framework.
- Define better policies and projects.
- Multiply the commitment of the stakeholders who will implement the vision.

In the 2030 Scenarios Workshop, participants initially adjusted and validated the 6 drivers of change presented by an Expert Panel, subsequently approving only 5 of them. The workshop dynamics guided the participants to disaggregate each of the drivers into a series of short-, medium- and long-term strategies and actions. The proposal resulting from the Workshop was developed by a group of 49 stakeholders including leaders of the main public and private entities that make up the maize value chain (see Annex 1, 2030 Scenarios Workshop Report).

Once the results of the 2030 Scenarios Workshop roundtables were systematized and synthesized, the objectives, expected results, and short-, medium- and long-term actions were evaluated by 19 institutional representatives in a second validation process carried out between December 2018 and March 2019. The result is a synthesis of 5 drivers, with concrete objectives and actions so that the vision can be taken to the operational level.

FIGURE 1.5 ACTIONS TO MOVE FROM SCENARIOS TO ACTION

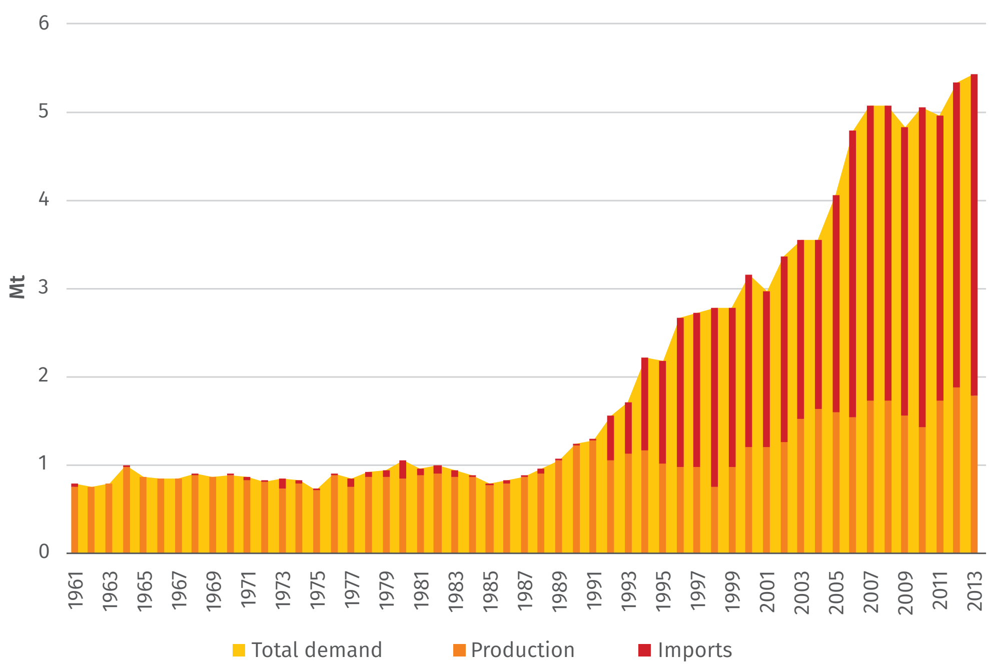
Drivers of change	Goal	Short-, medium- and long-term actions
Improved seed adoption	Improved seed adoption by 100% of area operating under technified system, and at least 10% of area under traditional system by 2030.	**1A.** Document the needs of the seed market. **1B.** Implement financing and incentive schemes that provide support and bring dynamism to the adoption of improved seed. **1C.** Develop resources for maize improvement research.
Nutritional security	Achieve a national human consumption of 50% biofortified white maize with high zinc content by 2030.	**2A.** Increase the volume of biofortified maize seed production and consumption. **2B.** Identify and address the collection and storage needs of biofortified maize farmers. **2C.** Develop a national dissemination strategy to increase the demand for biofortified maize in the country.
Climate-smart agriculture	Conversion to sustainable agriculture adapted to climate variability and change in at least 100,000 hectares of maize production systems by 2030.	**3A.** Develop an agroclimatic information system for better decision making and use of technologies. **3B.** Scaling up the use of CSA technologies, practices, and tools, including conservation agriculture. **3C.** Implement financing schemes and incentives to increase investment in technologies and systems for climate-smart agriculture.
Farm advisors innovation networks	Coverage of innovation networks as a standard of extensionism and technical assistance in at least 30% in the rural area.	**4A.** Develop a strategy of technical support networks based on diagnosis and regional productive categorization. **4B.** Establish the necessary mechanisms for the implementation of a farm advisors innovation network. **4C.** Incorporate public and private institutional financing mechanisms.
Linking competitive farmers to the market	Increase trade linkages for competitive farmers to the local, regional, and national market.	**5A.** Create a Maize Observatory to facilitate access to market information. **5B.** Link farmers in marketing associations at local, regional, and national levels. **5C.** Improve existing infrastructure and production systems to ensure market competitiveness.

The development of the *Maize for Colombia* strategic plan is based on the need for a national strategy focused on strengthening the Colombian maize production chain, through specific objectives and actions to increase national supply. This should be done respecting the culture and heritage of the crop, as well as strengthening the country's resilience and food security, in order to make Colombia a country with greater maize production. In this way, through clear actions and a defined tactic, the strategic plan seeks to promote sustainable agriculture for maize production in Colombia, achieve higher and stable yields, as well as higher incomes for Colombian farmers. In addition, this plan is an opportunity to simultaneously address, from a national perspective, several urgent development objectives, such as opening up agricultural potential to adapt production systems to climate change; integrating small and medium-sized farmers into the market; promoting improvements in the sustainable management of soil, nutrients, and water resources, as well as achieving food and nutritional security; and reducing rural poverty.

2. Where are we?

2.1 Demand

In just over 50 years, the demand for maize in Colombia has multiplied by 6.8 times. According to the Food and Agriculture Organization of the United Nations (FAO), between 1961 and 2013, demand increased from 0.8 Mt to 5.4 Mt (see Graph 2.1). According to data from the National Federation of Cereal and Legume Growers (FENALCE), for the period 1970-2013, the growth in demand had a similar trend equivalent to 622%; by 2016, the total demand for maize was 6.2 Mt. This growth is explained by the significant increase in maize consumption since the early 1990s, with a growth of 515% between 1991 and 2016.



GRAPH 2.1 DEMAND FOR MAIZE IN COLOMBIA 1961-2013, INCLUDING MAIZE IMPORTS AND NATIONAL PRODUCTION

Source: Own elaboration with FAO data.

There are two ways to explain this trend. The first is the gradual opening of trade, which dramatically reduced tariffs, allowing for an increase in the import of goods. Until 1991, Colombia was self-sufficient in maize production (although it is assumed that demand was really higher and sorghum was used as a substitute); from 1992, maize imports grew significantly, reaching 3.6 Mt by 2013. The second reason, which also explains the increase in imports, is the changing diets, which have been characterized by an increase in the demand for maize for animal feed.

In Colombia, the main types of consumed maize are yellow and white. Of these, yellow maize is mainly used for animal feed, whereas white maize is mainly used for human consumption. Changes in dietary patterns in recent decades have impacted the demand for both types of maize. According to FENALCE (see Graph 2.2 and Table 2.1), between 2007 and 2016, the total increase in demand for both was 25%, growing at an annual rate of 3% in this period. However, demand for yellow maize was higher (85%) than for white maize (15%).

GRAPH 2.2 DEMAND FOR MAIZE BETWEEN 2007 AND 2016

Source: Own elaboration with data from FENALCE.

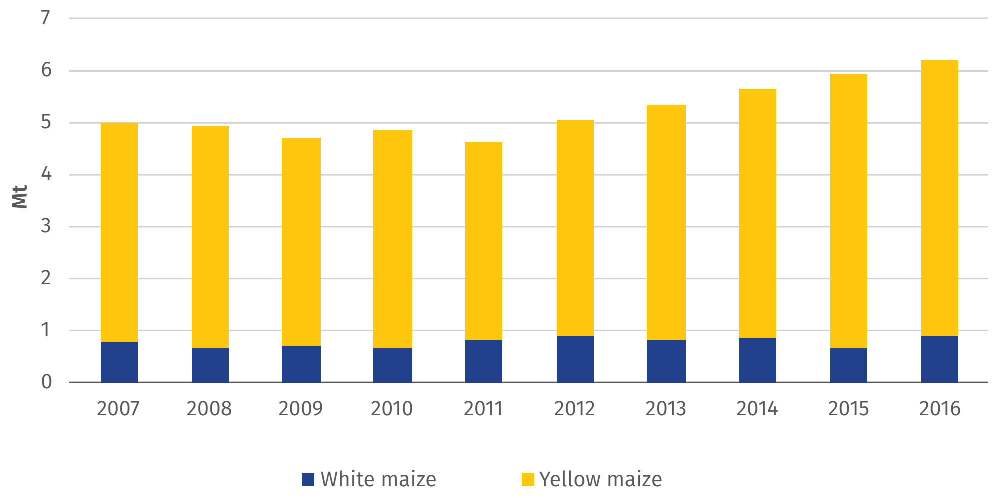


TABLE 2.1 DEMAND FOR MAIZE BETWEEN 2007 AND 2016

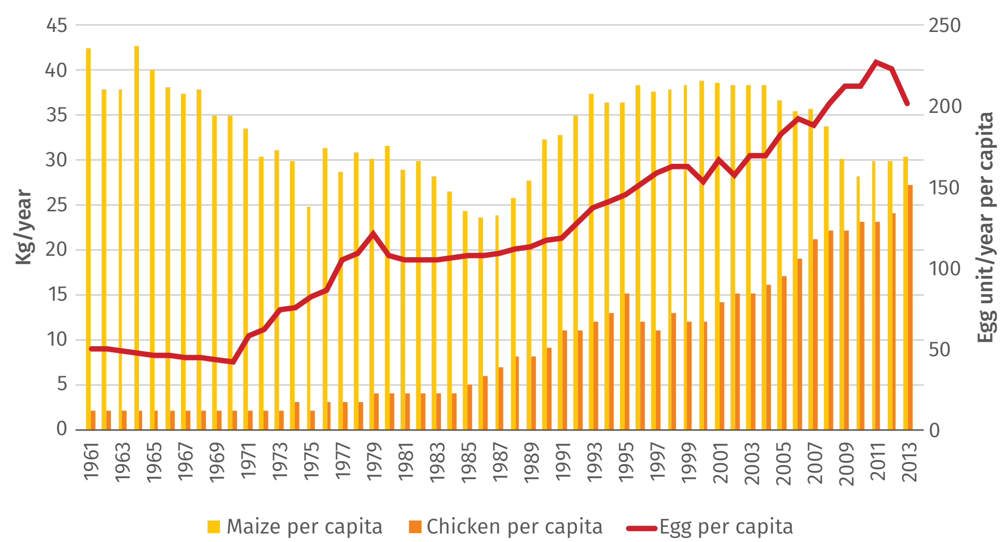
Source: Own elaboration with data from FENALCE.

Demand (Mt)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total increase	Annual increase
White	0.79	0.65	0.71	0.64	0.8	0.88	0.81	0.84	0.65	0.91	15%	2%
Yellow	4.18	4.27	3.96	4.22	3.79	4.17	4.50	4.80	5.24	5.30	27%	3%
Total	**4.97**	**4.92**	**4.67**	**4.86**	**4.61**	**5.06**	**5.30**	**5.64**	**5.89**	**6.21**	**25%**	**3%**

This change in diet is even greater if we consider the consumption of animal products which, according to FAO data, has increased drastically in recent years (see Graph 2.3). Between 1961 and 2013 there was an increase from 2 kg to 27 kg per capita consumption of chicken meat. Even taking into account that in this period Colombia's population almost tripled, chicken meat production has grown at a much faster rate, from 0.03 Mt to 1.2 Mt, that is, 42 times in less than six decades. In turn, egg consumption has increased four times its volume, while its production increased 13 times in the same period. However, human consumption of maize decreased by 30% compared to per capita consumption of animal products, from 42 kg to 30 kg per capita per year.

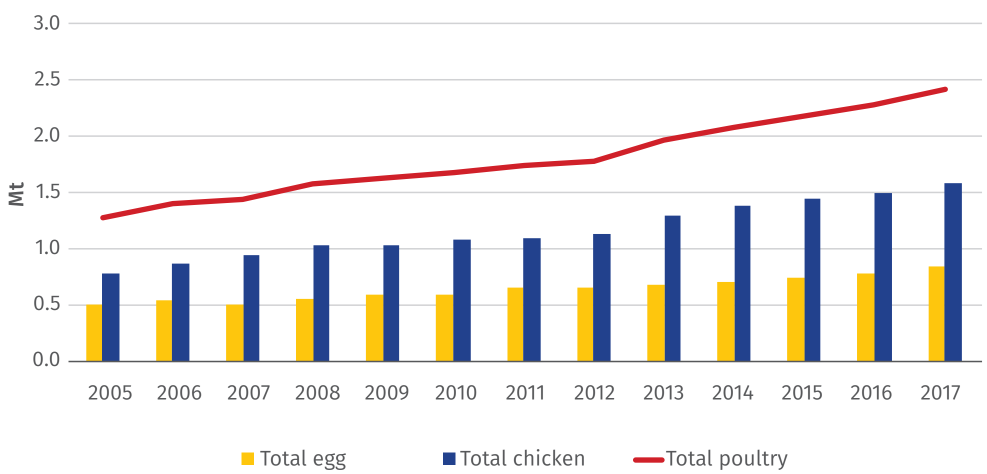
GRAPH 2.3 PER CAPITA CONSUMPTION OF MAIZE AND POULTRY PRODUCTS BETWEEN 1961 AND 2013

Source: Own elaboration with data from FAO.



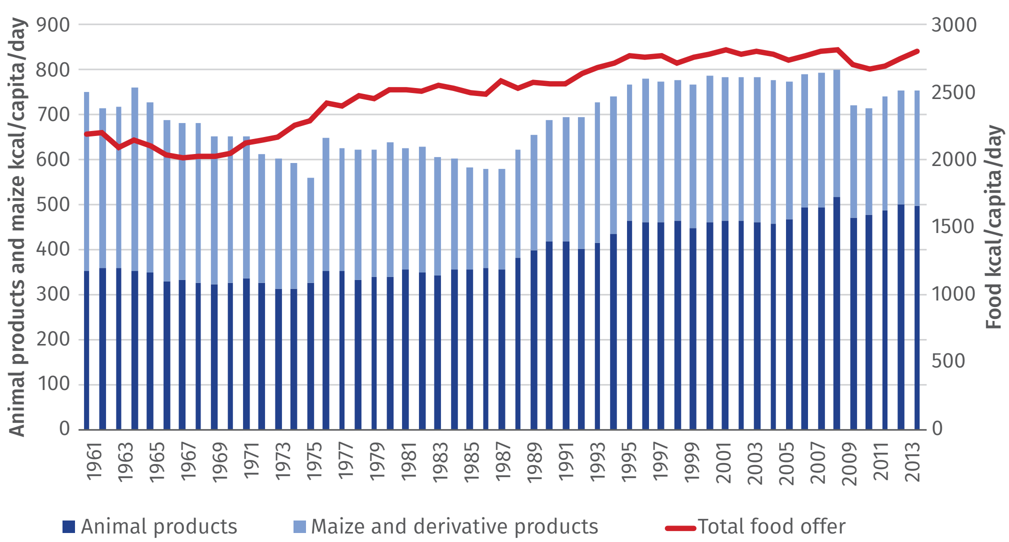
The growing demand for food for animal consumption is explained, to a large extent, by changes in income patterns —thus in the diet of Colombians and in the spending of the global population on animal products. As income increases, spending on cereals tends to decrease, while consumption of meat, milk, and eggs increases.

The dietary patterns of Colombians have changed in recent decades. One of the most noteworthy is the growth in poultry products consumption, i.e. chicken and eggs. Between 2005 and 2017, chicken consumption increased by 51%, whereas egg consumption increased by 41% (see Graph 2.4). As a result of these habits, human consumption of grains, such as maize, is decreasing. As can be seen in Graph 2.5, the amount of kilocalories (kCal) per capita per day in Colombia has increased by 28% for total food supply and shows a specific increase of 41% for animal products, while kCal for maize and maize products show a decrease of 35%. In general, these changing dietary trends reveal that, in recent decades, there has been a growing demand for livestock and chicken products, which in turn require more yellow maize for animal feed. This explains why between 2007 and 2016 there was a greater demand for this type of maize over white maize, which tends to be for human consumption (see Table 2.1).



GRAPH 2.4 CONSUMPTION POULTRY SECTOR BETWEEN 2005 AND 2017

Source: Prepared by the authors with data from the National Federation of Poultry Producers of Colombia (FENAVI).



GRAPH 2.5 PER CAPITA FOOD OFFER 1961-2013

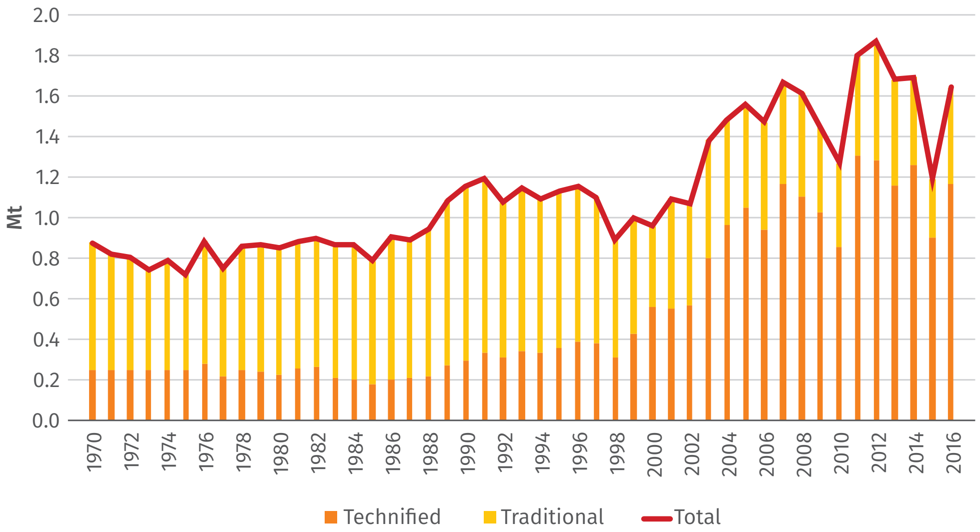
Source: Own elaboration with FAO data.

2.2 Production

Maize production in Colombia has been increasing in recent decades. According to FAO data, national maize production has increased by 76% between 1961 and 2016, with an annual growth of 0.4%. While national production amounted to 0.7 Mt in 1961, by 2016 it reached 1.3 Mt. According to information from FENALCE, maize production for the period 1970-2016 shows a similar trend. Considering production systems in 2016, the national production of maize under the technified and traditional systems was 71% and 29%, respectively.

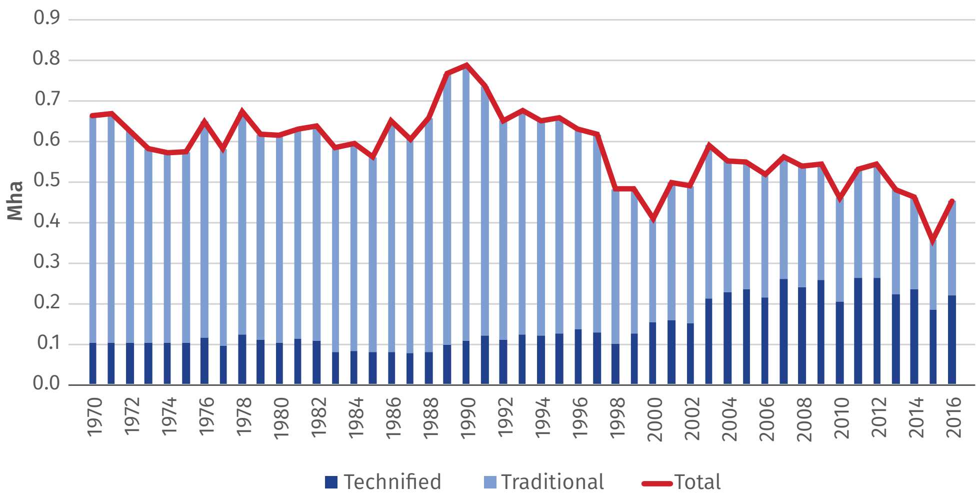
GRAPH 2.6 MAIZE PRODUCTION BETWEEN 1970-2016

Source: Own elaboration with data from FENALCE.



According to FENALCE, the distinction between traditional and technified production is due to the fact that traditional production comes from a farm that (1) does not use hybrid seeds, (2) does not use irrigation systems, and (3) limits fertilizer application to nitrogen levels of up to 40 kg/ha. Since year 2000, more than half of the national production (58%) comes from technified maize. In Graph 2.6 it is possible to identify a considerable increase in the production of technified maize. In contrast, traditional maize production has declined over the past 40 years.

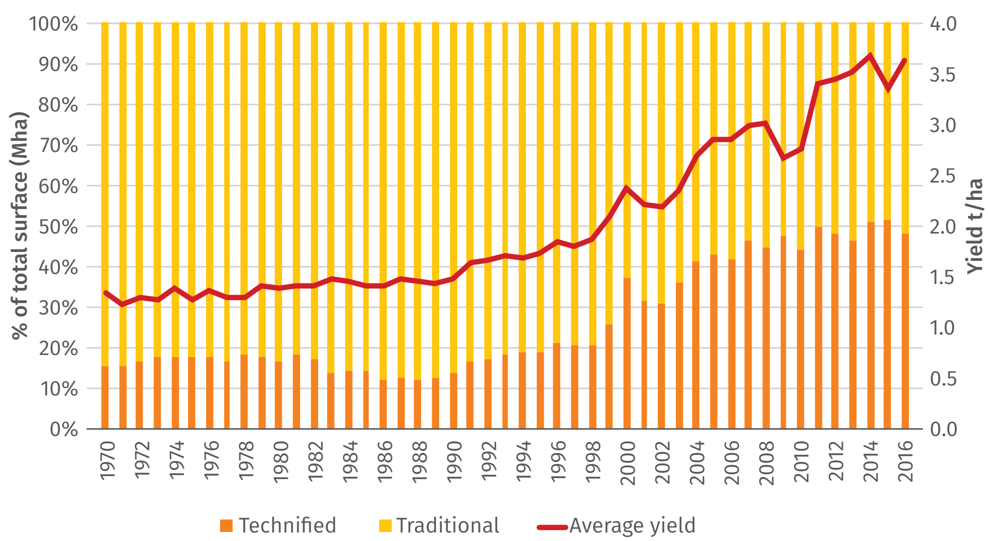
It is important to note that the increase in maize production in recent years does not respond to an increase in the total cultivated area. On the contrary, according to the FAO, the area for maize production has decreased by 47% between 1961 and 2016. Based on data from FENALCE, in 1970 the area sown for maize cultivation was concentrated around 0.7 Mha, while in 2016 there were only 0.5 Mha cultivated, which shows a decrease of 32% (see Graph 2.7).



GRAPH 2.7 TOTAL CULTIVATION AREA FOR TRADITIONAL AND TECHNIFIED MAIZE PRODUCTION BETWEEN 1970-2016

Source: Own elaboration with data from FENALCE

For the data series from 1970 to 2016, the proportion of area planted under the traditional system has decreased, whereas the area under the technified system has increased. Of the total area planted in 1970 (0.7 Mha), 85% corresponded to the traditional system and 15% to the technified system; by 2016, when 0.5 Mha was planted, these percentages were 52 % and 48 %, respectively (see Graph 2.8).



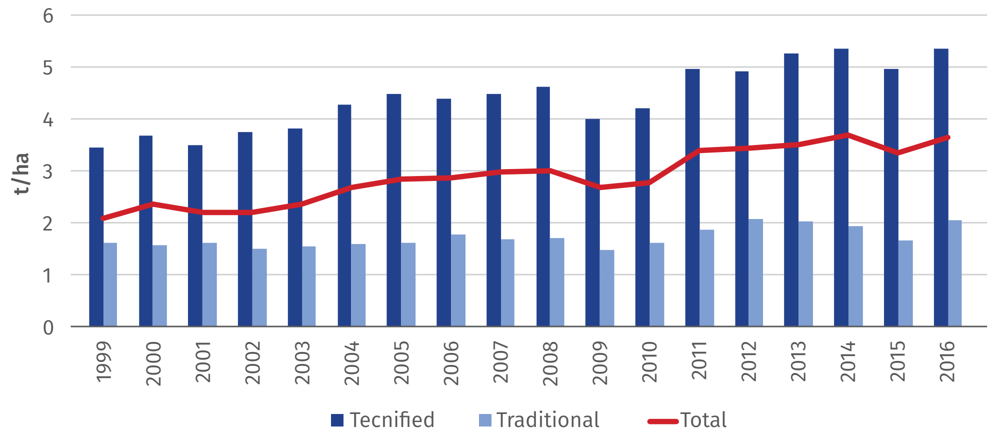
GRAPH 2.8 TOTAL AREA OF MAIZE CULTIVATED FOR TRADITIONAL AND TECHNIFIED PRODUCTION BETWEEN 1970-2016

Source: Own elaboration with data from FENALCE.

Although the total area of maize production in Colombia has decreased since 1961, according to data from FAO and FENALCE, the average yield shows an opposite trend almost tripling in just over 50 years, from 1.1 t/ha in 1961 to 3.6 t/ha in 2016. Maize yields under the technified system are higher than under the traditional system. According to data from FENALCE, between 1970 and 2016, yields under the technified system registered an increase of 121%, going from 2.4 t/ha to 5.4 t/ha. On the other hand, yields under the traditional system also increased, but at a slower rate, by 81%, from 1.1 t/ha 2.0 t/ha (see Graph 2.9).

GRAPH 2.9 YIELDS BY MAIZE PRODUCTION SYSTEM BETWEEN 1999-2016

Source: Own elaboration with data from FENALCE.

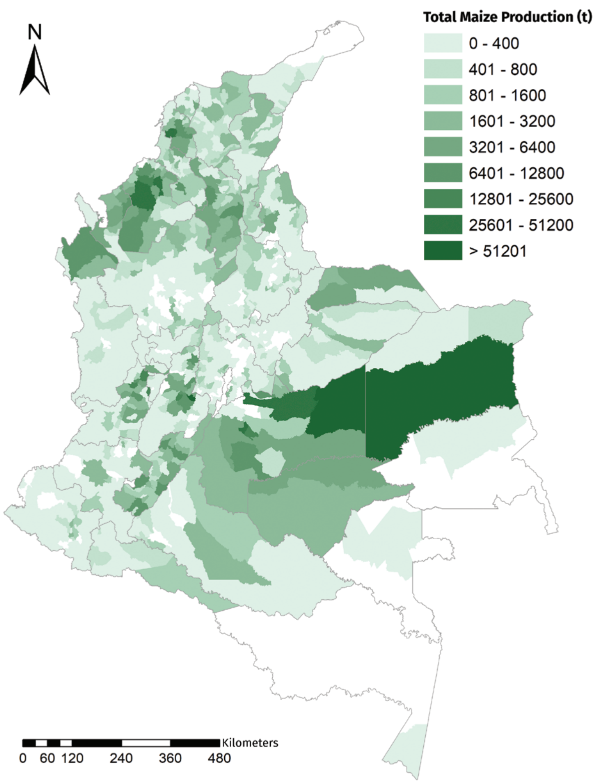


The analysis of local production shows that the departments of Colombia where the highest maize production is concentrated are located in the Orinoquia, Andean, and Caribbean regions. According to *Open Data* of the Government of Colombia, only in 2016, of the 32 departments of the country, only 5 represented 63% of national maize production: Meta, in the Orinoquia region; Vichada, in the Amazon region; Valle del Cauca and Tolima, in the Andean region; and Cordoba, in the Caribbean region (see Map 2.1). On the other hand, data from FENALCE indicate that the main departments having shown a particular increase in maize production are Meta and Tolima, which between 2007 and 2016 increased their production by 100% and 59%, respectively. It should be noted that 70% of maize production in 2016 was concentrated in technified farms, and the remaining 30% in traditional farms.

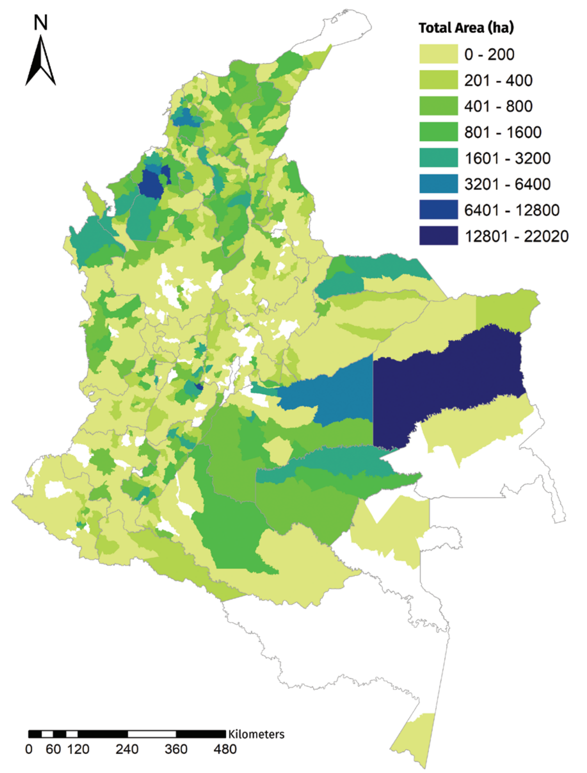
MUNICIPAL LEVEL MAPS

Source: Own elaboration with data from the *Open Data* platform of the Government of Colombia 2016.

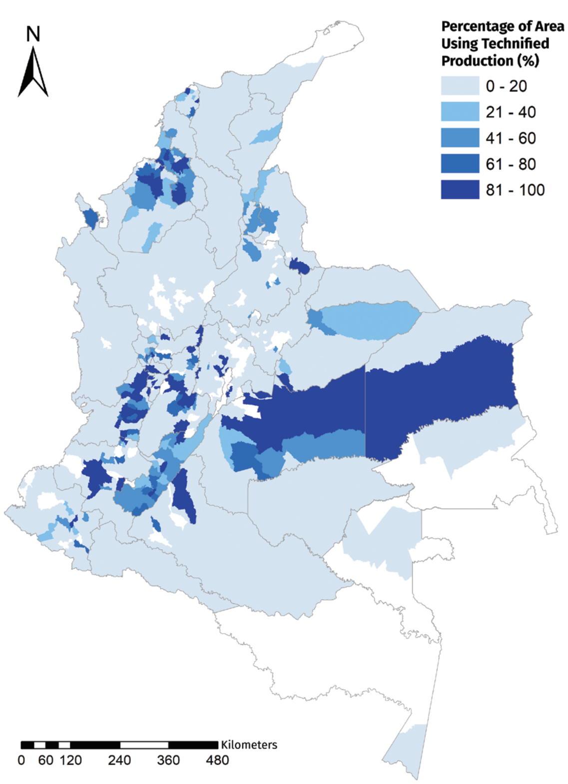
2.1 TOTAL MAIZE PRODUCTION



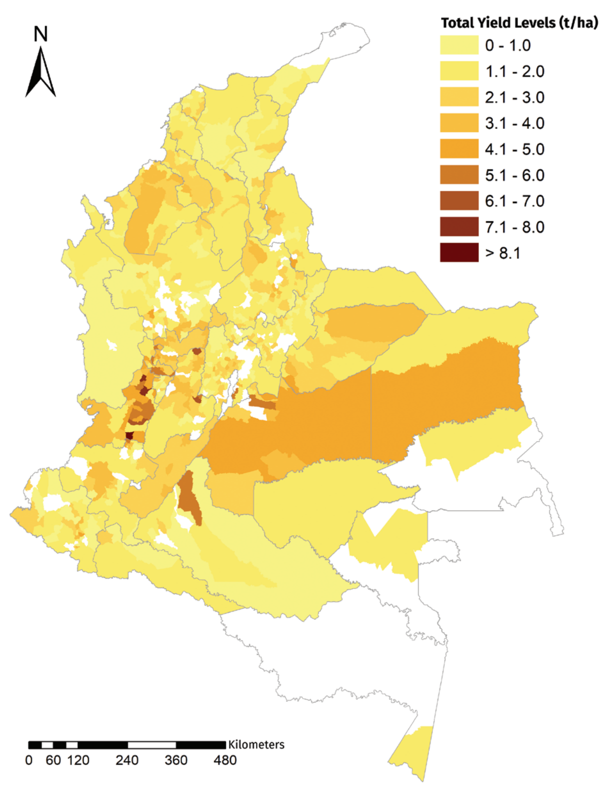
2.2 TOTAL AREA



2.3 PERCENTAGE OF AREA USING TECHNIFIED PRODUCTION



2.4 TOTAL YIELD LEVELS



On the other hand, despite an increase in the production of technified maize in Colombia, the *Open Data* figures of the Government of Colombia indicate that there are still 9 departments that until 2017 concentrated 100% of their production in traditional systems, representing around 7% of national production with an average yield of 1.4 t/ha. These departments are located throughout the national territory in the 5 regions of Colombia, and are Amazonas, Antioquia, Arauca, Guainia, Guaviare, La Guajira, Magdalena, Putumayo, San Andres and Providencia.

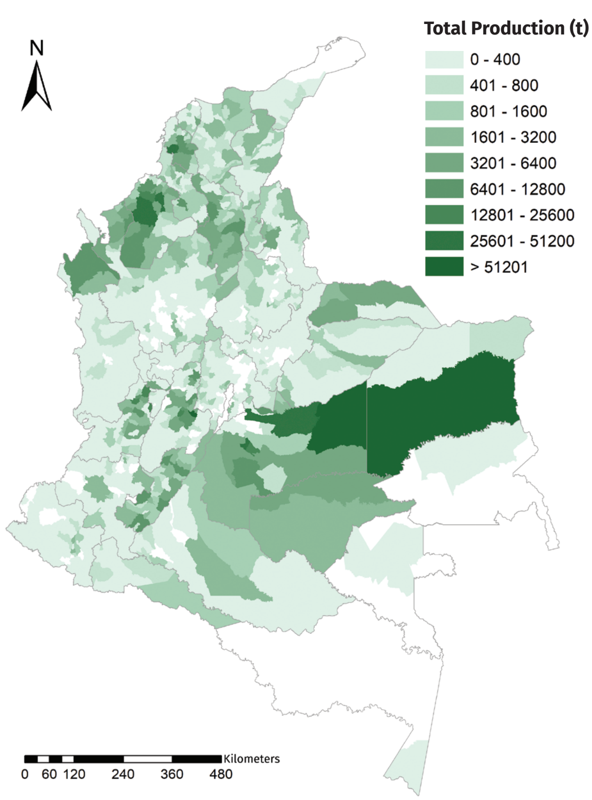
As can be seen in Maps 2.1 and 2.2, the trend towards higher yields occurs in the technified production system. In 2016, the average maize yield was 3.6 t/ha. However, as shown in Maps 2.5 and 2.6, there is a significant variation throughout the country. According to information from *Open Data* of the Government of Colombia the highest yields are in the departments of Valle del Cauca (4.3 t/ha) and Meta (4.1 t/ha). On the other hand, departments with the lowest yields are Choco (0.6 t/ha), San Andres and Providencia, (1 t/ha) and Magdalena (2.1 t/ha), all with traditional production systems.

Graph 2.10 shows the municipalities of Colombia categorized by yields in 2016. According to figures of *Open Data* of the Government of Colombia, 1,845 municipalities —i.e. 73% of the total area— register yields below the national average. Due to low yields, these regions produce only 43% of the country's total maize, whereas 267 municipalities have yields higher than average (>3.6 t/ha), representing 57% of Colombia's total maize production with an average yield of 5.4 t/ha. These municipalities belong mainly to the departments of Caldas, Cauca, Cordoba, Huila, Meta, Tolima and Valle del Cauca. Five of them (Cauca, Cordoba, Meta, Tolima and Valle del Cauca) are the departments with the highest national yields.

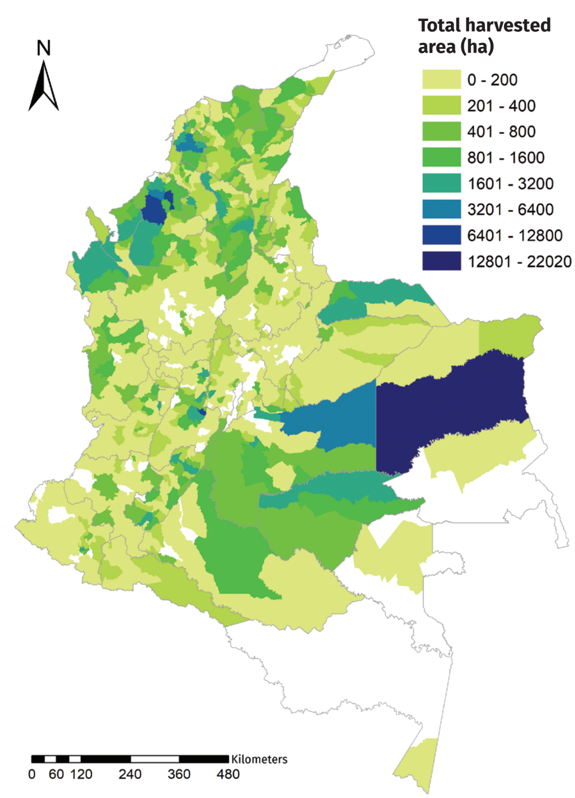
MAP OF AVERAGE YIELDS BY MUNICIPALITY

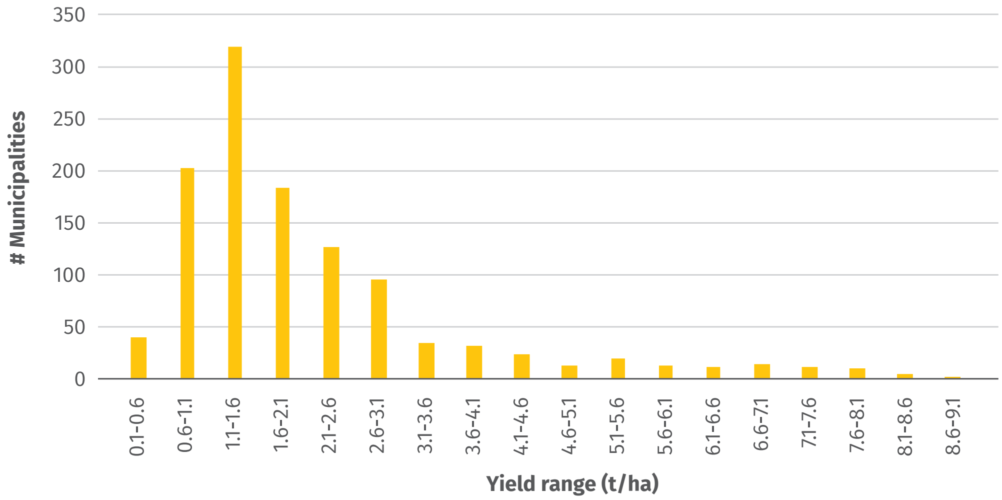
Source: Own elaboration with data from the *Open Data* platform of the Government of Colombia 2016.

2.5 TRADITIONAL SYSTEM



2.6 TECHNIFIED SYSTEM



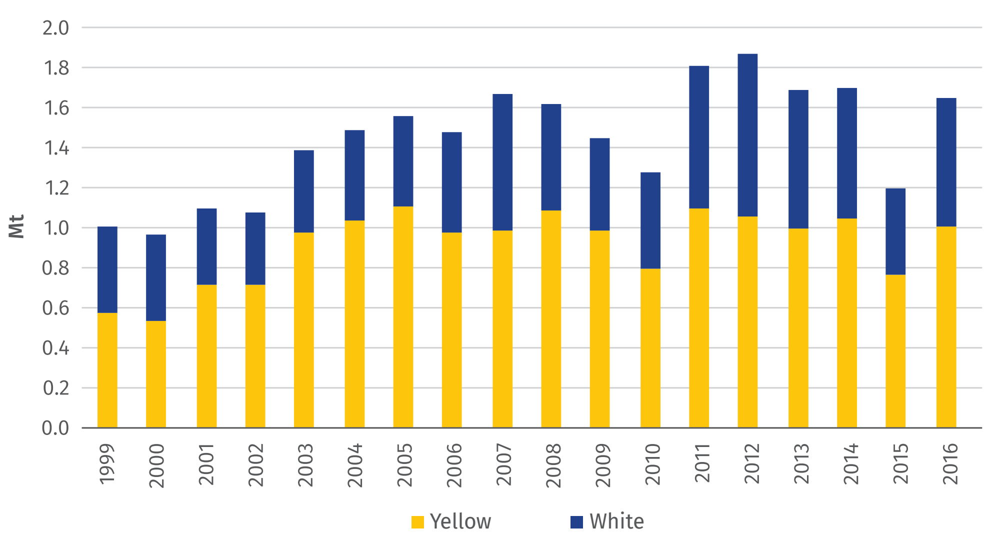


GRAPH 2.10 DISTRIBUTION OF YIELDS AT MUNICIPAL LEVEL IN 2016

Source: Own elaboration with data from the Open Data platform of the Government of Colombia 2016.

As for the type of maize produced in Colombia, both yellow and white depend entirely on the market conditions of the period being analyzed, although, at least in the last 20 years, the production of yellow maize is consistently higher than that of white maize. FENALCE has reported maize production figures differentiating yellow from white maize since 1999 (see Graph 2.11).

As can be seen in Table 2.2, there has been an increase in the area destined for technical production for both yellow and white maize. In 2016, this increase was 45% for white maize and 50% for yellow maize in the total area, while the total production of yellow maize was 1 Mt and 0.6 Mt for white maize. That is, 61% of national production was yellow maize. Both increases have more than doubled compared to production levels in 1999 —56% for yellow and 68% for white maize. According to reports from the United States Department of Agriculture- Foreign Agricultural Service (USDA-FAS) in 2017, farmers are gradually shifting their production to white maize. The reason is that prices for white maize —the main raw material for *arepa*, a staple food product— remain more favorable than prices for yellow maize.



GRAPH 2.11 YELLOW AND WHITE MAIZE PRODUCTION BETWEEN 1999-2016

Source: Own elaboration with data from FENALCE.

TABLE 2.2 SURFACE PERCENTAGE USED FOR TECHINIFIED PRODUCTION AND TOTAL PRODUCTION

Source: Own elaboration with data from FENALCE.

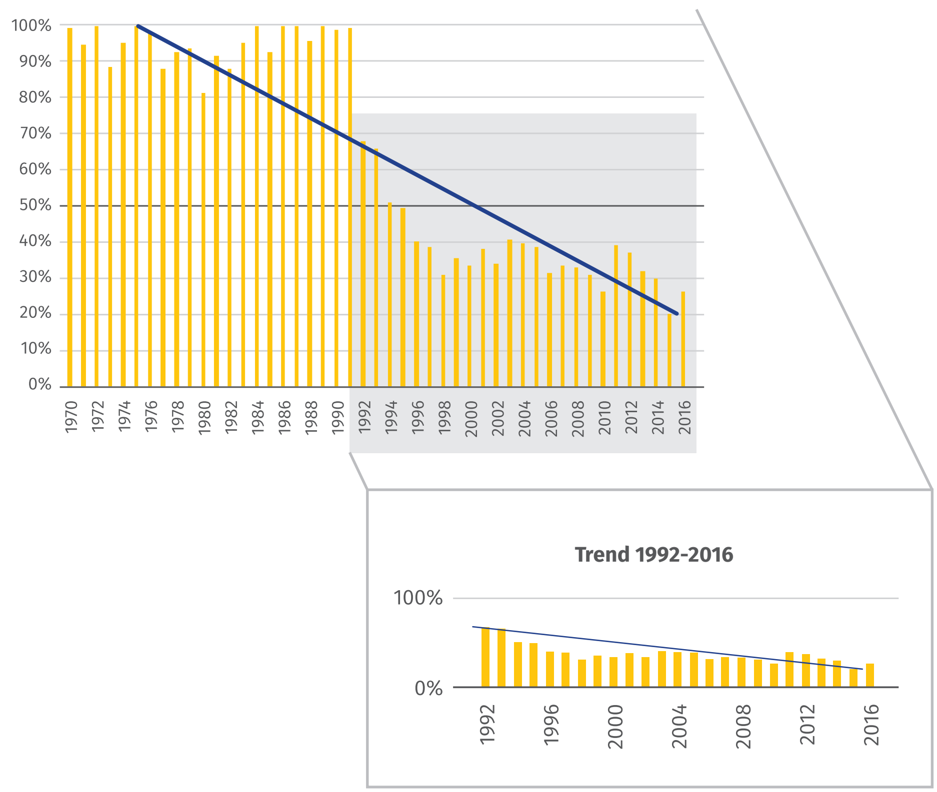
Year	Technified area (%)		Total production (Mt)		
	Yellow	White	Yellow	White	Total
1999	31%	20%	0.6	0.4	**1**
2016	50%	45%	1	0.6	**1.6**

2.3 Self-sufficiency and imports

Until 1991, maize self-sufficiency, measured by the relation between demand and national production, had been fairly stable, fluctuating in the range between 90% and 100% (see Graph 2.12). However, since 1991 there has been a sharp drop in maize self-sufficiency in Colombia. According to FENALCE data, in 1991 there was 99% self-sufficiency, but it fell to 26% in 2016. This is largely due to increased demand for yellow maize due to a growing consumption of animal products and the fact that production has not grown at the same pace as demand. In 2016, self-sufficiency reached 70% for white maize, compared to 19% for yellow maize.

GRAPH 2.12 MAIZE SELF-SUFFICIENCY BETWEEN 1970-2016

Source: Own elaboration with data from FENALCE.

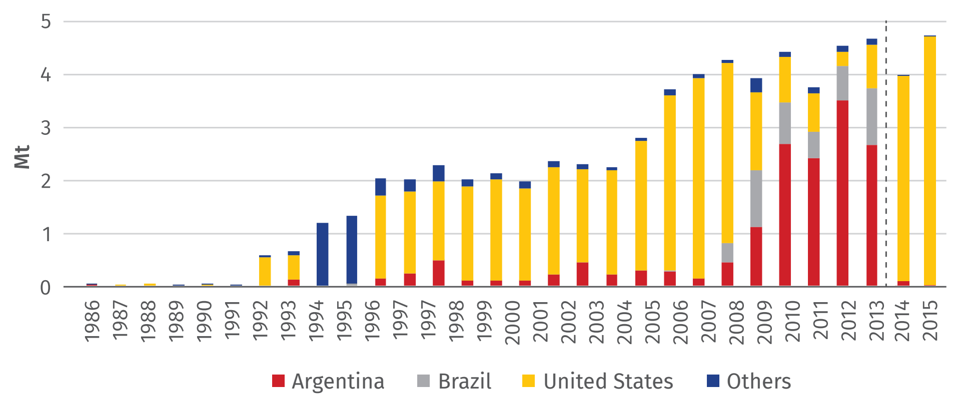


The progressive decline in maize self-sufficiency in Colombia has indeed occurred because of imports. According to FAO data, maize imports increased dramatically in the period from 1991 to 2015 (see Graph 2.13). In 1991, imports amounted to 0.01 Mt, increasing to 4.6 Mt by 2016. In 2016, yellow maize accounted for 94% of imports (4.3 Mt), while the remaining 6% (0.3 Mt) belonged to white maize[13].

13 DIAN.

Currently, most of the country's imports come from the United States, Argentina, and Brazil. Between 1996 and 2008, these came mostly from the United States, with an average of 84% in these 12 years. After 2008, imports from Brazil and Argentina began to become more predominant. In 2013, 57% of total imports came from Argentina, 23% from Brazil, 18% from the United States and 2% from other countries. In the same year, Colombia imported 3.6 Mt of maize worth more than US$1 trillion.

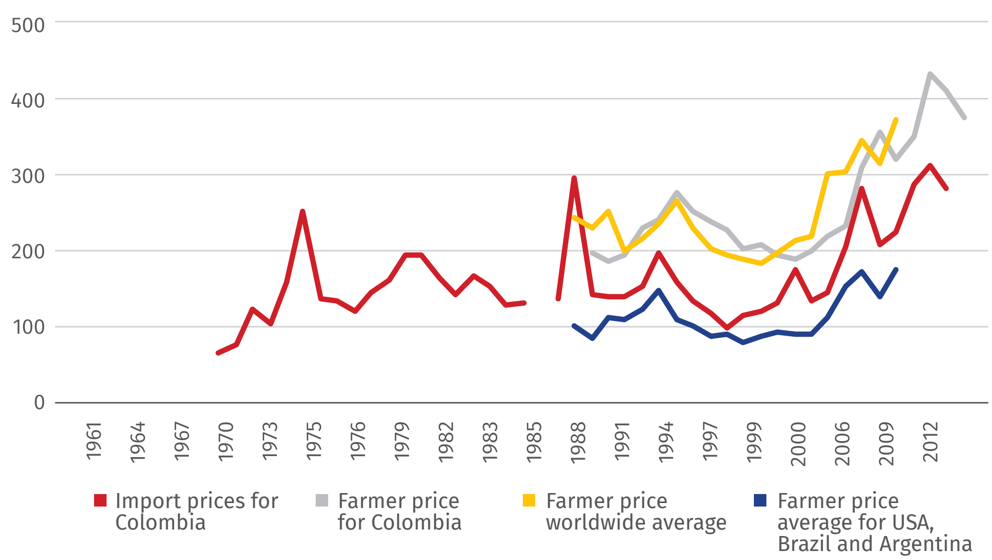
In 2012, the United States and Colombia signed the Free Trade Agreement, causing a significant impact on the proportion of imports from this country. For the years 2014 and 2015, almost all maize purchased by Colombia came from the United States, representing 96% and 98%, respectively (see Graph 2.13).



GRAPH 2.13 IMPORTS OF MAIZE TO COLOMBIA BY COUNTRY OF ORIGIN BETWEEN 1986 AND 2015

Source: Own elaboration with data from FAO and TradeMap.

On the other hand, although there is no disaggregated cost information, Graph 2.14 shows the values of maize imports and production costs for Colombia, globally and for the country's main importers. FAO defines farmer prices as those earned by farmers for primary crops —in this case maize— collected at the initial point of sale (farm gate prices). Production costs in Colombia, according to FAO, are higher than in Brazil, Argentina, and the United States. However, it should be noted that there is no systematic disaggregated information on maize production costs.



GRAPH 2.14 MAIZE IMPORT VALUES AND PRODUCTION COSTS

Source: Own elaboration with FAO data.

2.4 Food security

Colombia is currently in a position of vulnerability, and the trend observed is worrying: the increase in imports tending to accelerate over time. In that sense, the 2030 projection developed by CIAT, and detailed in the following sections of this report, places maize imports in Colombia at 5.9 Mt by 2030, that is, an increase of 39% with respect to 2016.

As mentioned in this section, national demand for yellow maize has been significantly impacted by the growing needs of the balanced food sector, which has grown at an accelerated pace over the past 15 years. As a consequence of the lack of response to satisfy the demand of this sector, in 2016, Colombia imported 81% of its yellow maize consumption —equivalent to 4.3 Mt— and, additionally, 30% of its white maize consumption —i.e. 0.3 Mt[14].

Colombia is increasingly dependent on imports of yellow and even white maize, so it is regressing in its objective to achieve food security. With a fall in self-sufficiency to 26%, FAO's suggested target of 75% self-sufficiency becomes increasingly distant. A major challenge lies for the coming years, considering, on the one hand, the increase in demand for yellow maize —in particular by the balanced food sector— and, on the other, the obstacles that will be encountered concerning the impact of climate change on the national production of this grain. The following section addresses the possible future scenario expected for maize in Colombia, if no change is made and the ongoing trend is maintained for the next 11 years. It is important to note that this is not a desirable scenario. However, it is necessary to be aware of and analyze where the maize sector is moving towards, should no change take place. Based on this analysis and its supporting data, relevant decisions can be made, and short-, medium- and long-term strategies determined to change the course towards a desirable scenario.

14 FENALCE consumption data and DIAN import data.

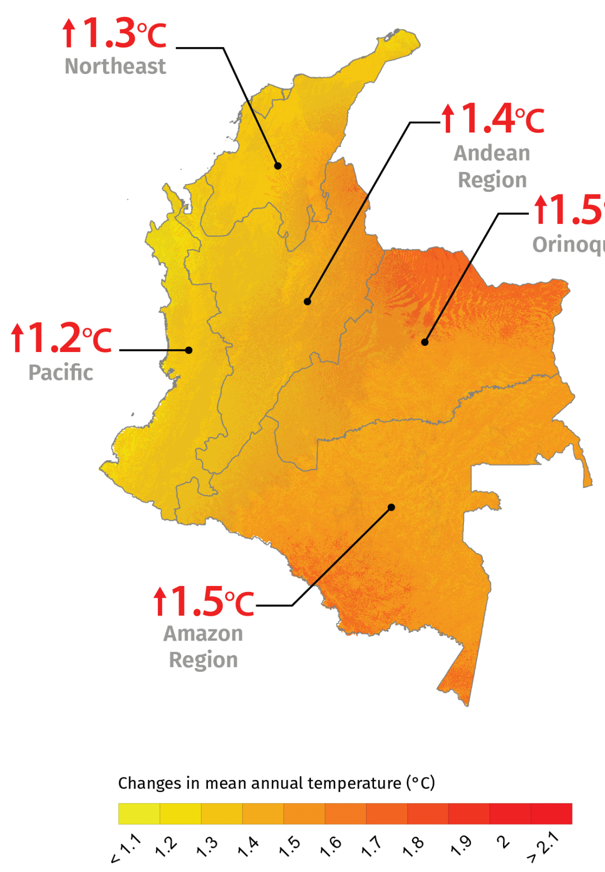
3. Where are we heading? 2030 Projection

The projections in this chapter show the possible scenarios in maize production for year 2030 under the assumption that there will be no unusual changes in the production or in the value chain of this cereal. The results of these projections will provide timely information on the obstacles that Colombia could face in the coming years in the production of maize, and even more, to close the growing gap in demand. It is worth noting that, considering the scope of these projections, a distinction was made between the demand for yellow and white maize, the former used mainly for animal feed, whereas the latter for human consumption. This is important because, as highlighted in the previous section, the demand for yellow and white maize follows different trends in Colombia, a fact that justifies a differentiated analysis for each type. In addition, the irrigation and rainfed maize production systems have been separated for the projections. This is substantial to bear in mind, as historical trends show that traditional maize production systems are progressively giving way to more technified ones.

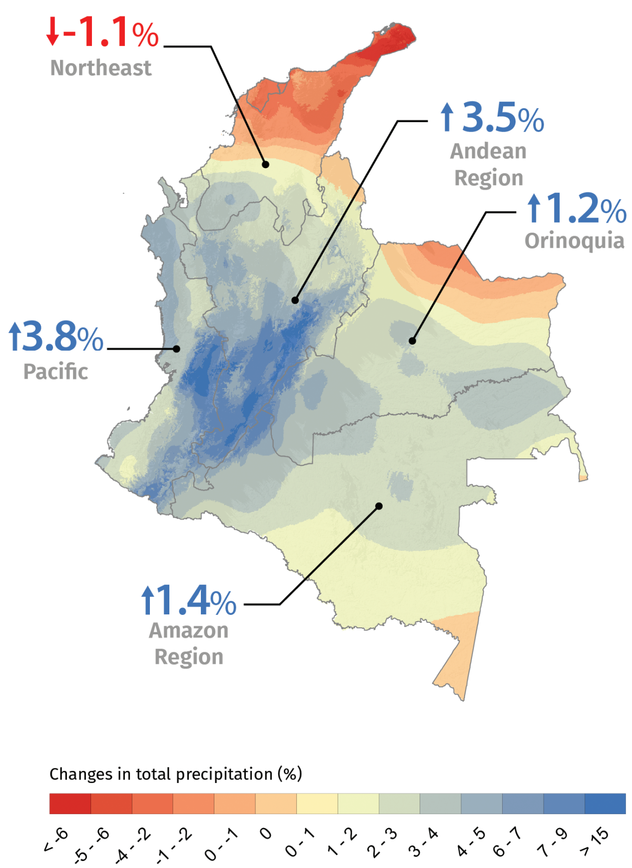
EFFECTS OF CLIMATE CHANGE MAP

Source: Own elaboration with data from the Coupled Model Intercomparison Project Phase 5 (CMIP5).

3.1. ANNUAL AVERAGE TEMPERATURE CHANGES (°C)



3.2. CHANGES IN TOTAL PRECIPITATION (%)



To develop the projections, climate variability was considered, and the effects of climate change were calculated using multiple models and scenarios for Colombia. As shown in Map 3.1, climate scenarios for 2030 indicate a general increase in temperature throughout the country (with greater intensity in the south), which could cause water shortages for agricultural production. The scenarios, as shown in Map 3.2, also show an increase in annual precipitation rates, especially in the Andean and Pacific regions. In turn, the Orinoquia and Amazon regions, as well as the northernmost region of Colombia, indicate a decrease in precipitation. These foreseen effects will have an impact on agricultural production and, for this reason, are taken into account when addressing maize production systems in Colombia.

Likewise, it was considered that maize production, being subordinated to global agricultural markets, would require an approach based on scenarios involving factors such as population changes, consumer behavior, income, technology development, and climate. Hence, the analysis of area, yield, production, demand, and imports that will be described in this chapter was conducted using the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), comprised of a set of integrated models (climate, crop, and economy). IMPACT, is defined as a multi-market partial balance economic model of 70 agricultural commodities. The results of this analysis are associated with levels of production, international trade, demand, food security, international prices, among others. Production is modeled at the sub-national level in regions called Food Production Units (FPU). In the case of Colombia, 3 main FPUs are included, which correspond to watersheds with socio-political divisions and are defined to connect the water-related models of IMPACT. This is done in the interest of calculating changes in maize cultivation area and yields. This regional disaggregation not only allows the connection with these models, but also provides the possibility to add climate impact to the performance equations of each FPU, obtaining heterogeneous results at the geographic level.

TABLE 3.1 THE SOCIOECONOMIC, ENVIRONMENTAL, POLITICAL AND TECHNOLOGICAL FRAMEWORK APPLIED IN IMPACT SCENARIOS

Source: Robinson et al., 2015.

Socioeconomic	Population growth
	Educational levels
	Rural-urban migration
	Gross domestic product and economic development
	Household income distribution
	Consumer behavior
	Transmission of prices and exchange rates
	Input costs (fertilizers, pesticides, energy, and others)
Environmental	Availability and use of key resources such as land and water
	Climate change
Political	Public investment in agricultural research and development
	Trade policy (taxes, tariffs, consumer and farmer support policies)
Technological	Changes in agricultural productivity due to improvements in varieties and management practices

The scenarios modeled with their possible future narratives in both climate and economic terms are explained by the following components: the Shared Socioeconomic Pathways (SSPs), which at the global level include different challenges that society faces to mitigate and adapt to the effects of climate change; and the Representative Concentration Pathways (RCPs), which represent the potential levels of greenhouse gas emissions into the atmosphere. In this scenario analysis of maize in Colombia, three different SSPs were used, summarized in Table 3.2. For the scenarios shown in this chapter, the average RCPs for each SSP were used —with the exception of the reference (*status quo*), a scenario in which it is assumed that historical climate conditions will continue over the projected period. Given the continued increase in greenhouse gas emissions, this scenario is not realistic, but offers a useful counterfactual approach to isolate the effects of climate change from other assumptions. Each of the 3 scenarios has two versions: one contemplating the effects of climate change, whereas the other does not. Thus, in the end, 6 scenarios were analyzed: SSP1, SSP2, and SSP3 considering climate change effects; and SSP1_NoCC, SSP2_NoCC, and SSP3_NoCC, without considering climate change.

This model has been designed to analyze scenarios and prospects (global futures), and not necessarily to make forecasts of agricultural production and food security on a national scale. This scenario analysis focuses on the dynamics of the system, generating a roadmap with possible futures. For this reason, this analysis considers the variables of maize production and demand in Colombia, including trends and non-linear interactions that may deviate significantly from the trends of the last 50 years.

TABLE 3.2 NARRATIVE SUMMARY OF SHARED SOCIOECONOMIC PATHWAYS (SSPS)

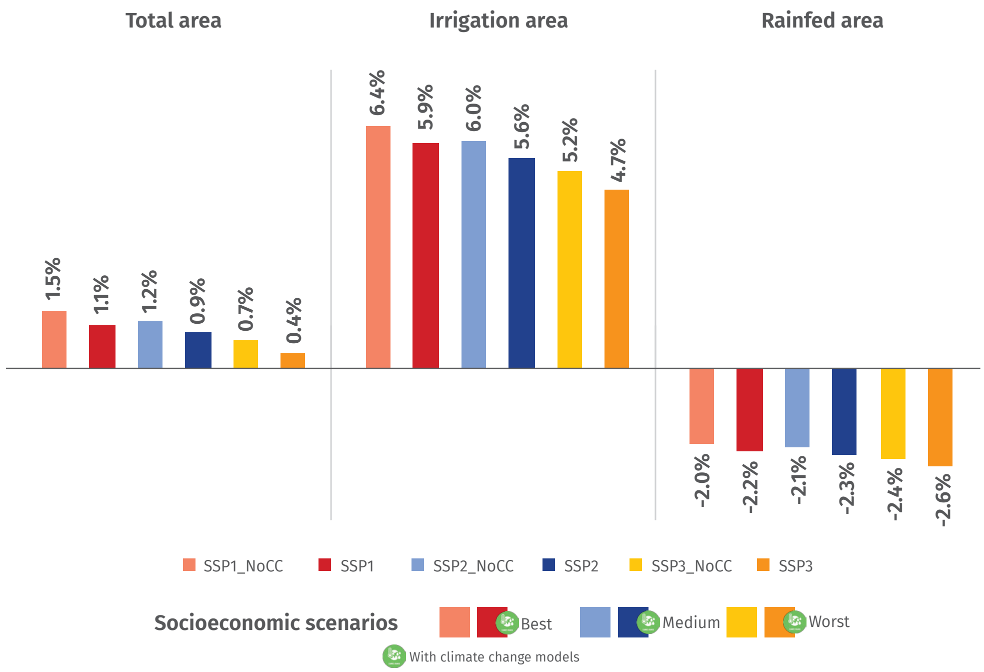
Source: Robinson et al., 2015.

SSP1 Resource Efficiency Scenario	Under this positive scenario, sustainable development occurs with relatively high levels of investment in research and development, leading to rapid technological change (with a focus on sustainability), decreasing inequality, energy intensity, and high soil productivity. This development pathway leads to a future where society can mitigate or adapt to climate change with relative ease. There is high economic development, low population growth, and rising levels of education globally.
SSP2 Business-as-usual Scenario	This is the intermediate scenario that follows historical trends (*status quo*). Economic development continues, but it is not uniform. Environmental degradation continues, but at a slow pace. There are general improvements, but at a much slower pace than in SSP1. Climate change presents moderate challenges in terms of mitigation and adaptation.
SSP3 Fragmentation Scenario	This is a potential negative scenario characterized by the intensification of protectionism with higher levels of conflict and challenges to global and regional cooperation. Barriers to trade are increasing and countries tend to look inward at the expense of globalized cooperation. There are reduced levels of technological change. Economic development is slow and the rate of population growth is high. Climate change presents significant challenges for both mitigation and adaptation.

3.1 Area destined for the production of maize

The area harvested is calculated using changes in land cost, the product of marginal income, and different price trends. These include population pressure, government programs for area expansion and area reduction due to soil degradation or conversion to non-agricultural uses.

Competitive demands for the variety of crops are calculated with a balance equation that determines land allocation and ensures that all demands on crop areas add up to the total land supply of each FPU.

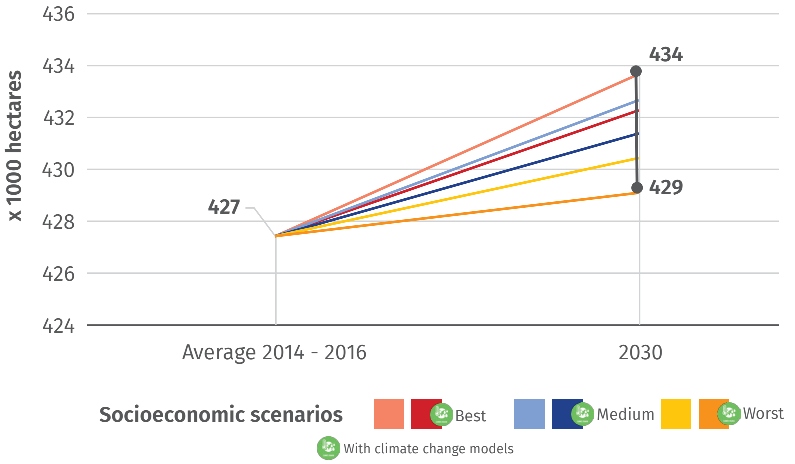


GRAPH 3.1 PERCENTAGE CHANGES IN TOTAL HARVESTED AREA FOR THE PRODUCTION OF MAIZE IN IRRIGATION AND RAINFED SYSTEM

Source: Own elaboration based on data calculated with the IMPACT model.

As can be seen in Graph 3.1, a slight increase is expected in harvested area in all 3 climate change scenarios versus the ones not considering it. In the most optimistic socioeconomic scenario (SSP1), taking into account the effects of climate change, a total area increase of 1.1% is expected, explained by an increase of 5.9% in irrigated area and a decrease of 2.2% in rainfed area. In the most pessimistic scenario, the harvested area would potentially increase by 0.4%; the irrigated area would reach 4.7%; and the rainfed area, 2.6%.

These changes, while minor, indicate a potential range of impacts on soil use for this crop, as a result of the changes in climatic variables (temperature and precipitation) and socioeconomic trajectories evaluated. Projecting this for 427,000 ha corresponding to the average for the period 2014-2016, potential changes in area ranging from 429,000 to 434,000 ha is foreseen across the variety of scenarios (Graph 3.2). In summary, in the worst future socioeconomic scenarios, the total increase of the area, although not entirely significant, will happen at a lower rate —both under irrigated and rainfed conditions.



GRAPH 3.2 PROJECTION OF HARVESTED AREA FOR 2030

Source: Own elaboration based on data calculated with the IMPACT model.

3.2 Areas suitable for maize production in 2030

EcoCrop is a model that calculates the climatic suitability of a specific site by comparing local monthly rainfall and temperature levels with optimal cultivation ranges. **EcoCrop** was used to determine the climatic suitability for both current and potential maize production areas. Current climatic suitability was determined using historical data from the WorldClim database[15]. Projections from 31 General Circulation Models (GCMs) from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[16] for 2030; and the RCP 4.5 scenario, which represents a medium intensity emissions pathway, were used to calculate future climatic suitability.

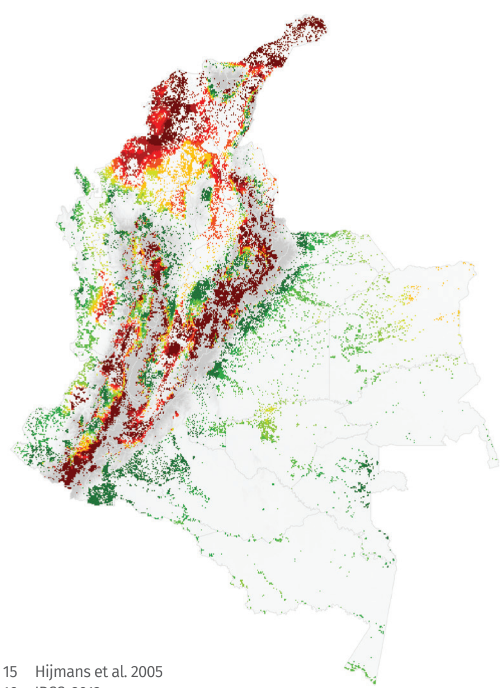
For current production areas, the location of farms was identified and then verified with the results of the EcoCrop model. Map 3.3 shows at each point the location of maize farms in 2016, where the color projected represents the climatic suitability by 2030. Map 3.4 also shows climatic suitability by 2030, but unlike the previous one, it shows areas identified by the Agricultural Rural Planning Unit (UPRA) as having medium and high potential for maize production. Looking at both maps it is possible to predict that, in some of the current maize production areas such as the department of Cordoba, climatic suitability will be reduced significantly by 2030, which will have a negative impact on yields in those farms. Further analysis indicated that this is largely due to elevated temperatures, and not to changes in precipitation.

Unfortunately, this indicates that working on irrigation systems alone will not be sufficient, and that adaptation on other levels will be equally necessary to reduce risks in a percentage of current maize producing areas.

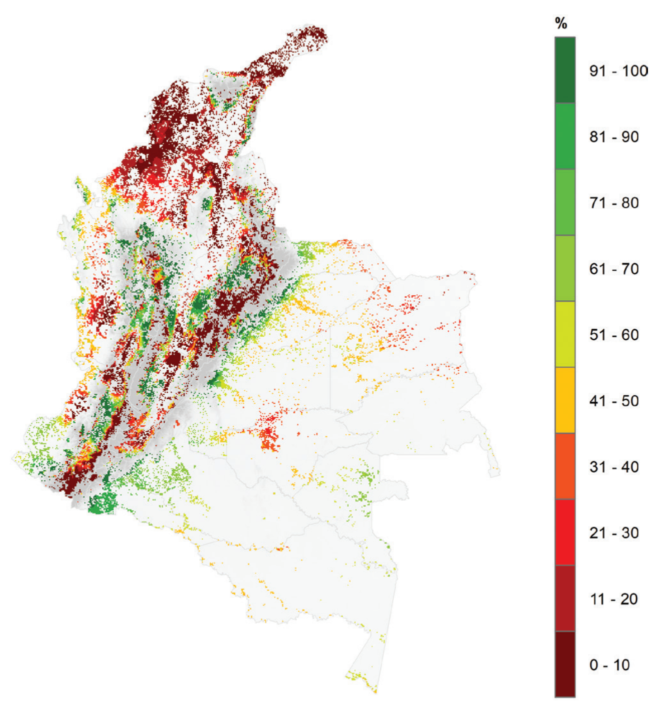
MAP 3.3 CURRENT MAIZE FARMS AND THEIR CLIMATIC SUITABILITY FOR CURRENT CULTIVATION AND IN 2030

Source: Superposition of the EcoCrop model in the National Agricultural Census (CNA, 2014).

3.3.A. CURRENT SUITABILITY



3.3.B. SUITABILITY IN 2030



15 Hijmans et al. 2005
16 IPCC, 2013

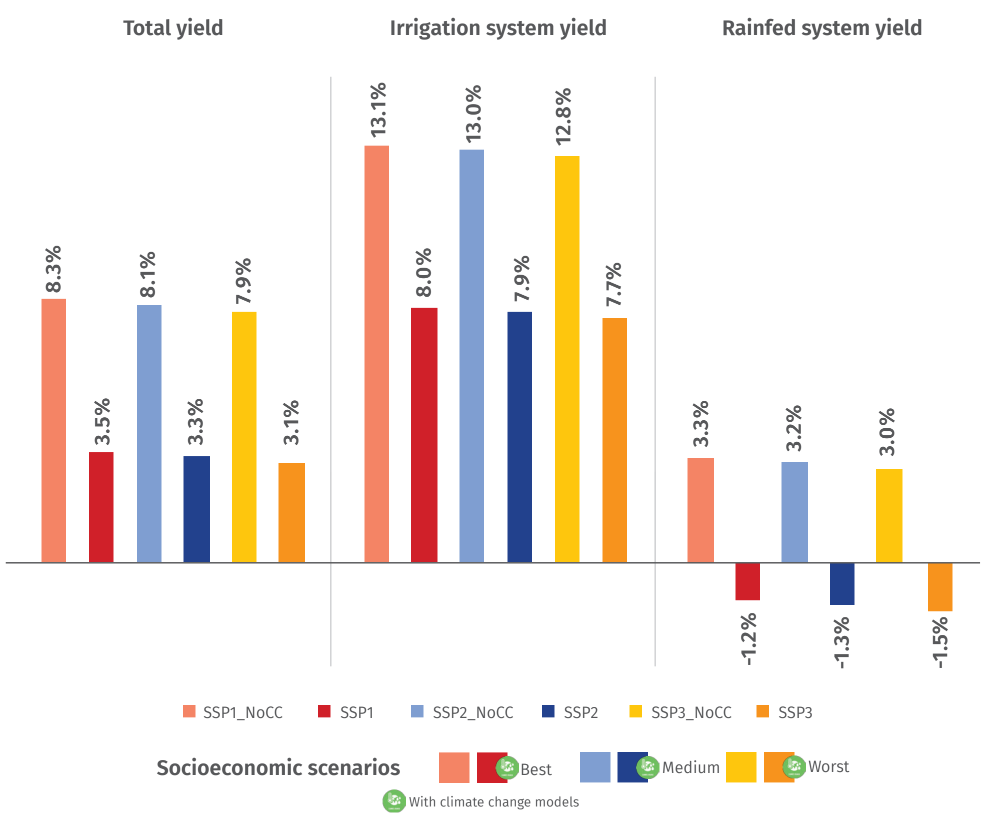
There are opportunities for growth in other areas, which, along with better infrastructure and the recovery of public order, could have high potential. In recent years, UPRA has been working on the mapping of additional arable areas for maize production. Taking into account several agronomic, socioeconomic and agroecosistemic factors, 12 Mha have been identified with medium and high suitability to cultivate maize, i.e. 30 times more than the current production area. However, when climate forecasts are added, the areas suitable for maize production by 2030 look very different. As can be seen in Map 3.4, only part of these identified areas will have favorable climatic conditions by 2030.

3.3 Yield 2030

3.3.1 Yield at the national level

Crop yields, as calculated in the IMPACT model, are a function of agricultural commodities, input prices, available water, climate, and exogenous factors. The model separates irrigated and rainfed systems, while these, in turn, are directly linked to water models addressing water supply for irrigation and for dry land, separately. This allows the model to capture the significant differences in yields that are observed between these two production systems.

As shown in Graph 3.3, the different scenarios do not seem to affect the results of yield forecasts. For example, the total yield increase is 8.3% in an optimistic scenario and 7.9% in a pessimistic one. However, climate impact is relevant in all scenarios. In the *status quo* scenario, where nothing changes, the effects on total yield would reduce growth from 8.1% to 3.3%, and from 3.2% to -1.3% for rainfed maize. When this is projected on the average yield between 2014-2016 in a pessimistic socioeconomic scenario, the increase fluctuates between 3.6 t/ha and 3.7 t/ha, including climate change projections; and 3.9 t/ha in an optimistic socioeconomic scenario, without taking climate change into account. In short, change in yields is not sensitive to different socioeconomic scenarios. Yet, when including the impacts of climate change, temperature and rainfall, productivity outcomes are affected and significantly reduced. Finally, it is important to consider that both elements together may threaten the Colombian maize sector in a 2030 scenario.

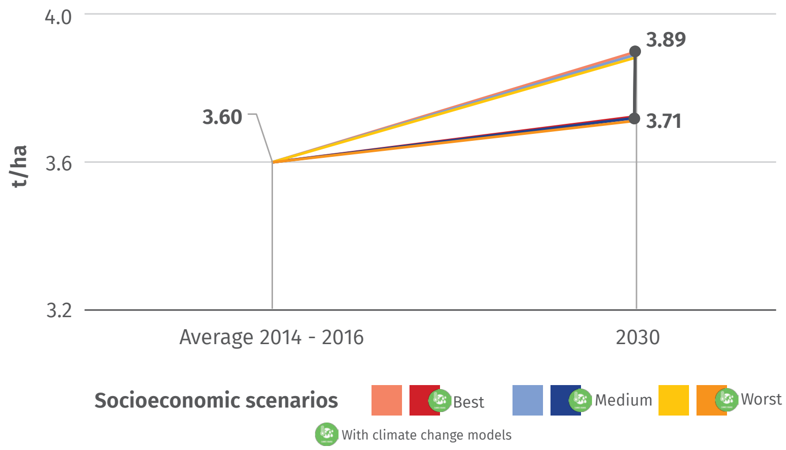


GRAPH 3.3 TOTAL YIELD OF MAIZE PRODUCTION IN IRRIGATION AND RAINFED SYSTEMS

Source: Own elaboration based on data calculated with the IMPACT model.

GRAPH 3.4 YIELD PROJECTION OF MAIZE PRODUCTION BY 2030

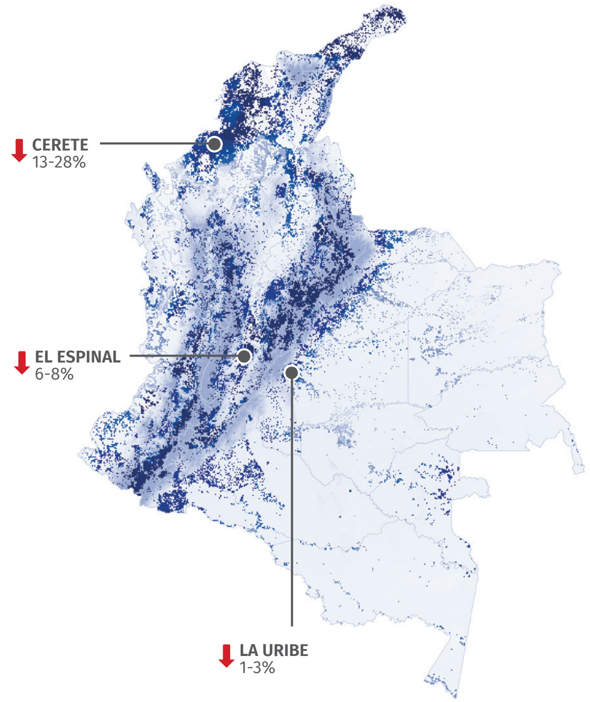
Source: Own elaboration based on data calculated with the IMPACT model.



3.3.2 Local-level yield

To make more specific yield projections for 2030, an analysis combining climatic and agronomic models has been carried out (Map 3.4) using the Decision-Support System for Agro-technology Transfer (DSSAT) model, previously calibrated and evaluated in Colombia by CIAT and FENALCE. The analysis was conducted in three locations: Cerete (Cordoba), El Espinal (Tolima) —both important areas for maize cultivation today— and La Uribe (Meta), a post-conflict region that currently has a small percentage of maize cultivation under the traditional system, but almost nothing under technified systems. La Uribe has been identified as a highly suitable area for this crop by the UPRA models and the models mentioned above on a national scale (see Maps 3.3 and 3.4). In the three regions, simulations of maize productivity were carried out for 3 previously calibrated hybrids (DK234, DK7088, and FNC3056), using sowing dates recommended by FENALCE (as they are the most favorable) for 2 cycles (or semesters) per year, for the period 1980-2013, and under rainfed and optimal management conditions. For all projections, an intermediate emissions scenario (RCP4.5) was used.

In general, under the current climate, the three regions show an average productivity above 8 t/ha. The hybrid with the best performance in the three locations is DK234, while the other 2 (DK7088, FNC3056) have lower yields. The three hybrids in the three sites show reductions in productivity to different extents (see Graphs 3.5 and 3.6).



MAP 3.4 CURRENT MAIZE GROWING AREAS WITH YIELD REDUCTIONS CALCULATED FOR THE 3 REGIONS

Source: Own elaboration based on data calculated with the IMPACT model.

According to the analysis, Cerete (Cordoba) showed the highest impact on the yields of hybrids, being the hybrid of national production (FNC3056) the one with the greatest reductions (28%) in yield potential compared to commercial hybrids (13-15%). This is due to a significant reduction in the crop cycle duration, associated with the increase in temperature (Graph 3.5). It is very important to determine the present and future methodologies of seed evaluation, adaptation, and selection, since these results show marked differences in terms of yields. On the other hand, it should be borne in mind that large yield reductions are projected for this region due to the reduction in the crop cycle as a result of high temperatures, and yield losses caused by scarcity of water resources. The latter highlights the importance of designing adaptation strategies that combine climate risk reduction and the development of new varieties adapted to future climates.

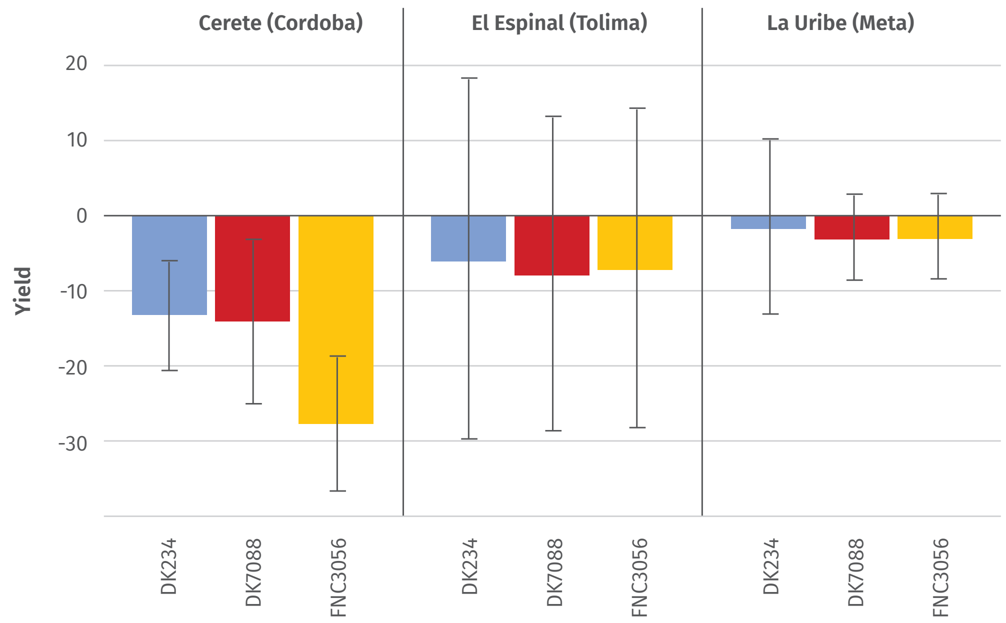
In El Espinal (Tolima), the different hybrids seem to have very similar performances. However, the variation among years and sowing dates is large, indicating that yield levels are not very stable in the region. There is a moderate effect of climate change on these hybrids, especially given the high variability in yields that exists today. As in Cerete, adaptation would be necessary for this area, especially when faced with the presence of major climate crises in the future.

In contrast, La Uribe (Meta) shows a less significant reduction in yield (1-3%) in relation to projected climatic conditions for 2030. Moreover, it was observed that yields can be significantly high in this region, both in present and future scenarios. This would be an area where increasing maize production under the aforementioned conditions would have a substantial and sustainable effect on crop production in Colombia.

In summary, when soils and climatic conditions specific to different geographical areas are modeled, a variety of patterns are obtained in present and future scenarios. The application of the model makes it possible to determine which hybrids will work best locally and the impacts of climate change on them. This type of analysis will thus be a key input for better-informed policy formulation, regional adaptation plans, and exploitation of the potential to expand the maize sector.

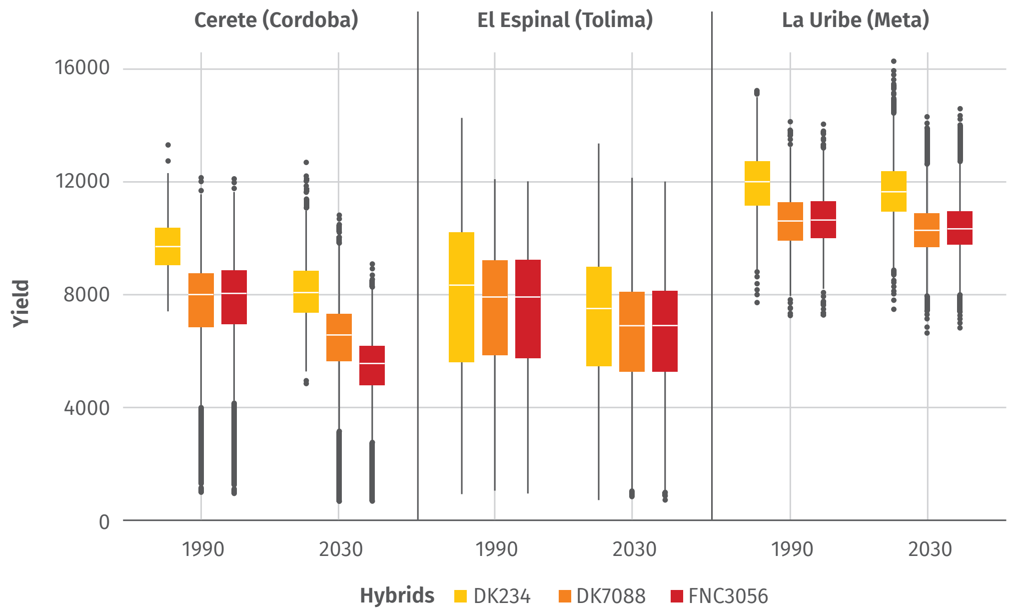
GRAPH 3.5 PATTERNS OF HYBRID YIELDS BY 2030 IN CERETE, EL ESPINAL AND LA URIBE

Source: Own elaboration based on data calculated with the IMPACT model.



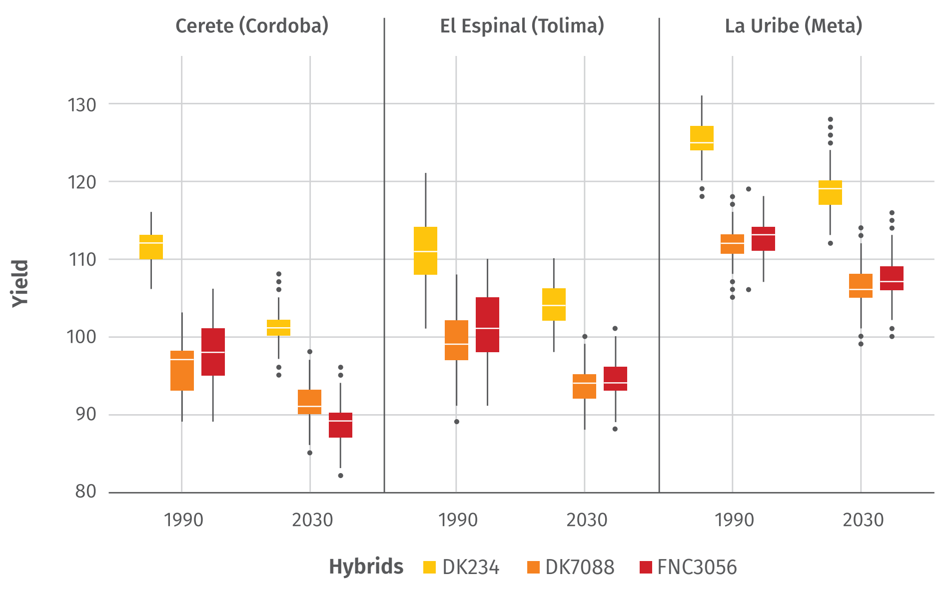
GRAPH 3.6 PATTERNS OF PRODUCTION YIELDS BY 2030 IN CERETE, EL ESPINAL AND LA URIBE

Source: Own elaboration based on data calculated with the DSSAT model.



GRAPH 3.7 PATTERNS OF MAIZE PRODUCTION YIELDS BY 2030 IN CERETE, EL ESPINAL AND LA URIBE

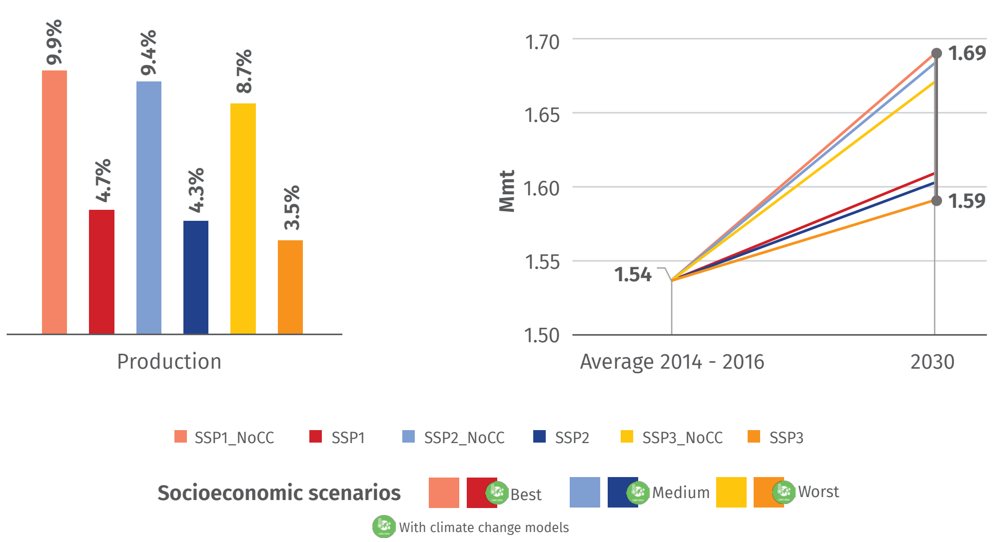
Source: Own elaboration based on data calculated with the IMPACT model.



3.4 Production 2030

In the IMPACT model, models of land supply, allocation of land to irrigated and rainfed crops, and yields are taken into account to calculate agricultural production. Projected maize production levels for 2030 have an expected growth of 9.4% in the *status quo* (SSPS2) scenario. However, when considering climate change, total production would not exceed 4.5%. The socioeconomic scenarios suggest a minor effect on production growth: 9.9% in an optimistic scenario and 8.7% in a pessimistic scenario —both without taking climate change into account. Yet, when including it, production levels show lower growth rates, i.e 4.7% to 3.5% in an optimistic and a pessimistic scenario, respectively.

Projecting these growth rates over the 2014-2016 average, i.e. a total production of 1.54 Mt, results in a range with potential changes of 1.59 Mt in a pessimistic scenario, considering climate change; and 1.69 Mt in an optimistic socioeconomic scenario, not considering climate change (Graph 3.8).



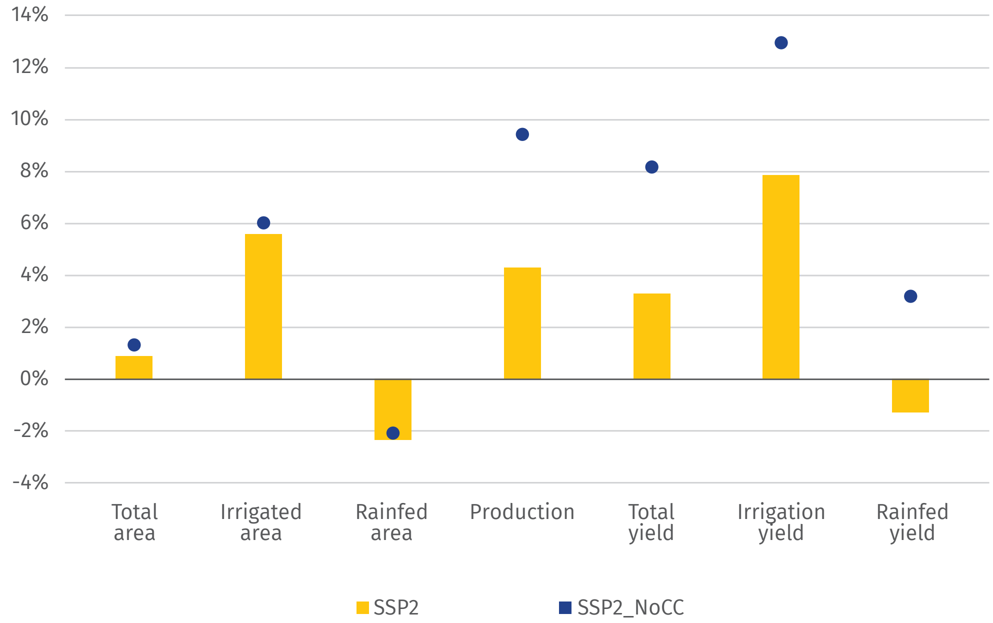
GRAPH 3.8 TOTAL MAIZE PRODUCTION AND 2030 PROJECTION

Source: Own elaboration based on data calculated with the IMPACT model.

In short, it is estimated that production will increase in any of the scenarios. However, the effects of climate change will have a negative impact on production growth. In addition, considering the effect of socioeconomic factors on maize production, the negative impact could be higher than what is described above. Graph 3.9 summarizes the factors that determine maize production in the *status quo* (SSP2) scenario, i.e. yields and cultivation area for both irrigated and rainfed systems. For rainfed systems, area and yields show a negative percentage change by 2030, whereas growth is expected in both area and yield for irrigated systems. The negative effects of climate change are stronger on yields. Thus, only half of the potential growth in total maize production is observed by 2030.

GRAPH 3.9 CHANGE IN PERCENTAGE OF MAIZE PRODUCTION BETWEEN 2016 AND 2030

Source: Own elaboration based on data calculated with the IMPACT model.

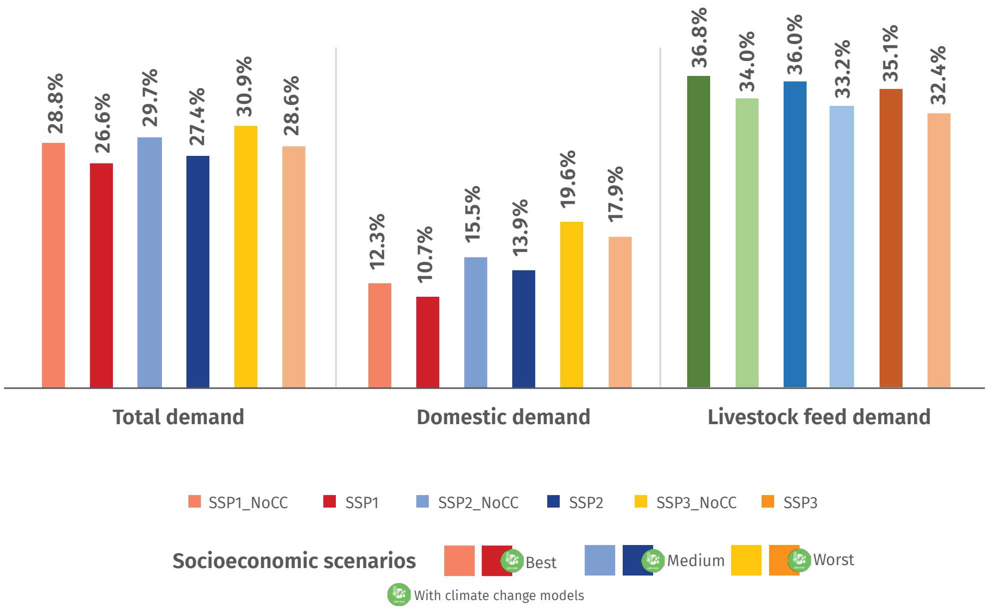


3.5 Demand 2030

Food demand (at the domestic level) is a function of the price of commodities and the prices of other competing commodities, per capita income, and total population. Per capita income, annual population increase —according to the specific population of the country—, income rate increase, and trends vary according to the socioeconomic scenario. In turn, the demand for maize for animal feed is determined by two components: animal feed needs defined by livestock production and feed requirements; and the effects on prices, taking into account possible substitution potentials between different types of feed. The equation also incorporates a technological parameter that indicates improvements in food efficiency over time. In the case of maize, consideration has been given to the gradual shift in demand from basic food products to high-value products such as meat, especially in developing countries. This assumption responds to expected economic growth, increased urbanization, and commercialization of the agricultural sector.

GRAPH 3.10 TOTAL DEMAND OF WHITE MAIZE FOR HUMAN CONSUMPTION AND YELLOW MAIZE FOR ANIMAL FEED

Source: Own elaboration based on data calculated with the IMPACT model.

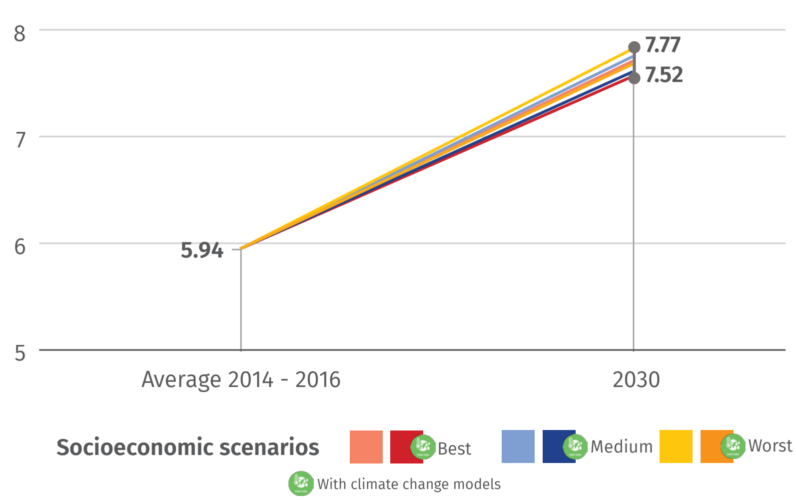


Graph 3.11 shows the potential increase in maize demand by 2030. In this case, the demand for maize intended for animal feed and human consumption shows opposite trends. Thus, the percentage growth of total demand does not vary much among different socioeconomic scenarios. Maize for human consumption, considering climate change, increases in an optimistic scenario by 10.7%, and 17.9% in a pessimistic scenario. For animal consumption, the trend is the opposite: the more positive the socioeconomic scenario is, the more the demand for animal feed grows. This growth ranges from 34.0% to 32.4% in a pessimistic scenario, both including climate change factors. This trend is logical, considering that economic growth goes hand in hand with an increase in meat consumption. To put it in figures, a total demand of between 7.5 and 7.8 Mt would be reached by 2030.

3.5.1 Meeting the demand for maize in 2030

National maize production and demand are linked to world markets through trade. In the IMPACT model, commodity trade is a function of production, demand and inventory changes, where countries that are net importers are those showing negative values —as is the case Colombia. In other words, local demand is greater than local production capacity. As mentioned above, production will increase by 4.3% in the *status quo* (SSP2) scenario. However, this growth is not significant considering the increase in total demand for maize expected in Colombia by 2030 (27.4%) in the same scenario, including both yellow maize (33.2%) and white maize (13.9%). This will create a gap between production and demand ranging from 5.9 to 6.2 Mt, which must be closed by importing maize from other countries. This situation, in turn, implies that Colombia's national self-sufficiency in terms of maize will be of approximately 21% by 2030, whereas the estimates for 2018 were of 26%. As can be seen in Graph 3.12, the results show that maize imports will increase by 39.2%. Considering these figures and considering that Colombia is positioned as the seventh largest importer of maize in the world (2016), it is very likely that the country will continue to be one of the largest importers of this grain globally.

3.6 What happens if we do not take action today?

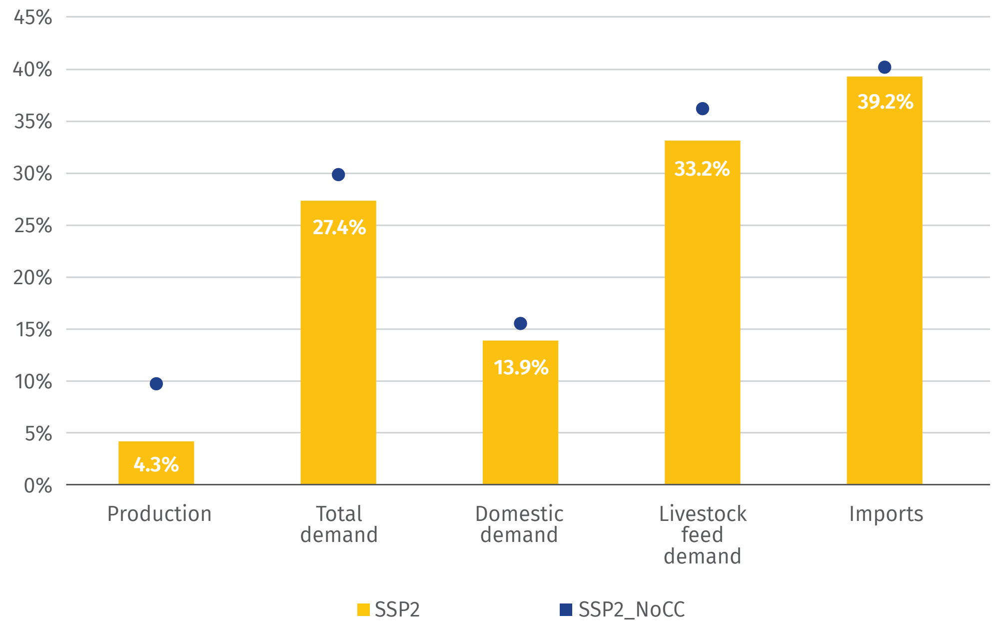


GRAPH 3.11 PROJECTION OF MAIZE DEMAND BY 2030

Source: Own elaboration based on data calculated with the IMPACT model.

GRAPH 3.12 FULFILLING THE DEMAND FOR MAIZE IN 2030

Source: Own elaboration based on data calculated with the IMPACT model.



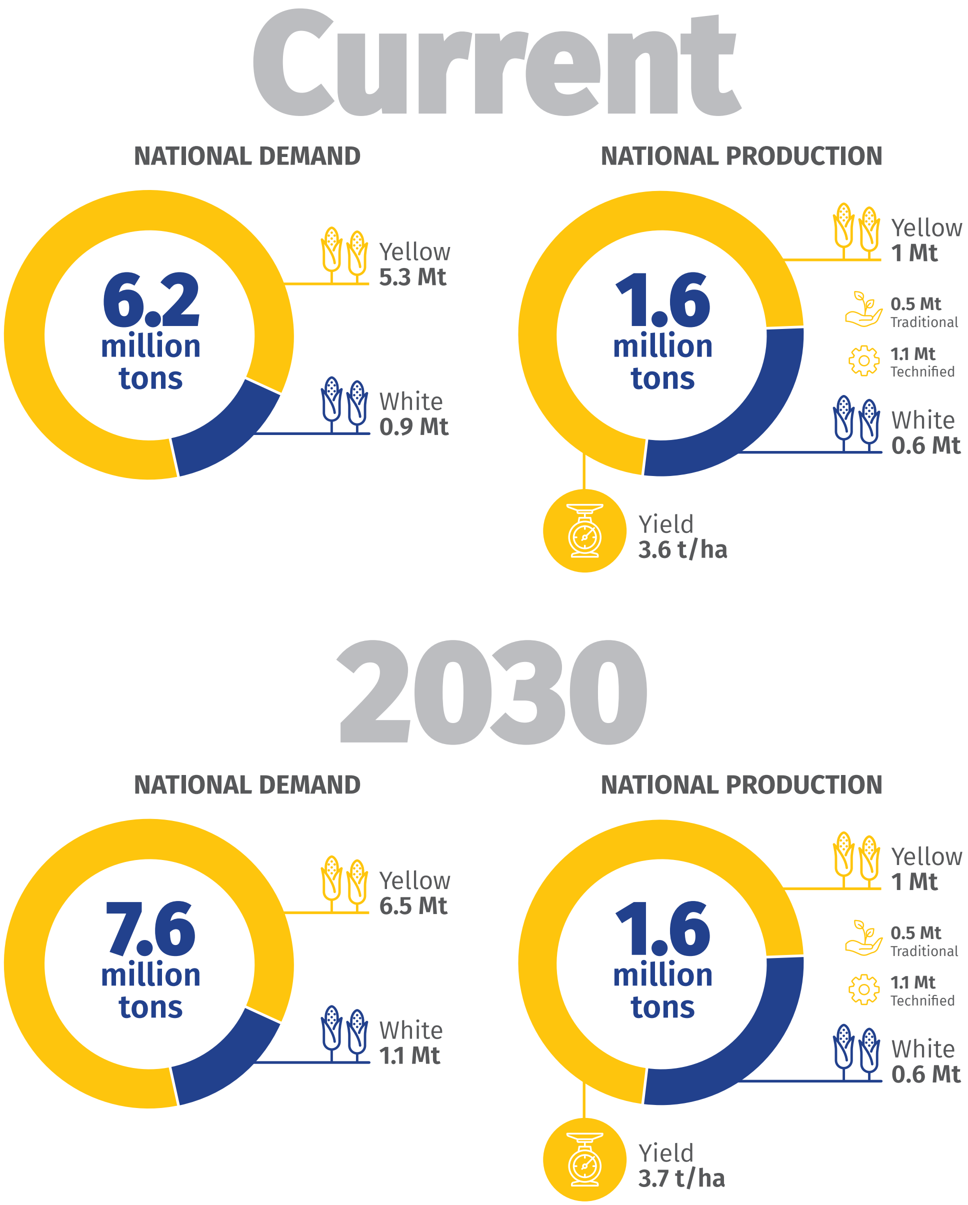
When we look at the historical trend and the 2030 models, the conclusion is that Colombia is evolving in the opposite direction: it is becoming increasingly vulnerable and less self-sufficient in relation to one of the most relevant crops for its food security. According to potential 2030 scenarios, and by simplifying scenario SSP2[17] —the intermediate model that follows historical trends—, demand is expected to increase by 27%, while production will only grow by 4%. Therefore, by 2030, there will be a deficit of 5.9 Mt, resulting in an increase in imports of 39%, and a decrease in self-sufficiency of 26 to 21% (see Figure 3.1).

It should be noted that growth will be mainly due to the increase in demand for yellow maize for animal consumption, whereas the growth of production will include a 0.9% increase in cultivated area, and a 3.3% increase in yields.

17 For indicative purposes, a simplification of the IMPACT model is offered to point out the most relevant variables, with the objective of discussing a possible future scenario for the maize sector in Colombia. As noted in section 3 of this document, the model does not make agricultural production or food security forecasts at the national level, but rather provides a road map with possible future scenarios. Along these lines, and with the aim of encouraging discussion, a simplification of the SSP2 scenario —considered *status quo* in the IMPACT model— is presented.

FIGURE 3.1 ***STATUS QUO*** **SCENARIO IF WE DO NOT TAKE ACTION**

Source: Own elaboration based on data calculated with the IMPACT model (simplified results).



4. How to achieve a better future?

Colombia has enough yield potential to shift towards an increase in production and thus cover a significant percentage of the basic medium- and long-term demands of its population and industry. For this reason, the *Maize for Colombia* strategic plan is focused on adding and articulating the strengths of those who see maize as a grain capable of contributing to the modernization of the Colombian countryside and generating a sustainable and profitable future for farmers in the country.

Colombia has enough productive potential to make a positive turn and increase production.

Despite its undeniable potential, Colombia has low average productivity rates compared to the main producing countries. At present, the average yield for maize grain in Colombia is 3.6 t/ha, while that of the United States is almost 11 t/ha. In the region, Argentina has an average yield of 8.0 t/ha, whereas that of Brazil amounts to 5.6 t/ha[18]. Add to this the results of the *status quo* projection, which highlights that maize self-sufficiency in Colombia will continue to show a negative trend, and that the country will import almost 40% of its total maize consumption by 2030 (deficit of 5.9 Mt). It is worth asking ourselves whether these results are desirable and whether the *status quo* scenario is an optimal one. The answer to these questions is negative if Colombia is to achieve a level of food self-sufficiency that is at least higher than the current one.

However, *there are viable optimal production scenarios for Colombia.* FAO's recommended target is to maintain 75% self-sufficiency. This translates into producing at least 4.7 Mt locally (Figure 4.1), for which, based on historical trends and the models presented, an average yield of 10.4 t/ha at the national level would be required. Figure 4.1 shows 4 scenarios: (1) a scenario that results from not changing the trend (model SSP2), with a level of self-sufficiency of 21%; (2) a scenario with a level of self-sufficiency of 50%, to achieve a production of 3.1 Mt, and an average yield of 6.9 t/ha; and scenarios (3) and (4) to achieve 75 and 100% self-sufficiency, accordingly.

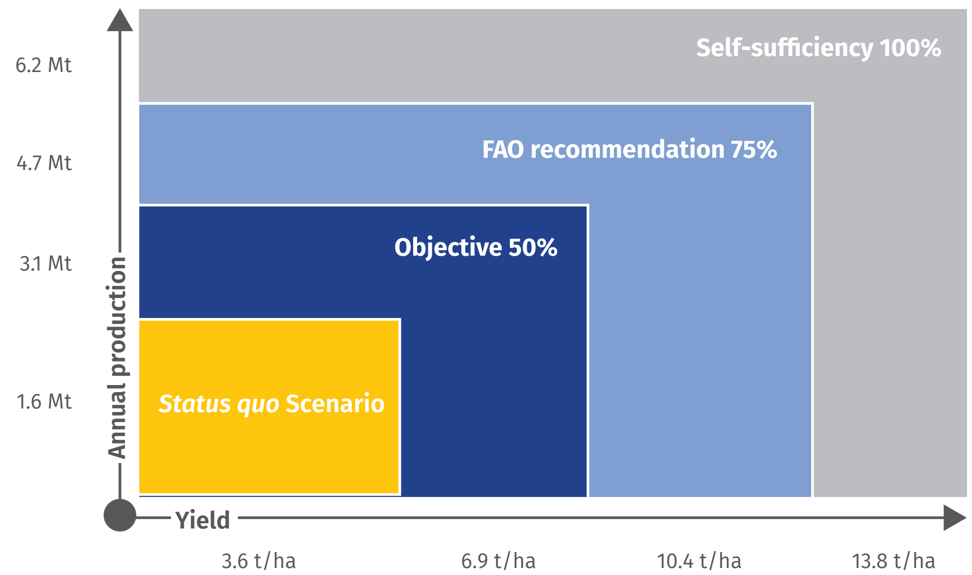


FIGURE 4.1 2030 SCENARIOS

Source: Own elaboration based on data calculated with the IMPACT model (simplification of results, see footnote 15).

18 SDA, World Agricultural Production Report, 2018.

Maize for Colombia seeks to positively transform not only the way farmers produce, but also the way other stakeholders who are indispensable for a competitive and sustainable value chain operate.

4.1 Changing for the common good

Every transformation initiative takes a change. Achieving the above-mentioned goals, however plausible they may be, necessarily implies structural changes in the sector and, in particular, in the production practices of both technified and traditional systems. It should be noted that 70% of maize production in 2016 was concentrated in technified farms, whilst the remaining 30% took place in traditional farms[19]. Around 73% of the total area planted with maize registers yields below the national average, producing only 43% of the country's total maize[20].

Maize for Colombia *seeks to positively transform not only the way farmers produce, but also the way other stakeholders who are indispensable for a competitive and sustainable value chain operate*. In order to fulfill the domestic demand while facing the challenges of the global market and adapting to climate change, modifications are required in areas ranging from scientific research to the regulation and incentive of trade. However, the main challenge can be summarized as motivating farmers to change their behavior through the adoption of farming practices and technologies that have proven to be productive, endorsed by the political will of the Government and other actors.

4.2 Methodology for change

One of the main objectives of *Maize for Colombia* is to define strategies, called *drivers of change,* that allow reorienting the observed trends and propose different ways to achieve a desirable scenario for 2030. To this end, one of the most important instruments of **Maize for Colombia (MpCo)** is the **Expert Panel**, whose function was to identify and support the key drivers for the transformation of the maize sector based on experiences and case studies relevant to the Colombian context. This Panel was composed of experts in 6 thematic areas:

TABLE 4.1 PANEL TOPICS AND EXPERTS

Driver	Topic	Institution	Expert Representative
1	Seeds and improvement	AGROSAVIA	Carlos Galeano
2	Post-harvest, processing, and nutrition	HarvestPlus	Marilia Nutti
3	Climate Change	CIAT	Julián Ramírez
4	Capacity building and extensionism	FENALCE	Henry Vanegas
5	International market and trade	ANDI	Laura Pasculli
6	Post-conflict, infrastructure, and rural development	UPRA	Daniel Aguilar

With predetermined terms of reference, experts were asked to offer a broad overview in relation to their thematic area of specialization, identifying, based on the evidence of real cases, drivers of change with an opportunity to improve the situation of maize in Colombia.

Additionally, the team formulating **Maize for Colombia** had valuable contributions from CIAT experts —among them Wietske Kropff, Jeimar Tapasco and Julián Ramírez, all three from the Expert Panel— who made their methodological contributions based on the models that informed the 2030 *status quo* scenario. Similarly, Yadira Peña and Daniel Aguilar gave their input as relates to the Ministry of Agriculture and Rural Development's (MADR) exercise of productive ordering and experience in the field of public policies on grains.

19 FENALCE, 2016.
20 *Open Data* of the Government of Colombia.

4.2.1 Identification and validation of strategies and actions for Maize for Colombia

Based on the thematic prioritization process, the members of the Expert Panel developed their arguments and case studies with a view to identifying the following priorities for defining a strategy for *Maize for Colombia* (Table 4.2).

TABLE 4.2 TOPICS WITH POTENTIAL FOR CHANGE

Scope	Topics with potential for change
PRODUCTION	Seeds and seed improvement
	Climate change
	Capacity building and extensionism
WELL-BEING	Post-harvest, processing, and nutrition
MARKET	International market and trade
INFRASTRUCTURE	Post-conflict, infrastructure, and rural development

Feedback on the preliminary arguments was provided in several working sessions. From these discussions, *the experts identified and presented 6 drivers of change* to key actors in the agricultural sector within the framework of the 2030 Scenarios Workshop held on 30 August, 2018. The purpose of these drivers was to provide a frame of reference for alignment and agreement on specific actions that are essential for change.

Based on the identification of these 6 drivers of change and together with the experts' feedback, general objectives, expected results for 2030, and a list of specific actions in the short, medium and long term for each of the strategies proposed were identified during the Scenarios Workshop. (For the activities and results of the 2030 Scenarios Workshop, see Annex 1).

Once the results of the Scenarios Workshop were systematized, a validation process was held to determine their relevance. For this process, 19 actors representing the sector were selected in relation to the thematic areas addressed during the 2030 Scenarios Workshop so as to validate the actions identified.

TABLE 4.3 VALIDATING INSTITUTIONS BY SECTOR

Sector	Validating Institution
Research	AGROSAVIA
	HarvestPlus
	International Center for Tropical Agriculture (CIAT)
International Organizations	Inter-American Institute for Cooperation on Agriculture (IICA) in Colombia
	Embassy of the United Kingdom
	Inter-American Development Bank (IDB) Colombia
Guild	National Federation of Cereal and Legume Growers (FENALCE)
	National Federation of Poultry Producers of Colombia (FENAVI)
	National Federation of Coffee Growers of Colombia (FNC)
Association	Society of Farmers of Colombia (SAC)
	National Association of Entrepreneurs of Colombia (ANDI)
	Colombian Association of Seeds and Biotechnology (Acosemillas)
Government	Ministry of Agriculture and Rural Development (MADR)
	Agricultural Rural Planning Unit (UPRA)
Academia	University of Los Andes
	School of Agronomy of the National University of Colombia - Bogota Campus
Private sector	Association of Agricultural Plant Biotechnology (Agro-Bio)
	Corteva Agriscience
	Grupo Bios

The validation process was carried out between December 2018 and April 2019 by means of both face-to-face and virtual interviews with stakeholders to assess each of the objectives, expected results, and actions identified. Eight evaluation criteria (see Table 4.4) with a rating scale from 1 to 5 were applied. In addition to validation based on identified actions, all interviews yielded additional information and provided further references to be included in **Maize for Colombia's** Strategic Planning scope.

TABLE 4.4 EVALUATION CRITERIA FOR VALIDATION

Evaluation criteria	Scoring
1. Social impact that the action can generate in the rural milieu including the creation of jobs and the incorporation of small farmers in the supply chain.	1 (Low) 2 3 4 5 (High)
2. Required changes in applicable legislation or regulations for implementing the action.	1 (Low) 2 3 4 5 (High)
3. Financial resources required to implement the action.	1 (Low) 2 3 4 5 (High)
4. Institutional changes or coordination required for implementing the action.	1 (Low) 2 3 4 5 (High)
5. Available and accessible knowledge related to the action.	1 (Low) 2 3 4 5 (High)
6. Existence of relevant previous experiences or similar actions available that can be used for the implementation of the action.	1 (Low) 2 3 4 5 (High)
7. Time for completion of preparatory work so that the action begins to yield results.	1 (Low) 2 3 4 5 (High)
8. Visibility generated by the implementation of the action.	1 (Low) 2 3 4 5 (High)

From the validation process and based on the results from each of the interviews with the institutions mentioned, the drivers for change initially defined in the 2030 Scenarios Workshop —and their content— were modified. This implied reducing the number of drivers from 6 to 5. Driver 6, "Post-conflict, infrastructure, and rural development", was integrated into the other five in the form of different specific actions. The reason for this merging was that Driver 6 included cross-cutting issues that are essential to each one of the rest.

Another adjustment derived from the validation activity is that Driver 2, originally called "Postharvest, processing and nutrition", changed its name to "Nutritional security" to reflect its goal to combat malnutrition among the Colombian population through actions that encourage human consumption of biofortified white maize. This driver particularly supports the collection and storage of the harvests of farmers operating under the traditional system. In other words, it proposes various post-harvest technologies to ensure adequate grain storage.

Finally, Driver 5 incorporated part of Drivers 2 and 6, transforming its name from "Markets and international trade" to "Linking competitive farmers to the market". It is worth mentioning that many of the validating institutions highlighted the importance of motivating farmers to maintain a commercial and entrepreneurial vision. In doing so, they are likely to adopt technological innovations that increase productivity, reduce costs, and increase competitiveness, while generating confidence to achieve a stable and lasting link with local, regional and national buyers of maize as an agricultural commodity.

5. Drivers of Change

5.1 DRIVER 1. Improved seed adoption

Improved seed adoption by 100% of area operating under technified system, and at least 10% of area under traditional system by 2030.

5.1.1 Background and rationale

Access to good quality seed is indispensable in any production system as it contributes significantly not only to high yields, but also to quality production and, thus, profitability. The quality of the seed, and the genetic potential it entails, determines to a large extent the yield potential, resistance to pests and diseases, adaptability to the climate of each agroregion, and resilience to the impacts of climate change. Seeds are recognized as the most important basic input for all crops. Due to their genetic configuration, improved seeds, once employed in conjunction with sustainable cultivation techniques such as Conservation Agriculture (CA), can generate higher yields than native seeds. However, at present, not all farmers in Colombia are aware of the importance of the quality of seeds or the means to access them.

The traditional sector is characterized by small farmers growing native maize varieties or non-certified seed varieties. Undoubtedly, small farmers have severe limitations to access and use quality seeds because of high costs and risks. It is important to note that seed quality is paramount to obtain a good harvest [21]. For most farmers in the traditional system, production is for self-consumption. In this system, seeds may have a cultural value, which may come with the obligation to preserve varieties that farmers have been improving from ancient times. Of the 220 breeds of maize cultivated in Latin America, *Colombia has 23 and 5,600 accessions that contribute to safeguarding the biodiversity of this grain*[22].

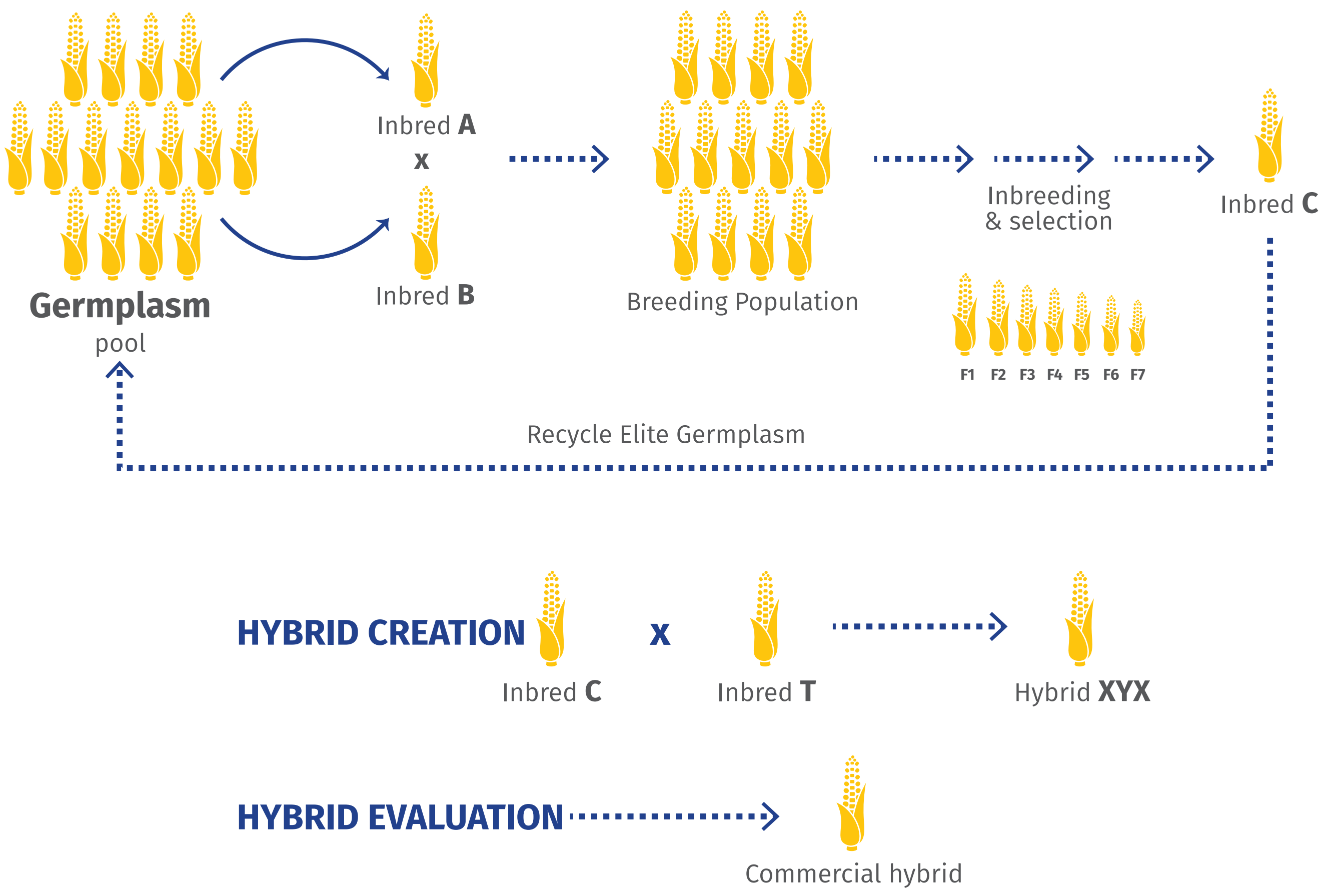
The CIMMYT Germplasm Bank conserves more than 28,000 accessions of maize, including the world's largest collection of native maize —which farmers have improved over decades, centuries, and even millennia— in the form of samples of wild relatives of maize, such as *teocintles* and tripsacum, as well as samples of other improved varieties.

Plant breeding is a practice as old as agriculture itself. For thousands of years, mankind has genetically improved all kinds of plants through selection and crossing processes. Maize originated between 8000 and 5000 B.C. and was domesticated in the 19th century. From its origins, it has mainly evolved by natural selection. However, its evolution has also been influenced by farmers since the beginning of agricultural practices, and later by professional breeders in the last 160 years[23]. The maize breeding methodology can be divided into two large groups: 1) recurrent selection schemes for population improvement; and 2) development of pure lines and hybrids[24]. In short, a maize hybrid is the result of the genetic improvement of the species, which allows the creation of lines or parents that, when crossed, produce a hybrid seed. A maize hybrid is a type of seed that produces a higher grain yield than its parents, as a result of a natural biological phenomenon called heterosis or hybrid vigor. There are 3 types of hybrid maize: single, triple, and double, depending on whether it is formed by 2, 3, or 4 parents, respectively. The best example of heterosis lies in the single hybrid (Figure 5.1).

21 Arenas Calle, Wendy Catalina, et. al., "Análisis de los sistemas de semillas en países de América Latina" Ecofisiología, Metabolismo de Cultivos, Tecnología, Producción y Fisiología de Semillas, ISSN 0120-2812, p. 243.
22 Cardona, José O. Análisis de diversidad genética de las razas colombianas de maíz a partir de datos Roberts et al., (1957) usando la estrategia Ward-MLM. CienciAgro [online]. 2010, vol.2, n.1 [cited 2019-06-11], pp. 199-207. Available at: <http://www.revistasbolivianas.org.bo/scielo.php?script&pid=S2072-14042010000100003&lng=en&nr m=iso>. ISSN 2072-1404.
23 Paliwal, R.L., "Consideraciones generales sobre el mejoramiento del maíz en los trópicos" en El maíz en los trópicos: mejoramiento y producción, FAO, 2006.
24 *ibid.*, p.123.

FIGURE 5.1 DEVELOPMENT OF A MAIZE HYBRID

Source: Arturo Silva, CIMMYT.



Some of the benefits sought through this technique are: improvements in yield and grain composition, tolerance to pests and diseases, adaptation to situations of abiotic stress, resistance to root-lodging and precocity, among others. The process can last from 5 to 7 years. For this crossing between two different genotypes[25] to generate a successful hybrid, the new seed must have "a unique genetic configuration, resulting from both parents, and produce a plant with certain characteristics, such as specific maturity, disease resistance, certain grain color, processing quality, etc[26]."

The success of any maize breeding program will depend on the superiority and usefulness of the basic genetic resources used from the beginning, and from which improved varieties and hybrids are sought[27]; since the hybrid is not produced in a laboratory, but in a field, in addition to its genetic configuration, the quality of the hybrid seed will be determined by the production methods used in the field.

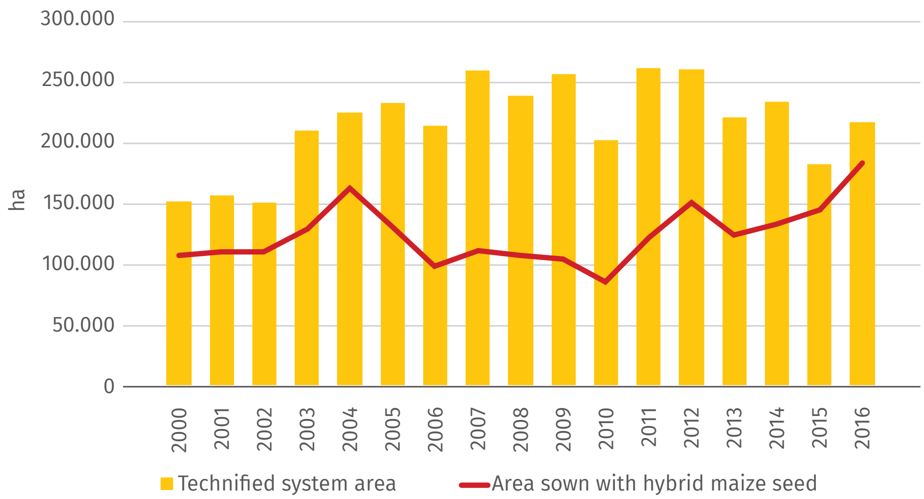
25 The genotype, together with environmental factors acting on the DNA, determines the characteristics of the organism, i.e. its phenotype. Otherwise, the genotype can be defined as the set of genes in an organism, and the phenotype as the set of traits in an organism.

26 MacRobert, J.F., et al., 2015, "Manual de producción de semilla de maíz híbrido". Available in: CIMMYT http://repository.cimmyt.org:8080/xmlui/bitstream/handle/10883/16849/57179.pdf?sequence=1&isAllowed=y (consulted on 27 April 2017).

27 *ibid.*, p. 123.

5.1.2 Seed market in Colombia

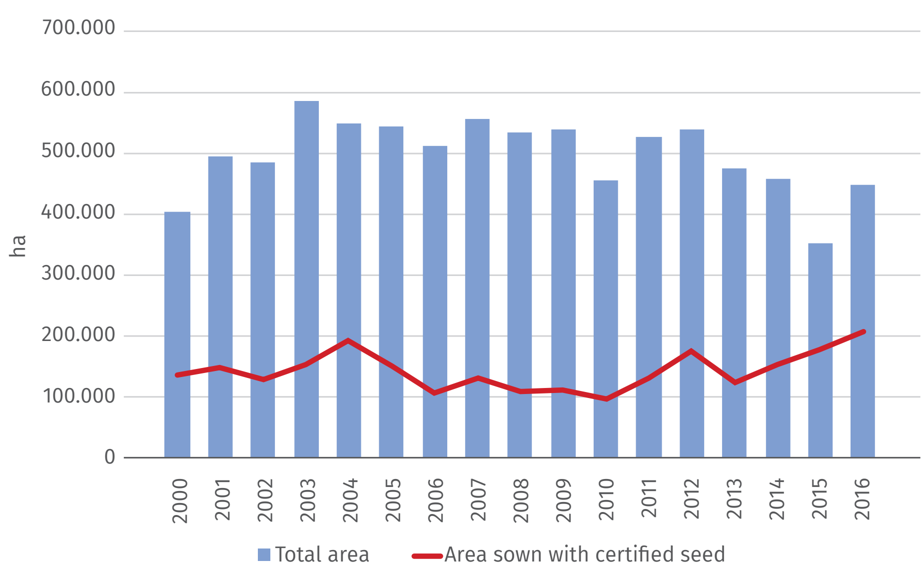
Currently, there is a very significant gap with respect to the adoption of improved seed by production system in Colombia. As mentioned in the first section of this document, 48% of the planted area belongs to the technified system, whereas 52% to the traditional system[28]. By definition, production under the traditional system is that which does not use hybrid seeds or irrigation technology, and where the application of fertilizer is limited to nitrogen levels of up to 40 kg/ha. In contrast, 84.5% of the technified system has adopted the use of hybrid seed[29] (see Graph 5.1). For the former, the average yield is 2 t/ha, whereas for the latter, it amounts to 5.4 t/ha. The yield gap results in a national average of 3.6 t/ha.



GRAPH 5.1 AREA SOWN WITH HYBRID MAIZE SEED IN 2000-2016 UNDER THE TECHNIFIED SYSTEM

Source: Own elaboration with ACOSEMILLAS data.

Of the 451,471 ha planted with maize in 2016, 48% corresponds to the technified system (217,458 ha) in which certified seed is planted, including both hybrids and varieties. Of the total area under the technified system, 58.9% is cultivated with hybrid maize seed —although in 2016 this value increased to 84.5% (Graph 5.1). Approximately one third of the total area planted with maize is using certified seed; from 2014 onwards, there is an increase in the area planted with this type of seed (Graph 5.2). This increase is due to a greater use of hybrid seed: while in 2000 the area planted with hybrids was 107,163 ha, in 2016 it amounted to 183,804 ha (Graph 5.3).



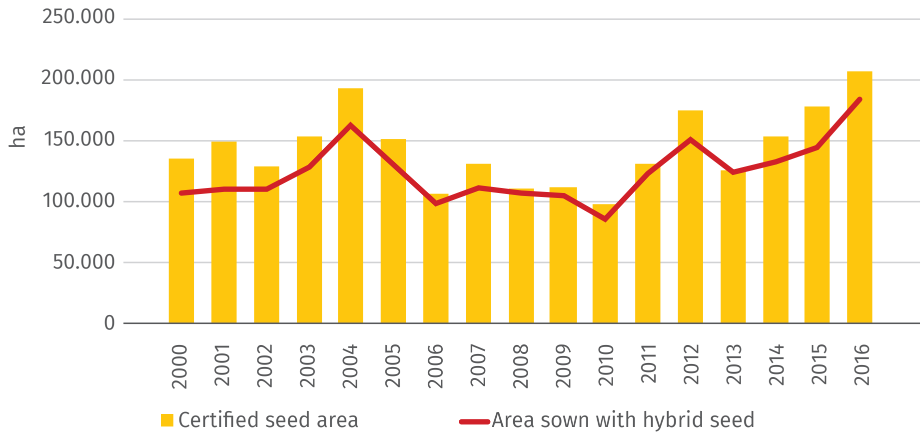
GRAPH 5.2 TOTAL AREA OF MAIZE AND AREA SOWN WITH CERTIFIED SEED 2000-2016

Source: Own elaboration with ACOSEMILLAS data.

28 FENALCE, 2016.
29 ACOSEMILLAS, 2016- Sale of hybrid seed in Colombia- sales data of seed companies.

GRAPH 5.3 AREA SOWN WITH HYBRID MAIZE SEED IN RELATION TO THE AREA SOWN WITH CERTIFIED SEED IN THE 2000-2016 TECHNIFIEDSYSTEM

Source: Own elaboration with data from ACOSEMILLAS.



Along with cotton, maize is one of the crops that uses the highest percentage of certified seed[30]. In accordance with Resolution No. 3168 of the Colombian Agricultural Institute (ICA), it is a requirement for the production of certified maize seed that the improved cultivars, varieties or hybrids are registered in the National Registry of Commercial Cultivars. For certification purposes seed, of the basic and certified categories is allowed; for hybrids, in turn, only the certified category is accepted. This resolution details the minimum specific requirements for certification including sowing, isolation, genetic purity, field inspections, treatment, packaging, and sampling for quality analysis.

5.1.2 Search hybrid standards

Although the use of certified seed is an important objective to achieve guaranteed quality seeds, within the framework of the strategic planning of *Maize for Colombia*, hybrids represent the genetic improvement standard we intend to achieve. Achieving this standard involves an improvement process for the generation of parental lines (parents), the formation of experimental hybrids, their evaluation through different environments (localities), and the selection of the best hybrids. Experiences at CIMMYT show that improved hybrids had a yield increase between 37% in irrigated lands and 105% in rainfed land as per regional controls[31]. This process normally takes 5 years of development until the qualities of the hybrids are perfected. However, state-of-the-art techniques can reduce that time by 2 or 3 years.

5.1.3 Opportunities and success cases

In order to address these constraints and encourage small farmers to increase and stabilize their yields while increasing their incomes, the Sustainable Modernization of Traditional Agriculture (MasAgro) program was institutionally implemented in 2011. This is a research and rural development project launched in Mexico by the Ministry of Agriculture and Rural Development (SADER) —formerly the Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA)— and CIMMYT. Its main objective is to promote the sustainable intensification of maize and wheat production while increasing the profitability and income of farmers. MasAgro works directly with local farmer communities for capacity building based

30 Agronegocios, "Cultivos de maíz y algodón lideran en semillas certificadas," published on 8 March 2019 (Consulted on 6 June 2019). Available at: https://www.agronegocios.co/agricultura/cultivos-de-maiz-y-algodon-lideran-en-semillas- certificadas-2836848.
31 Based on CIMMYT information on the Mexican municipalities where it operates, between 2010 and 2015, the farmers of the MasAgro program achieved an average yield higher than the regional samples of 37% for maize irrigation and

Genetically modified maize

In October 2007, the ICA approved the use of genetically modified maize as a controlled crop. This happened after conducting studies on 1,350 ha controlled and studied by the ICA planted with hybrids of Monsanto and Dupont in the wet Caribbean, dry Caribbean, and Eastern Plains areas. Authorizations were made under a controlled sowing model after approval by the ICA (Final Report, 2010. The economic benefit of adopting GMO technology for maize in Colombia. Agro-Bio, Los Andes University, Livestock and Agriculture Studies Corporation (CEGA)).

A genetically modified organism (GMO) is one whose genetic material has been altered using genetic engineering techniques, which allows modification through mutation, insertion or deletion of one or more genes in the genome. In contrast, improved seed varieties or *hybrids*, as described above, originate through the identification of genetic markers in the phenotype of parent plants and subsequent selective crosses. Through laboratory visualization techniques, which determine the presence of these markers, it is possible to assess the traits of plant DNA and, therefore, its potential in terms of qualities and adaptability to different environmental and cultivation conditions. However, the producing of a new plant follows a traditional pollination process without using genetic engineering techniques. Therefore, *hybrids* are not considered genetically modified organisms.

In 2018, according to ICA figures, Colombia planted 76,014 ha of maize. The department with the largest area planted with genetically modified maize was Meta with 21,510 ha, followed by Tolima with 18,492 ha; however, the total area of maize —whether traditional, technified or transgenic— was lower than the previous year. Despite the efforts made by GM maize seed companies in terms of investment and compliance with requirements, the areas planted with GMOs in Colombia have decreased, apparently due to the complexity of the regulatory system (Final Report, 2010).

on collaborative research schemes, the development and dissemination of improved high-yielding climate-resilient seed varieties, and sustainable agronomic technologies and practices.

The concept of MasAgro was created by CIMMYT in 2008 after the implementation of the first innovation innovation hubs, which aimed to address the main consequences of the global food crisis and promote the adoption of an innovation node model. This was done to promote co-creation and development, validation and adoption of sustainable practices, and innovations among farmers in the northwestern regions and in the area of Valles Altos in Mexico. This is how the program began its development within the framework of the National Development Plan 2007-2012, seeking to strengthen food security through research and development, capacity building, and technology transfer[32].

MasAgro is composed of four areas that carry out research for the development of productive capacities:
(1) MasAgro Biodiversity, (2) MasAgro Maize, (3) MasAgro Wheat, and (4) MasAgro Farmer[33]. In general, the conjunction of these components points to the fulfillment of the following objectives:

1. Achieve higher and stable yields, higher net incomes for farmers, and the adoption of a culture of conservation of natural resources.
2. Promote the integration and collaboration of stakeholders in the maize and wheat production chain, as well as that of associated crops, to develop, disseminate and adopt sustainable solutions in selected agroecological zones.
3. Promote the development of the national seed sector and contribute to increasing maize production in Mexico through collaborative research on genetic resources, to develop white and yellow hybrids with high potential for yield and stability.
4. Develop participatory improvement activities hand in hand with native maize farmers in Mexico.
5. Take advantage of the genetic resources conserved by CIMMYT and develop state-of-the-art technologies and capabilities in Mexico to accelerate the generation of high-yielding maize and wheat varieties that are stable and resilient to climate change.
6. Strengthen the capacities of Mexican researchers to increase the yield potential and adaptability to climate change of improved wheat varieties.

32 Cosechando Innovación: un modelo de México para el mundo, IICA, 2016, pg.58. 33 *ibid.*, pg.59-60
33 *ibid.*, pg.59-60

MasAgro Maize Component

This component of MasAgro promotes the sustainable development of maize farmers —both grain and seed— through the participatory improvement of native maize and the generation of hybrids improved through conventional methods. MasAgro's improved maize is evaluated in collaboration with the national seed sector, which commercializes the best adapted materials in the main productive regions of the country.

Achievements highlighted so far:

- Establishment of 17 groups of genetic or agronomic improvement trials; 16 nurseries (genetic improvement or increase of native maize); and three plots of integrated soil fertility management. The latter is part of a participatory improvement project of native maize in 13 villages of 11 Oaxacan municipalities, in addition to two increase-improvement nurseries in Celaya, Guanajuato and Texcoco, State of Mexico.
- Conduction of 35 training events in which 407 farmers (32% women) from 61 Oaxacan communities participated, in addition to 47 technicians and 64 students.
- In 2016, the seed companies of the MasAgro consortium increased their seed market share by 6% with respect to 2011, while that of multinationals decreased from 75% to 68%.
- The development of new MasAgro hybrids, together with the growth of the seed sector in the last six years in Mexico (32%), drove an increase of 1 million bags in the availability of seeds. The supply of new products that were not previously on the market also increased.
- In 2017, more than 30 small and medium national companies produced the new MasAgro hybrids and sold them in 24 states, 118 regions, and 398 municipalities across the country —mainly in the southeast and Valles Altos.
- The new hybrids were marketed under 147 trade names, including 46 hybrids and five varieties.
- In addition, using different production criteria, type of farmers and macro-environments of maize, 26 areas across 8 states were proposed as areas of greatest impact (quick win zones): Chiapas (4), Veracruz (5), Campeche (2), Jalisco (2), Michoacan (3), Guanajuato (2), Guerrero (4) and Oaxaca (4).
- The datasheets, or production technology, of 16 MasAgro hybrids were made available to the participating seed companies.
- Production of 11,074 kg of seed in 2017, which was affected by biotic and abiotic factors; for example, in the winter cycle, plants were found affected by fusarium, which drastically reduced their seed production; in the summer cycle, in turn, some pollinations were affected by rains in the flowering period, which decreased the quantity and quality of available pollen and, as a result, fertilization and seed production.
- Distribution of 12,236 kg of seed, specifically 3,357 kg of basic seed and 8,879 kg of pre-commercial seed among participants and collaborators of MasAgro Maize.
- Establishment and agronomic management of 6 evaluation-demonstrative plots of yellow MasAgro maize in Texcoco, State of Mexico; Agua Fria, Puebla; Ameca and Puerto Vallarta, Jalisco; San Juan del Rio, Queretaro; and Ocozocoautla, Chiapas.
- Identification of 15 new hybrids developed at CIMMYT (9 tropical hybrids, 4 subtropical hybrids, and 2 from the Valles Altos region) as materials that are competitive and adapted to the environmental conditions of the targeted regions.
- Production of 6,151 double haploid lines (DH) and completion of the haploid induction process in 27 populations (2 of them are germplasm developed by the National Institute for Forest, Agricultural and Livestock Research (INIFAP)).

As part of the program and given the importance of having quality genetic material, in 2011 the national network of MasAgro seedbeds was activated with the initial participation of 20 Mexican companies. This network has grown, integrating in 2017 60 companies with expertise in production technologies, seed business management, and quality and improvement technologies. Collaborative research on genetic material has accelerated the development of improved maize. Thus, through the evaluation network, MasAgro, in collaboration with INIFAP, has established 160 test locations with the participation of 75 collaborators in the three main maize producing areas, where a total of 90 hybrids of the national public and private sector are evaluated.

MasAgro Maize's example highlights the demand for a hybrid seed market and the existence of the potential to increase yields through this seed.

Evidence gathered from the innovation hubs of the MasAgro program, explained under Driver 4 below, shows that increases of even more than 100% in average state yields can be achieved through the use of hybrid seed in conjunction with additional technologies such as irrigation, integral fertilization, or crop rotation.

As part of the program, since 2011, a national seed network called "Consorcio de Semillas MasAgro" (MasAgro Seed Consortium) has been established to train Mexican seed companies in production technologies, business management, quality, and seed improvement technologies, such as the use of double haploids (DH). In 2015, companies were provided with tools to monitor the quality of their products using a uniform criterion aligned with international standards. *This public-private effort drove a seed production chain that connects seed breeding and development with commercial production and distribution.* MasAgro's Evaluation Network multiplies and commercializes the seeds including the new hybrids tested in the evaluation network. Until 2016, seed companies produced about 1.1 million 20 kg bags of hybrid maize, each containing 60,000 seeds.

MasAgro Maize's example highlights the demand for a hybrid seed market and the existence of the potential to increase yields through this seed. It is estimated that if it were possible to reconvert the areas of southeastern Mexico, where native seed or a variety is used today, the yields of the three regions could reach an average of 5.5 t/ha. This is a significant improvement if one considers that the yields of these regions are currently below the national average (3.5 t/ha): in the South and Southeast the average is 1.7 t/ha; and, in the Central East, 2.1 t/ha.

Previous experience shows than the use of improved seed, accompanied by appropriate agronomic practices, can increase the yields and quality of maize production in Colombia.

5.1.4 Key messages

In general, some main challenges are identified for accessing hybrid seed in the country, which respond to supply and demand problems. Among these challenges is that of "expediting the transfer of genetic material between the public and private sectors in order to facilitate the access of enterprises to suitable and adapted varieties; and accelerating the regulation and enforcement of appropriate seed laws"[34]. Overcoming these obstacles undoubtedly requires the coordination and collaboration of the private sector, public institutions and, of course, the participation of farmers in order to achieve access to and adoption of high-quality seeds.

The success case of MasAgro in Mexico indicates that farmers located in more isolated production areas with fewer resources generally do not have access to seed coming from conventional seed production systems. This happens either because they are not subject to credit or because the seed industry is not interested in these areas due to the fact that their profits are not attractive[35]. In the Colombian case, the focus of the seed companies is, as expected, in the technified system. This leaves just over 50% of the traditional system without the possibility of access to quality seeds.

Hence, the expansion of a program that facilitates access to quality seed would allow existing maize farmers in the country to make use of one of the most determinant inputs to achieve better yields. Developing the market potential of improved seeds can significantly contribute to achieving the objectives of increased food production, productivity, profitability, and sustainability. The use of improved quality seed could ensure an increase from 5.4 to 6.5 t/ha in the average yield in the technified system, and from 2 to 3 t/ha in the traditional system.

Previous experiences show that the use of improved seed, accompanied by appropriate agronomic practices, can increase the yields and quality of maize production in Colombia. The quality and characteristics of improved seeds must not only ensure better yields, but also meet the needs of color, nutritional quality, and other specific aspects sought for in the market. Maize, from the seed, must meet the requirements to help farmers —from the smallest ones— to fulfill consumer demands and enter the market. To achieve this, it is important to promote and disseminate the benefits of the use of quality seeds that are technically and legally guaranteed.

In this sense, it is substantial to emphasize that changes are needed in each of the links and mechanisms of the seed value chain: from public research centers, entities that multiply the basic seed, seed companies, distributors, to farmers themselves. Synergy between the public, private, and research sectors is also necessary so that, along with improved seed availability and distribution, challenges in terms of marketing, financing, and input procurement are met. Farmers must be able to obtain the seed where they need it, in a timely manner, and at a fair price. A strategy of this nature would involve a public-private partnership to meet the demand for improved maize seed that allows 100% of farmers in the technified system and at least 10% of farmers in the traditional system to plant hybrid maize.

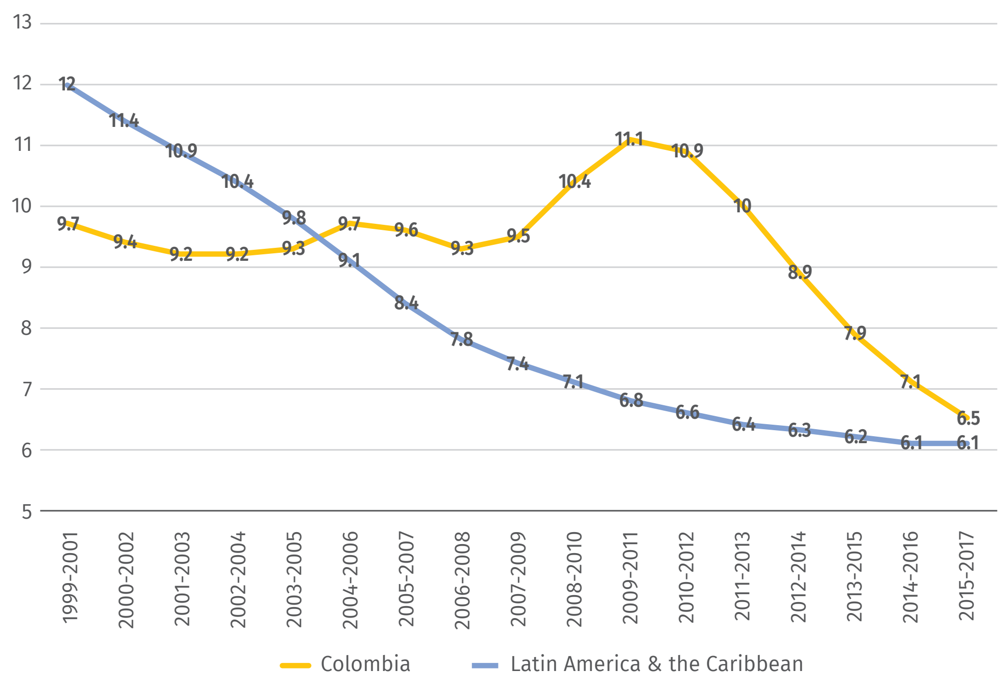
34 Langyintuo, A. S., et al. 2010. "Challenges of the maize seed industry in eastern and southern Africa: A compelling case for private-public intervention to promote growth". Food Policy 35(4):323-33.
35 García-Salazar, J. Alberto, Ramírez-Jaspeado, Rocío, "El Mercado de semilla mejorada de maíz en México. Un análisis del saldo comercial por entidad federativa". Revista Fitotecnia Mexicana [online] 2014, 37.

5.2 DRIVER 2. Nutritional security

Achieve a national human consumption of 50% biofortified white maize with high zinc content by 2030.

5.2.1 Background and rationale

Hidden hunger or micronutrients and vitamins deficiency in the diet is one of the nutritional challenges that most threaten global public health and make it impossible to achieve food and nutritional security, and full poverty reduction. In the case of Colombia, although the prevalence of undernutrition has declined steadily since 2010, it has not fallen below the average recorded in Latin America and the Caribbean. With 6.5%[36] of its population presenting malnutrition problems in the period 2015-2017 —with an additional 10.8%[37] of children under 5 years of age suffering from chronic malnutrition, the world malnutrition prevalence being of 10.9% — Colombia needs to take measures to guarantee food and nutritional security. Similarly, a reduction in the vulnerability of the national population to diseases and infections derived from nutritional deficiencies is paramount.



GRAPH 5.4 COMPARISON OF MALNUTRITION PREVALENCE (%) IN COLOMBIA AND THE REST OF LATIN AMERICA AND THE CARIBBEAN REGION 1999-2017

Source: Own elaboration with FAO data, 2019.

36 FAO, 2019.
37 Colombia's National Nutrition Situation Survey (ENSIN), 2015.

The main causes of malnutrition prevalence in the country are attributed to deficiencies in micronutrients such as zinc, iron and vitamin A. According to data from Colombia's National Nutrition Situation Survey (ENSIN) 2015, zinc deficiency affects 22% of the Colombian population, while in some departments it affects more than 60% of people[38]. On the other hand, iron deficiencies affect 44.5% of women of childbearing age, which means that around 50% are anaemic due to this deficiency. In addition, vitamin A deficiencies, which affect about 27% of children under five years of age, cause not only a decrease in the capacity of the immune system, but also the risk of developing blindness, preventing children's proper development. Considering that breast milk is an important source of vitamin A for children in their early development, it is essential to address the micronutrient deficiencies of childbearing age women.

TABLE 5.1 HEALTH CONSEQUENCES BY ZINC, VITAMIN A AND IRON DEFICIENCY

Source: HarvestPlus, 2018.

Zinc deficiency	Vitamin A deficiency	Iron deficiency
Decreases the capacity of the immune system.	Delays growth in boys and girls.	Increases weakness and fatigue.
Contributes to growth retardation and causes loss of appetite.	Causes damage to the eyes, and in severe cases causes blindness.	Impairs mental development and learning capacity.
Increases the risk of diarrheal disease, and respiratory diseases and infections.	Increases the risk of infections, such as diarrheal disease.	May increase the risk of a woman's death during childbirth.

The main causes of the prevalence of malnutrition in the country are attributed to micronutrient deficiencies such as zinc, iron, and vitamin A.

In this sense, it is clearly important for every country —in this case, for Colombia— to establish comprehensive public policies enabling food and nutritional security of the population, since the lack of such policies brings both social and economic consequences at the national and local levels. According to data from the Economic Commission for Latin America and the Caribbean (ECLAC), in 2007, a period in which the prevalence of malnutrition in Colombia was increasing, its cost to the country's economy was calculated at around 10% of the national gross domestic product (GDP)[39].

To avoid such costs and develop effective strategies to address hidden hunger in Colombia, it must be understood that food and nutrition security exists when all people have, at all times, physical and economic access to sufficient and nutritious safe food to meet their food needs and preferences for an active and healthy life. In 2015, *food insecurity prevailed in 54% of Colombian households;* and, still today, more than half of these continue to face difficulties in obtaining quality and nutritious food[40]. For Colombia, the challenge is to ensure access to quality foods for the entire population, mainly those that make up the market basket, such as rice, meat, eggs, *arepa*, among others, rich in nutrients and quality for consumption.

An important resource for the production of such highly-consumed foods among the Colombian population is maize. Although today the recommendation is to limit consumption of red meat, trends in the Colombian diet reveal that, in recent decades, there has been a growing demand for livestock, porcine, and especially poultry products, which is reflected in a high demand for yellow maize for animal feed.

On the other hand, white maize presents a national consumption level of 15%, or a per capita consumption of 30 kg per year in the form of artisanal products such as *arepa*, among others. In addition, it should be noted that maize is prevalent in the feeding of 32% of Colombian children between 4 and 12 years of age, 16% of adults between 18 and 64 years of age, and 22%

38 ENSIN, 2015.
39 ECLAC, 2007-2008.
40 *ibid.*

of childbearing age women[41]. The increase in the demand for these products and the relevant prevalence of white maize consumption among the Colombian population make it necessary to ensure that it contains the micronutrients necessary to properly feed the population and thereby ensure their proper development.

According to FAO, the increased availability and accessibility of maize has contributed to a rapid decline in the number of hungry people in countries where maize is a staple food for both animal feed and human consumption[42]. This is the case of Asia in 2011, where annual per capita consumption of maize increased by more than 20 kg, and the proportion of undernourished people fell from 40% to 16%. Yet, this progress was not only due to the increase in the consumption and availability of maize in the region, but also to the micronutrient load it provided to the population. Dietary diversity and the use of biofortified maize varieties have the potential to address the nutritional deficiencies of any country[43]. For example, *an* arepa *made from biofortified maize has the potential to provide up to 5 times more zinc than* arepas *made from commercial maize.*

Similarly, in order to ensure access to safe, nutrient-rich maize grains for the entire population, their production needs to be free of aflatoxins or mycotoxins generated by fungi that can appear at any stage of the value chain —from planting, drying, harvesting or storage of the maize grain— resulting in serious and chronic impacts on human and animal health. Controlling the occurrence of aflatoxins at all stages of the value chain depends, above all, on the adoption of good agricultural practices throughout the cultivation process.

By the end of 2018, around 21 countries in the world had included biofortification as an element of their agricultural and nutritional strategies.

5.2.2 Opportunities and success cases

Biofortified food systems have the potential to serve more than 2 billion people worldwide who do not get enough essential vitamins and minerals, such as vitamin A, iron or zinc, in their daily diets. These people are characterized by hidden hunger and are highly vulnerable to disease, infection, and even death. That is why, *by the end of 2018, about 21 countries around the world have included biofortification as a key element in their agricultural and nutritional strategie* [44].

FIGURE 5.2 OPPORTUNITY OF MAIZE BIOFORTIFIED WITH ZINC

Source: HarvestPlus, 2018.

41 *ibid.*
42 FAO, 2011.
43 FAO, 2013.
44 HarvestPlus, 2018.

In the case of Colombia, at the beginning of the same year, *the first variety of maize high in zinc was released, named BIO-MZN01* and generated by CIMMYT with the support of HarvestPlus, as well as the Maize Research Program (MAIZE) and the Agriculture Research Program for Nutrition and Health (A4NH) —both part of the CGIAR System. This release aimed to help combat zinc deficiencies in populations of regions that consume maize as their main food[45], such as the Caribbean, Orinoquia, and Amazonia. This biofortified maize variety was generated using traditional phytogenetic techniques and contains naturally higher concentrations of zinc to counteract health consequences such as respiratory infections, diarrhoea or general weakening of the immune system.

The biofortification strategy of a crop such as maize seeks to introduce micronutrients in varieties that already have good agronomic characteristics —such as high yields and resistance to crop diseases— through conventional breeding techniques, i.e. through selection and crossing of plants of the same species. In this sense, its production allows generating surpluses to be marketed locally and promotes access to its consumption in both rural and urban areas. Such strategies provide a greater scope for addressing a public health problem such as malnutrition in rural areas as opposed to complementary interventions for access to food supplements, which rarely reach populations outside urban areas. It should also be noted that the opportunities for biofortified crops —mainly in Latin America, which stands out for not concentrating its consumption on a particular staple food— should focus on the development and adoption of biofortified grain varieties that belong to the basic basket, to achieve greater impact in reducing hidden hunger and promoting sustainable agrifood systems.

The release of the first variety of biofortified maize in Colombia has made it possible to visualize the existing potential that the country has to encourage the participation of different actors, whether public, private or civil society, in an alliance to increase the demand for this crop at the national level. Thus, *although there is already a precedent for the production of biofortified-maize-derived food and its use for human consumption, it is necessary to establish comprehensive policies for the dissemination of its benefits:* the importance of its consumption; the development of more varieties containing higher amounts of zinc and vitamins such as A; and that these developed varieties are resistant to common maize diseases such as grey leaf spot, tar spot, virosis or the appearance of aflatoxins in the grain, as well as the adoption of these biofortified varieties by Colombian farmers.

Among the main success cases, comprehensive national strategies developed in the Latin American and Caribbean region have been identified, which seek to replace the use of conventional varieties with biofortified varieties of maize, in order to boost not only consumption for its nutritional benefits, but also to increase crop yields, impacting farmers' lives.

5.2.3 Success case: Linking family agriculture to biofortified crops in school feeding in Brazil

In 2009, the state-run Brazilian Agricultural Research Enterprise (EMBRAPA) initiated the BioFORT project as part of an international alliance to develop varieties of rice, beans, cowpea, sugar cane, cassava, sweet potato, maize, squash, and wheat —which are included in the country's market basket— with a high micronutrient content. The main objective of the project is to substantially reduce malnutrition, which is particularly prevalent in the Northeast of the country, and to ensure greater food security by increasing the levels of iron, zinc, and vitamin A in the population's basic diet.

The project, co-funded by the Federal Government, state governments, research institutions, and international organizations such as the HarvestPlus program (supported by the Bill & Melinda Gates Foundation), the World Bank, and others, was able to benefit more than 11 states in the country by 2013. Fifteen municipalities link family farming of these biofortified crops with local school feeding, where more than 1,860 family farmers work directly for the production of these crops. The challenge remains for biofortification to become part of Brazil's national food security policy, which should broaden the scope and adoption of these varieties.

However, in the case of maize, the country developed the School Lunch Program (PAE, its acronym in Portuguese), which includes among its basic foods biofortified maize with provitamins A, not only as an essential source of calories but also as a source of vitamin A for children. The supply for this program is supported by another, focused on the direct purchase of food from local farmers, called the Family Farming Public Procurement Program. This program promotes the insertion of small and medium farmers in the national market and is backed by a law that establishes as obligatory for schools belonging to the PAE to buy 30% of their products, in particular maize, from family agriculture. This comprehensive strategy has allowed farmers who have adopted biofortified maize cultivation to have a local market for surplus production.

45 ENSIN, 2015.

5.2.3 Success case: Sustainable agrifood systems

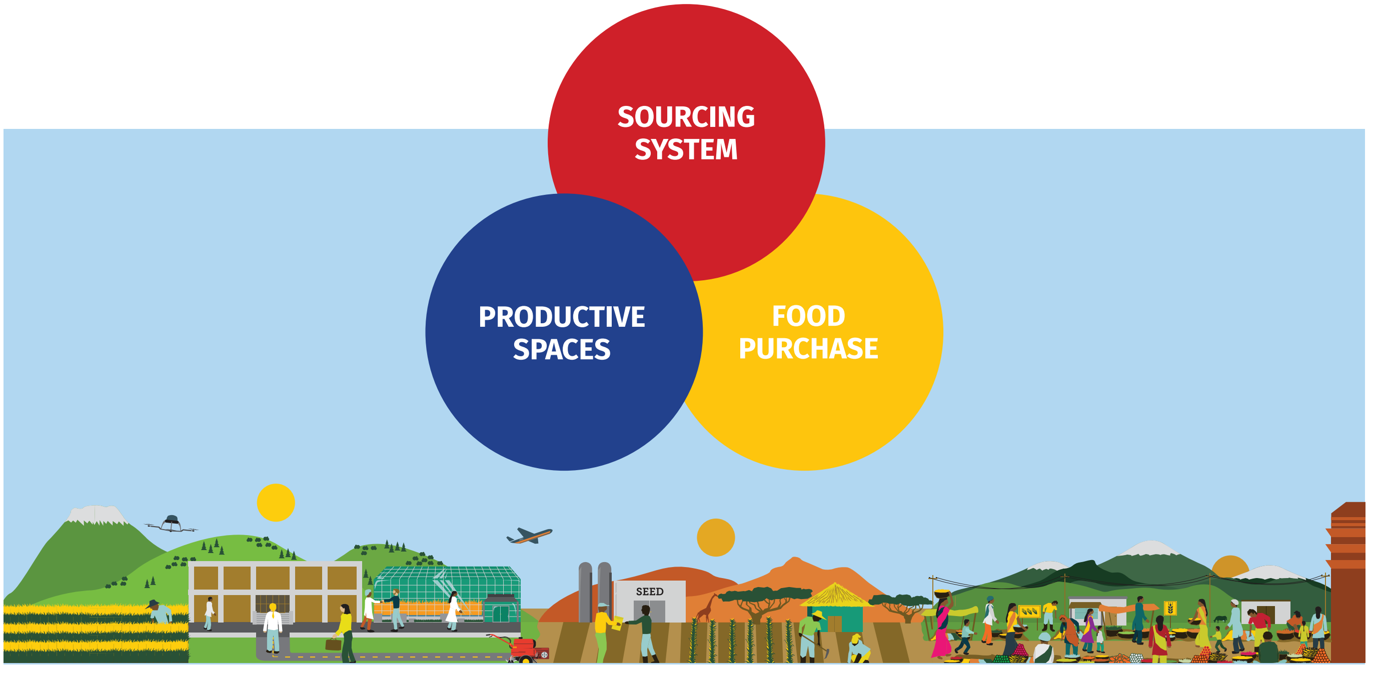
In order to achieve adequate nutrition for the population, it is also necessary to ensure that the origin of products for human and animal consumption presents safe and quality characteristics. This is with the aim to prevent the spread of diseases among the population. Ensuring this depends fully on the proper functioning of agrifood systems, ranging from field food production to consumers —including food processors, consumers, and food loss management.

For a sustainable maize agrifood system, a key element is post-harvest management, i.e., controlling the good storage conditions of the grain and its transfer to consumption or processing centers while ensuring its quality and safety. In the absence of adequate means, maize grain is exposed to various risks, such as mycotoxin contamination. The latter includes aflatoxins, which, as mentioned above, have serious consequences for public health. It is important to emphasize that the strengthening of agrifood systems must benefit farmers operating both under technified and traditional systems. The latter are especially at risk of not being able to ensure the safety in the production and storage of their grain when developed in rural areas.

Currently, Colombia has the potential to strengthen connectivity between urban and rural centers for integral development. This would boost the growth of traditional maize production systems in the country by encouraging the development of resilient and sustainable food systems, and small-scale agricultural practices. Similarly, an increase in rural and urban production in a sustainable manner, higher levels of employment and income of medium- and small-scale farmers, as well as an improvement of livelihoods, food, and nutrition security for all would be achieved.

FIGURE 5.3 ELEMENTS OF A SUSTAINABLE AGRIFOOD SYSTEM

Source: CIMMYT, 2019.



5.2.4 Key messages

Taking advantage of the benefits brought by the adoption of biofortified maize for production and human consumption in Colombia requires the development of a comprehensive public policy not only focusing on the increase of the volume of biofortified seeds at the national level. This policy to address malnutrition would have to consider fundamental and complementary characteristics of maize: (1) significantly more nutritious, (2) high yield potential and with tolerance to biotic and abiotic stresses, (3) farmer acceptance and adoption, and (4) consumer acceptance[46].

Generally, the benefit of biofortified maize is most visible in rural areas that remain unreached by most national dietary supplement programs. The challenge to reduce malnutrition in rural areas lies in ensuring access to biofortified seeds for small and medium farmers, but also in guaranteeing the nutritional safety of the grain by identifying and addressing the specific collection and storage needs of farmers in Colombia's traditional maize system.

The benefits are clear if the biofortified maize strategy is developed in a context of sustainable agrifood systems, where there is coordination among each of the actors involved, traceability, as well as a national commitment to disseminate its benefits. Similarly, this coordination should be reflected in the creation of seed networks between public and private sector seed farmers to ensure production and delivery to farmers in rural areas.

46 MAIZE HarvestPlus: Biofortifying maize with provitamin A carotenoids, Kevin Pixley, Natalia Palacios, Raman Babu and Abebe Menkir, 2011. pg.3.

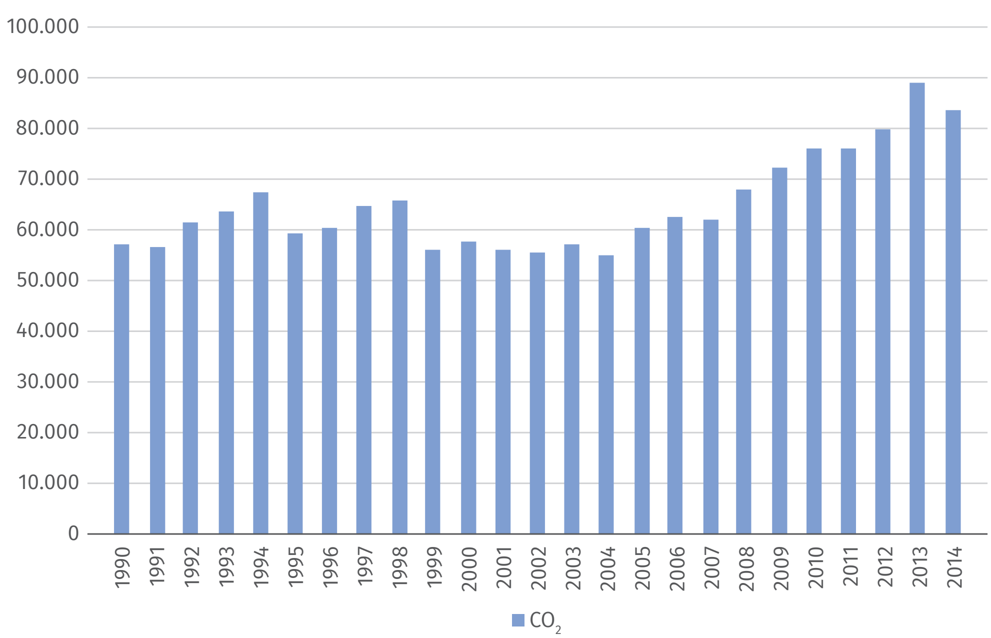
5.3 DRIVER 3. Climate-smart agriculture

Conversion to sustainable agriculture adapted to climate variability and change in at least 100,000 ha of maize production systems by 2030.

5.3.1 Background and rationale

Climate change is having negative impacts in the living conditions of farmers, not only in the form of changes in the biodiversity of maize and agroecological zones, but also as regards the conditions to produce their crops. In fact, for crops such as rice, wheat, maize and soybeans, there have been significant increases in prices, which has limited people's access to these crops. The latter, in turn, are some of the main sources of food for the population in most developing countries, including Colombia[47].

Climate variability and change have great effects on Colombian agriculture. In 2018, for example, losses due to climate variability and extreme events were estimated at 168 billion Colombian pesos per year[48]. On the other hand, the El Niño phenomenon, which is generally associated with a decrease in rainfall relative to the monthly historical average and an increase in air temperatures —especially in the Caribbean and Andean regions[49]— has translated into losses of around US$ 2.064 million for Colombia between 1997 and 2016. These losses are associated with variations in crop yields, decreased river flow, increased risk of forest fires, and possible rationing of water, both for irrigation and for animal and human consumption.



GRAPH 5.5 CO_2 EMISSIONS IN COLOMBIA 1990-2014.

Source: Own elaboration with World Bank data, 2018.

47 IFPRI, 2009. Available at: http://www.fao.org/fileadmin/user_upload/AGRO_Noticias/docs/costo%20adaptacion.pdf
48 CIAT and CIMMYT, 2018.
49 Ministry of Agriculture and Rural Development Available at: https://www.minagricultura.gov.co/atentos-clima/Paginas/default.aspx

The main causes of climate change are attributed to the increase in greenhouse gas (GHG) emissions, mostly from industrial activities.

The projections of the Fifth IPCC Report indicate that Colombia's temperature will increase between 1.3 °C and 1.5 °C by 2030[50].In addition, precipitations are expected to be lower on the Caribbean coast, while they will increase in the Eastern Plains and in the geographic valleys of Magdalena and Cauca. It is estimated that by 2050, the total area planted with maize will experience temperature changes of at least 2°C, 20% will experience changes above 2.5°C, and about one-third of the planted area will experience precipitation reductions. These changes would reduce the length of maize production cycles, thus affecting productivity if comprehensive actions are not taken. Without drastic measures to curb the effects of climate change, it is estimated that, by 2030, there will be a significant reduction in areas suitable for maize production, as well as a decrease in crop productivity of up to 30%. Addressing climate change will require the comprehensive transformation of the Colombian maize sector to achieve sustainable, profitable and climate-adapted production.

The main causes of climate change are attributed to the increase in greenhouse gas (GHG) emissions, mostly from industrial activities. According to the most recent World Bank data, only from 1990 to 2014 CO_2 emissions increased by 63% globally. It should be noted that in the same period, Colombia has registered an increase of 68% (Graph 5.5), highlighting even more the need not only to address the causes of climate change by seeking a reduction in emissions, but also to reduce its direct effects on agricultural productivity and its impact on food security through climate-smart practices.

The Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) highlights the limited adaptive capacity of the Colombian maize sector, with low agricultural insurance coverage and difficulties in the transfer of technology packages[51]. Although these difficulties are not specified, there are a number of limitations in the country. Some examples are the establishment of an agricultural extension that reaches both large and small farmers; the development and use of technological packages (seeds and agronomic management practices) aligned with the principles of climate-smart agriculture; and the development of participatory research that puts the farmer at the center of the adaptation process[52].

50 Fifth Report of the United Nations Intergovernmental Panel on Climate Change (IPCC), 2014.
51 IDEAM & UNDP, 2017.
52 World Bank, 2015.

In recent years, some actions have been taken in the maize sector for climate adaptation, including agroclimatic tables and the implementation of site-specific agriculture projects. In addition to these, however, it is necessary to promote the development of germplasm tolerant to biotic and abiotic stresses; the generation of an understanding of climate vulnerability and its consequences; and the identification of actions at the local, regional and national levels in conjunction with farmers to adapt Colombian agriculture to climate change.

5.3.2 Opportunities and success cases

Colombia's maize production systems have the potential to transform and reverse the effects of climate change if the principles of climate-smart agriculture (CSA) are adopted. This is an integrated approach, which addresses the principles of ecosystem management and sustainable land and water use, and directs actions needed to transform and reorient agricultural systems to achieve three main goals: sustainable increase in agricultural production and income; adaptation and increased resilience to climate change; and reduction or elimination of greenhouse gas emissions[53] (Figure 5.4). Thus, CSA has the potential to increase food security, improve resilience, and reduce greenhouse gas emissions. However, the adoption of each of the CSA variants will depend on each region's specific context, and will require an alignment with the existing programs for an effective implementation.

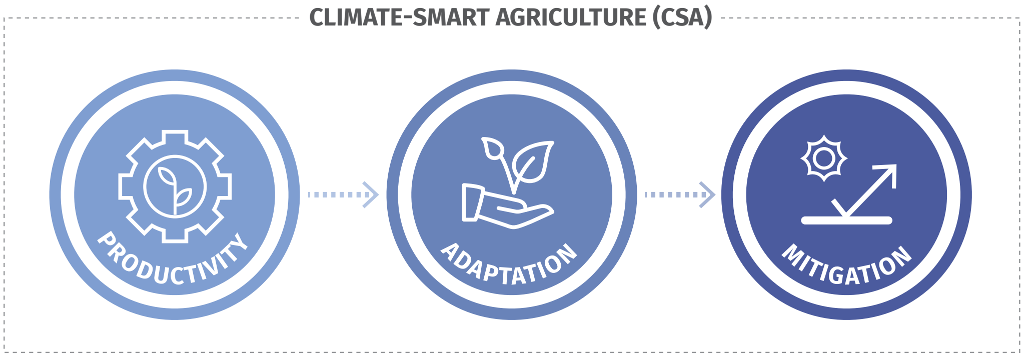
CSA initiatives increase productivity, improve resilience and reduce or eliminate greenhouse gases (GHGs) in a sustainable manner. Yet they require planning to address trade-offs and synergies among these three pillars[54]:

A practice falls under CSA if it meets the following two requirements: first, it maintains or achieves an increase in productivity; and second, it includes at least one of the other CSA objectives (adaptation or mitigation). Hence, hundreds of technologies and methodologies used around the world are classified as CSA[55].

53 Verhulst, N. et al, 2012. "Conservation agriculture as a means to mitigate and adapt to climate change, a case study from Mexico". CIMMYT. 54 FAO, 2013.
54 FAO, 2013.
55 Climate-Smart Agriculture Sourcebook. Food and Agriculture Organization of the United Nations. Rome. FAO, 2013.

FIGURE 5.4 CLIMATE-SMART AGRICULTURE

Source: FAO Success stories on Climate-Smart Agriculture FAO, 2013.



To continue strengthening the capacity of the maize sector, it is necessary to build on existing CSA lines of work, including agroclimatic forecasts, site-specific agriculture, new varieties, and water and carbon footprints (Figure 5.5). The generation, provision, translation, and use of agroclimatic information to support farmers' decision-making can reduce risk through an improved choice of sowing dates (resulting in higher productivity) and varieties more adapted to expected conditions. Also, site-specific agriculture is key to closing production gaps as it identifies practices that tend to increase productivity, and other CSA objectives.

For this strategy of change in particular, an array of technologies, good practices, and measures, which comprise a climate-smart systems proposal, are suggested. The technological menu includes, for instance, the adoption of varieties tolerant to drought and high temperatures or floods; irrigation technology systems for efficient use of water; conservation agriculture, among other technologies. Also, good practices and other climate-adapted measures include *in situ* biodiversity conservation; participatory breeding for native maize; and technical support and access to inputs, especially for small farmers. In addition, it suggests long-term planning of crop systems and, of course, genetic improvement programs that can respond to the needs of agriculture in the context of climate change.

The proposed technologies and measures demand, of course, adoption and adaptation actions that take into consideration the local and regional contexts of the Colombian territory, which entails a multiplicity of agroecosystems and socioeconomic conditions. For example, conservation agriculture is a CSA practice, with three basic principles and direct benefits to the farmer: (a) minimizing soil movement (no tillage); (b) leaving the previous crop stubble on the ground surface to form a protective layer; and (c) crop rotation. The benefits of conservation agriculture are, on the one hand, the reduction of costs and the use of practices that favor efficiency in the use of consumables. Further advantages are a lower use of fuel; easier water infiltration and the reduction of water surface runoff and soil erosion (allowing less moisture to evaporate); and a less intensive use of tractors and labor to prepare the ground. On the other hand, in the medium and long term, the amount of soil organic material (SOM) increases, which improves the productive efficiency of the soil and, as a consequence, generates higher and more stable yields.

In addition, long-term planning of crop systems and improvement programs is highlighted. In this sense, successful cases that are currently being developed in Colombia and that would have the potential to be developed on a national scale were identified for the adoption of climate-smart agriculture.

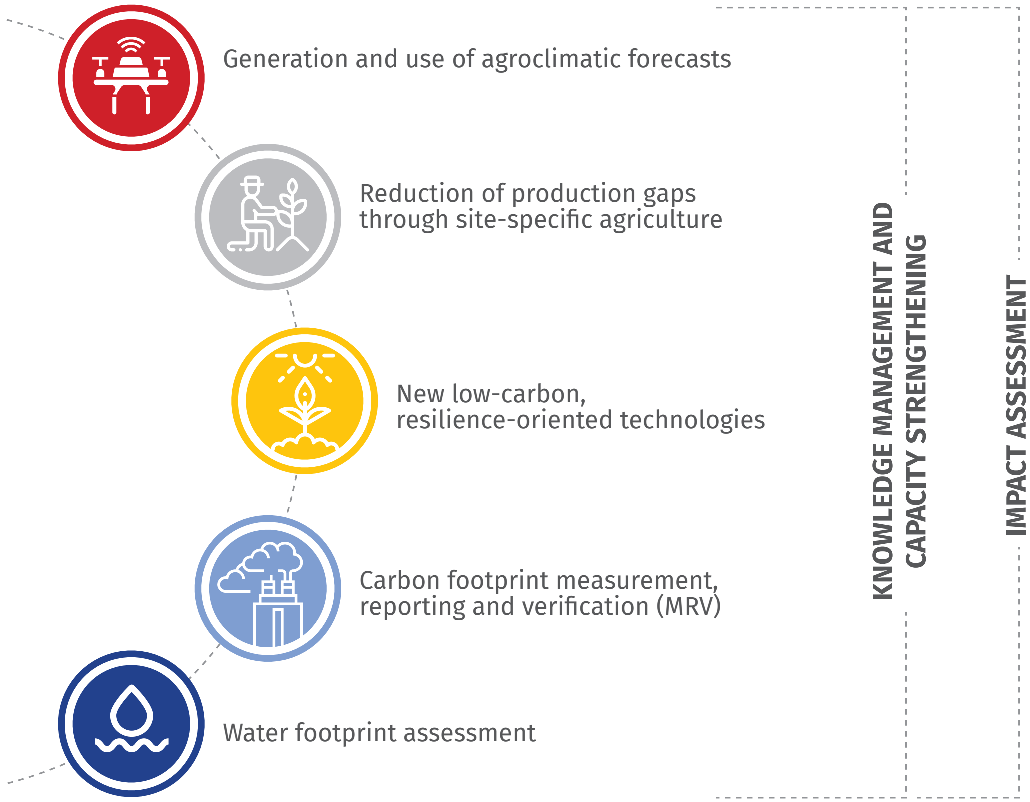


FIGURE 5.5 CSA TECHNOLOGICAL MENU

Source: CIAT, 2018.

5.3.3 Success case: Interleaved maize system in permanent crop[56]

Through a project developed by the Agricultural Rural Planning Unit (UPRA) of the Ministry of Agriculture and Rural Development of Colombia, maize systems have been developed interspersed with permanent crops, in which sustainable agricultural practices adapted to the climate are developed. This system consists of interspersing the cultivation of maize with coffee and cocoa in an area of 0.1 Mha and 0.02 Mha, respectively, to obtain an annual production of 0.5 Mt, with a yield of 4 t/ha in the coffee and cocoa area of Colombia. This project has brought benefits concerning the production costs of the two crops in association with maize, as it is efficient in managing the availability of nutrients for each crop and protecting the soil. The latter is achieved through conservation agriculture techniques, which consequently optimize the use of rainwater and light in the associated system.

In addition, further benefits of maize production, particularly in association with coffee, are an increase in profitability of up to US$ 800 per hectare; two maize harvests during the 18 months that the coffee crop takes to yield its first production; generation of additional employment, i.e., 50 daily wages per hectare of cultivated maize; and cash flow with available income for farmers during the unproductive period of permanent cultivation.

56 UPRA, 2018.

Climate-smart production systems involve the sum of measures and technologies that each farmer requires based on their need and the agroecological environment they live in

5.3.4 Key messages

Climate-smart production systems involve the sum of measures and technologies that each farmer requires based on their needs and the agroecological environment they live in. Under this approach, there is a need to continue strengthening the capacity of the maize sector through existing CSA lines of work, including agroclimatic forecasts, site-specific agriculture, new varieties, and water and carbon footprints. It is important to emphasize that there is no single formula or "technology package" that could work for a country like Colombia. It is therefore essential to identify the most appropriate climate-smart options that can be easily adopted and implemented by each farmer. No technology is mutually exclusive, and the sum of conservation agriculture, with appropriate varieties, more irrigation technology, for example, can make maize production more efficient and achieve better yields, while allowing the farmer to adapt to the new challenges of climate change and scarcity of natural resources.

In addition to identifying the best options, technical support is undoubtedly one of the most substantial challenges for the correct identification and implementation of appropriate measures or technologies for farmers. Technical support can be key to helping farmers adapt to different climatic extremes and related challenges, such as floods, pest damage and disease, which present significant difficulties throughout the agricultural cycle.

The third challenge, although more general, is the access to subsidies, guarantees or loans for the acquisition of consumables and qualified technical support services. The latter would allow farmers to acquire the necessary inputs and tools for an effective implementation of climate-smart systems. In accordance with the agroecological zones, and leveraging the most appropriate practices for each farmer, there should be mechanisms and incentives that allow for the adoption of a variety of technologies and suggested measures. Considering regionalization and the existence of technologies at different scales, access to a set of technologies is essential to achieve production systems that can, on the one hand, increase yields and reduce production costs and, on the other, strengthen climate change resilience.

None of the practices or technologies mentioned is a novelty in the Colombian agricultural sector. However, the concept of climate-smart agriculture is a new term, still in development, seeking to encompass the desire to improve the integration of agricultural development and the capacity to respond to climate change. For the adoption of CSA practices, it is important to identify current practices and promising future options according to each agroregion and type of farmer; and, of course, to consider the support of institutional and financial facilitators for their adoption.

Every technology under the CSA range benefits the farmer's economy while contributing to climate change-oriented targets. The negative effects this phenomenon will have on agriculture are currently measurable. However, the way to deal with it is a task few stakeholders in the agricultural sector —especially in the maize sector— have looked into. Comprehensive planning, together with the rest of drivers of change, cannot be postponed. This is in the interest of responding to the growing demand for maize in the country in a way that is aligned with the possibilities and needs of each farmer so that a level of self-sufficiency is achieved.

5.4 DRIVER 4. Farm advisors innovation networks

Coverage of innovation networks as a standard of extensionism and technical assistance in at least 30% in the rural environment.

5.4.1 Background and rationale

Extensionism is a practice in which professionals from the agricultural sector —called extensionists— promote and favor the transfer of knowledge and productive processes for rural development. The main task of the extensionists is to help farmers develop practices and tools to increase their productivity

Extensionism emerged in Europe at the end of the nineteenth century as a response to food crisis, amidst which the need for innovation emerged from the primary sector in the form of new and better forms of production[57]. Subsequently, this process was institutionalized and implemented in different countries through knowledge and innovation transfer schemes. However, today, there is no single model of extensionism, but rather a multiplicity of schemes depending on the country and context, the degree of professionalization of the sector, etc. It is therefore difficult to define precisely the term and the practices that it comprises. Throughout this section, and promoting future change, it has been decided to replace the term *extensionism* by *farm advising support*, which describes in a more precise and updated way the work of knowledge transfer and adoption of efficient practices for the development of innovation in the field. However, the use of the term extensionism is maintained when addressing the background and current situation given its relevance.

In the case of Colombia, the concept of technical support for agriculture in legislation is recognized as a tool for the provision of technical assistance services, without contemplating extension actions. At the level of social programs and projects, the concept of support is understood as the transfer of technologies from one technical expert to another. In this regard, at the national level, there is an approximate of 42% municipal coverage of technical support for the agricultural sector, with available resources for its promotion. In 2017 alone, 16 agreements were signed for 30 billion Colombian pesos to benefit 67,893 small and medium farmers[58] with technical agricultural support.

GRAPH 5.6 TECHNICAL SUPPORT COVERAGE ESTIMATE AT THE MUNICIPAL LEVEL

Source: Own elaboration with data from IICA, 2015.

57 Jacobsen, B.H. "Farmer's decision making behaviour: empirical findings from Denmark" In: Jacobsen, B.H.; Pedersen, D.E.; Christtensen, J.; Rasmussen, S., ed. (1994) Farmer's decision making - a descriptive approach. Proceedings from the 38th EAAE Seminar 1994, October, Kopenhagen, 1994. Pp.77-89.
58 IICA, 2015.

Despite this, public investment for technical support in the agricultural sector has not been sufficient. Historically, Colombia has seen obstacles for the development of knowledge and innovation in its countryside. Among the main ones are the difficulty to define programs and projects for extension systems and rural technical assistance that are aligned with existing research findings; the absence of statistical information for consultation; the low feedback and updating among the actors providing extension services and rural technical assistance; the scarce supply of professionals in the provision of services; and insufficient quality in the provision of rural extension services[59].

On the other hand, the institutional conception of technical support in Colombia has the weakness of not considering extensionism as part of its fundamental elements. Although rural extension services have contributed in some way to Colombia's agricultural development, there is an important gap between the available knowledge and its adoption by farmers. This reduces services and their perception as core elements in agricultural development policies[60]. Currently, new trends exist for the development of self-management capacities through rural extensionism or farm advising support.

5.4.2 Opportunities and success cases

The current situation in Colombia has enabled the adoption of this new technical support concept. In 2017, Law 1876 established the creation of the National Agricultural Innovation System (SNIA). One of its main goals is to articulate research and technological development with the agricultural extension service in order to ensure a technological offer geared to innovation and the needs of farmers and other actors involved in agricultural value chains. The system aims to improve their competitiveness and sustainability, as well as their contribution to food security.

On the other hand, stakeholders of the agricultural sector in Colombia have endorsed participatory research for farm advising support. Such is the case of the National Federation of Coffee Growers of Colombia (FNC) who, together with the National Federation of Cereal and Legume Growers (FENALCE) and in coordination with the Ministries of Agriculture and the municipalities through their Municipal Units of Agricultural Technical Assistance (UMATA), have promoted a strategy of interaction between coffee growers, extensionists, and researchers. This interaction aims at validating, adapting, and transferring technologies according to the socioeconomic and cultural conditions in each entourage.

5.4.3 Networked innovation as a vehicle of knowledge

Networked relationship models have proven to be a vehicle for accelerating high-efficiency innovation in multiple fields[61]. Initially based on the analysis of the spread of epidemics and then on the viral adoption of social trends[62], these models are based on the selection of key actors who have great influence in a network and show a high number of social interactions with other members, thus being the most effective elements to channel knowledge flows. That is to say,

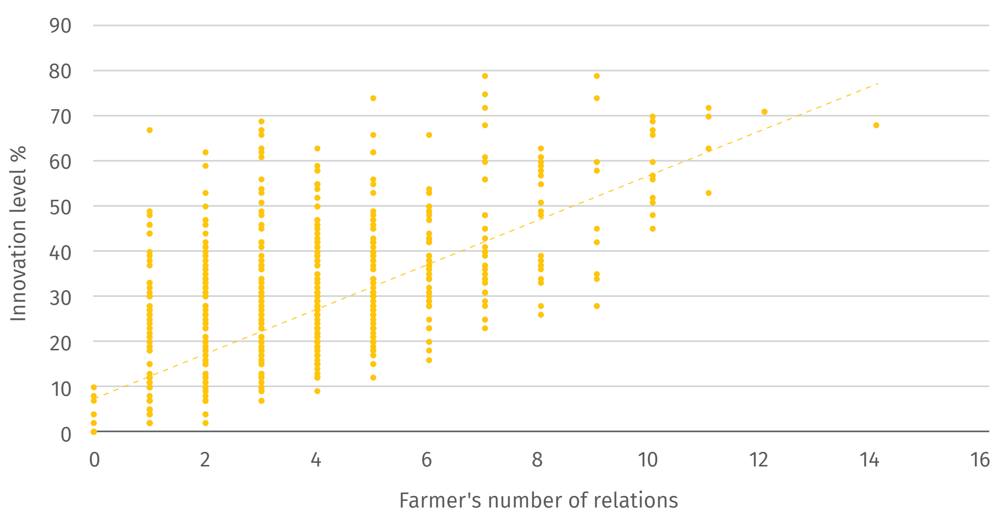
59 *ibid*.
60 Corpoica, 2016.
61 Rycroft, Robert, "Self-organizing Innovation Networks: Implications for Globalization", 2003.
62 Innovation networks are all those organizational forms that aid the exchange of information, knowledge and resources among stakeholders; through an iterative learning process among at least three parties, these networks generate innovation based on trust and cooperation relations among the different actors involved. It is also observed that innovation activities are coordinated while stable relationships are established among companies and other stakeholders (training and research institutions, political actors, etc.) to obtain competitive advantages in a joint and cooperative manner; these joint efforts, in turn, generate innovative products, processes, and services. InnoSupport: Supporting Innovations in SME. 11. Innovation Networks, 2005.

within a social context there are always some stakeholders more looked up to by their peers; and the diversity and intensity of the relations generated by these stakeholders favor the replication of the messages.

In the area of agricultural production, an innovation network is a social structure among farmers and other actors such as technical extensionists, researchers, and institutions based on institutional agreements. This also includes companies. An innovation network aims at facilitating the exchange of information and knowledge and increasing levels of innovation; similarly, it promotes understanding innovation as any knowledge-based change that generates greater productivity and, therefore, wealth[63].

Working under the model of innovation networks allows for the measurement of public resource allocations to innovation, since it is possible to identify key actors, measure interactions, identify the level of adoption of innovations, and construct baseline and final measurement indicators.

Innovation networks increase the number of interactions between farmers, technicians, and extensionists. These interactions facilitate knowledge and information flows. Because of this, innovation benefits from the number and diversity of relationships (across different types of actors). In case studies observed in Mexico, each link (extensionist) increases the level of innovation by 5.4%, that is, the number of new adoptions of practices and technologies in relation to the total number of decisions made by a farmer throughout a production cycle. Likewise, an 8% increase in innovation relates to an increase in production of one ton per hectare[64] (Graph 5.7).



GRAPH 5.7 INNOVATION AS A RESULT OF INTERACTION

Source: Sánchez G., J. and R. Rendón M. 2012. Capital relacional en la adopción de innovaciones por los agricultores en México.

Other examples show evidence that the interaction of a farmer with an extensionist doubles both the percentage innovation level from 12% to 23%, and maize yields from 1.37 t/ha to 2.62 t/ha[65] (Table 5.2).

63 Cotec Foundation, 2006.
64 Sánchez G., J. and R. Rendón M.,"Capital relacional en la adopción de innovaciones por los agricultores en México", 2012.
65 Roldán S., E. and R. Rendón M. 2016. In press.

TABLE 5.2 IMPACT OF EXTENSIONIS

Source: Roldán S., E. and R. Rendón M. 2016. In press.

Variable	Interaction with an extensionist	
	Yes	No
Observations	388	1,849
Age (years)	51.71[a]	48.46[b]
Schooling (years)	6.66[a]	5.18[b]
Area (ha)	2.08[a]	1.29[b]
Innovation level (%)	23[a]	12[b]
Yield (t/ha)	2.62[a]	1.37[b]

Note: The letters a and b in the superscripts indicate that the results are significant.

5.4.4 Direct impacts on productivity: The case of MasAgro in Mexico

The case of the Sustainable Modernization of Traditional Agriculture (MasAgro) program, conceived for developing over a period of 10 years (2010-2020) led by SADER, together with CIMMYT, has been recognized internationally as one of the most successful and innovative initiatives in Latin America and the Caribbean. The Program seeks sustainable rural development, food security, poverty eradication, and climate and environmental resilience that can be replicated in diverse rural territories and at multiple scales. The fundamental element of MasAgro's success is the methodology and its farm advisors innovation networks, standing out for achieving a level of effectiveness 10 times higher than traditional extension strategies[66].

Primarily, MasAgro develops a strategy of generation, validation and extension of sustainable agrifood systems. It makes use of networks to promote innovation, technology transfer, and the adoption of improved seed of maize, wheat and associated crops, as well as sustainable agronomic practices among small-scale farmers. This, as a whole, envisions to generate high and stable yields, reduce environmental impact, and bring higher incomes.

The work under this scheme is carried out territorially, considering local farmers as central stakeholders who benefit from the aforementioned innovation hubs. The creation of these hubs promotes the integration of the agrifood chain through innovation networks that allow the implementation of actions and interventions based on specific production systems and agroecological zones. Socioeconomic factors and the generation of a network of knowledge, dissemination, research, and training where the farmer is co-owner and developer are taken into consideration. Innovation hubs contemplate the installation of experimental technological platforms dedicated to the research and validation of sustainable agriculture principles and new technologies based on problems experienced in the field. They encourage the development and adaptation of innovative agronomic production practices or solutions, and also allow for real-time interaction among the different actors involved in the production chain aiming to find tangible solutions to the specific problems of each area.

Research platforms are established with the support of national public and private institutions dedicated to research and education, where a scientist makes direct contact with technicians and farmers in the region. Likewise, the model contemplates the establishment of demonstration modules in key areas where farmers can test, integrate and adapt the technologies generated in the platforms while giving feedback on the effectiveness of the proposed solutions.

66 Rendón et al, Center for Economic, Social and Technological Research in Agroindustry and World Agriculture (CIESTAAM), 2016.

In the established plots, or modules, farmers and technicians work together to adopt the agronomic solutions developed and link up with government officials, input suppliers, credit, machinery workshops, among others. In addition, a comparison of processes and outcomes of traditional and sustainable agriculture based on conservation agriculture is performed.

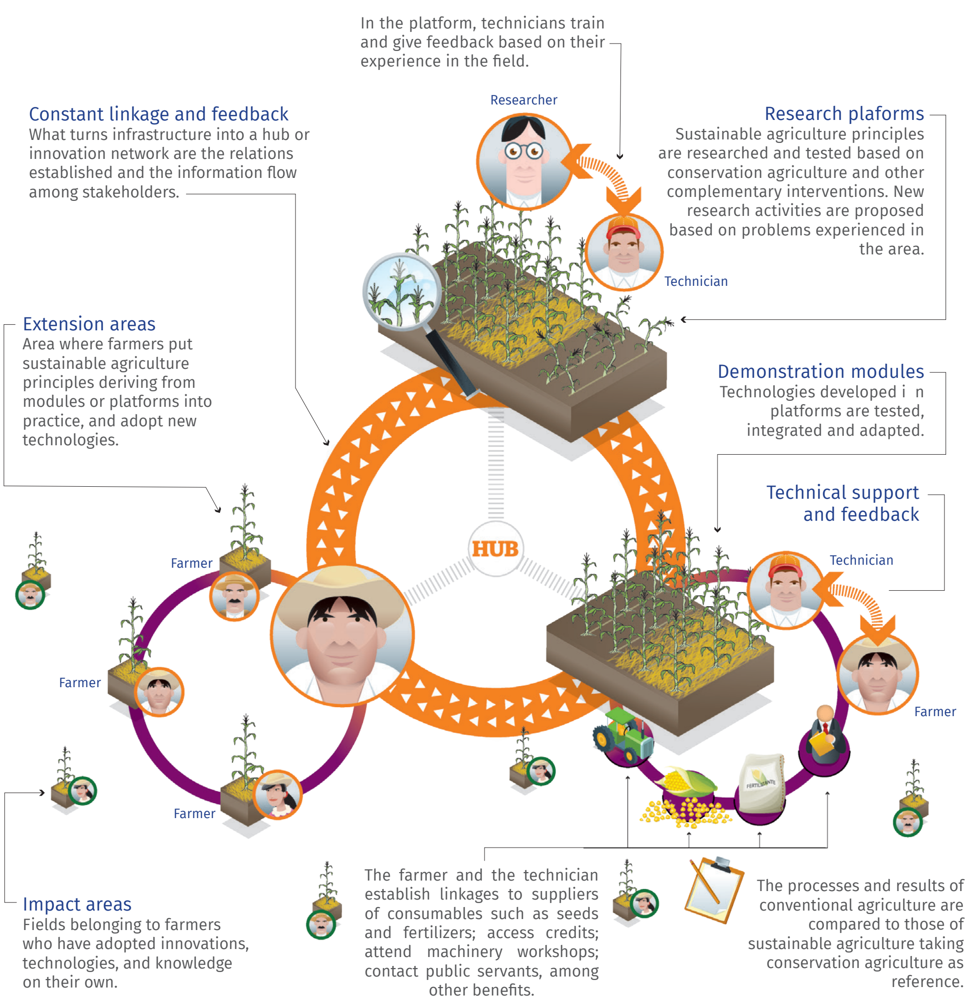
The support scheme is mainly based on promoting experimentation and adoption of good practices with leading farmers, researchers, and change agents. This is done by fostering close collaboration among researchers, input suppliers, farmers, and extension agents as well as political support and the alignment of federal and state programs. Under this scheme, the different strata of farmers in the various agroecological zones of the country (small owner, intermediate productive potential and high technology), adapt technological innovations in extension areas. In such a way, they encourage increased productivity and capacity building. Also, promoting a farmer-to-farmer adoption generates impact areas.

FIGURE 5.6 SCHEME OF THE INNOVATION HUBS PROCESS

Source: CIMMYT, 2018.

The hub

The physical infrastructure of the hub consists of system comprising research (research platforms), implementation (demonstration modules), and dissemination (extension areas). This infrastructure lays the foundations for a network of stakeholders from the agricultural chain, i.e. farmers, technicians, scientists, research centers, private sector, press, and public servants, among others. The common goal: bringing innovation to the production system in order to develop a more sustainable, productive, and profitable one.



An innovation network is the social structure between farmers and other actors to exchange information and knowledge, as well as to increase levels of innovation in the agricultural sector.

Through this methodology, farmers' demands are incorporated in real time into an innovation model, aided by the interaction of agricultural farmers economic organizations, educational institutions and technology generators, change agents, among others. This interaction allows the model to timely respond to the needs of the process catalyst —the farmer. In the same way, the model contemplates a set of strategies that contribute to the development of the innovation model such as:

- Development of conventionally improved high yielding seeds.
- Training and capacity building of key stakeholders in the innovation network, and training of change agents.
- Dissemination, scientific valorization and distribution of information to key actors.
- Development of smart and precision agricultural machinery.
- Development of post-harvest technologies.
- Strategic research in the management of integral fertilization.
- Strategic research in systems based on Conservation Agriculture.
- Use of information technologies.
- Socioeconomic analysis of the processes within the model's innovation network.

Through this model, a technician generates 263 dollars more in income per hectare. The hubs serve to visually present situations in order to remove communication barriers, allowing MasAgro and farmers to combine the old and the new, as well as to generate new and improved practices that both farmers and local communities can use[67].

5.4.5 Key messages

Farm advisors innovation networks have become a vehicle for effective communication between researchers and farmers since they are based on the selection of key actors with a higher level of social interactions, which helps to catalyze knowledge flows. That is to say, the diversity of current relations among stakeholders in a network favors the replication of knowledge.

An innovation network is the social structure between farmers and other stakeholders to exchange information and knowledge, as well as to increase the levels of innovation in the agricultural sector. The latter is to be understood as any knowledge-based change that generates wealth. Working under this model makes it possible to identify key actors, measure interactions, identify the level of adoption of innovations, and construct baseline and final measurement indicators.

Colombia has the opportunity to adopt these practices to significantly boost the agricultural sector and, in particular, the cultivation of national maize. Through the farm advisors innovation networks, it is possible to increase the level of innovation per hectare by 5.4%, where the 8% increase in innovation in production units can translate into one ton of maize per hectare, while improving yields and increasing production through interactions between farmers and technicians.

67 Liedtka, Jeanne, Randy Salzman, and Daisy Azer, "Design Thinking for the Greater Good" in Columbia University Press, 2017.

5.5 DRIVER 5. Linking competitive farmers to the market

Increase trade linkages for competitive farmers to the local, regional, and national market.

5.5.1 Background and rationale

Colombia is a maize-deficit country. As noted in the first section of the document, there is a current deficit of 4.6 Mt. National production is therefore insufficient to meet the growing demand for maize —particularly yellow maize— that exists in the balanced food industry for livestock feed. Another percentage, although smaller, is also demanded by the Colombian consumer for the production of products such as *arepa*.

However, the deficit figures are even more pessimistic leading to 2030. According to the projection presented in the second chapter of this document, Colombia will be importing 5.9 Mt should the current strategies —or *status quo*— of national production not change. Therefore, this driver suggests that, *in order to reduce the deficit in the maize sector, it is necessary to generate conditions that encourage production, but are aligned with markets.* Among these, one can resort to the incorporation of business schemes that promote and disseminate specialized advisory services (technical, commercial, financial, fiscal, etc.), and a more efficient management of production units at the individual level, and of farmer associations. On the other hand, it is also important to provide the infrastructure conditions to link farmers or farmer organizations to the market. In doing so, the market will not be affected by the lack of services or means required to maintain a successful maize value chain from the seed to the furthest end —trade.

As follows, some of the premises proposed to achieve a successful linkage of farmers to the market[68]:

(1) Maintain constant quality, fulfillment of agreements and offer a competitive cost.
(2) Ensure that the final price of products is not subject to subsidies.
(3) Operation of both parties according to trade rules.
(4) Offer price parity.

These minimum conditions to achieve a value chain with linkage of farmers to the local, regional, and national market, however, present a series of obstacles. Some examples are land ownership, legal security for investment, lack of road-maritime-transport infrastructure that hinders the transfer of grain from production areas to those of consumption or transformation. In the face of these challenges, it is important to consider that, in order for continuity to prevail in a functional business model, transparent conditions of contract farming, quality certification, and grain storage infrastructure are required.

Among the factors for the determination of maize prices are import prices expressed in dollars and the futures market established by the Chicago Stock Exchange. To face this volatility, supports and compensatory services for commercialization are available, which contribute to the ordering and development of markets, while strengthening farmers and buyers for agricultural competitiveness. The existing support programs and financial services boost the viability of production; yet they are circumscribed to a specific population, limiting the participation of a broad segment of farmers. Technical support is therefore indispensable, as it encourages the creation of credit subjects who can benefit from financing and thus expand the financial frontier.

On the other hand, a fundamental requirement for linking farmers to the market is to ensure adequate storage and traceability of the grain produced. Traceability is understood as the identification of the food product from the farmer to the consumer, aiming to improve and control quality —in this case that of maize— and guarantee a safe food product[69]. Collection and storage infrastructure for post-harvest handling is essential for processing, packaging, distribution, and logistics. In sum, some of the challenges faced by markets in general can be seen in Figure 5.7:

68 Presentation Laura Pasculli, Scenarios Workshop 2030 vision, August 30, 2018.
69 J. Briz, I of Felipe, “Seguridad Alimentaria y Traceabilidad”, Universidad Politécnica de Maíz. 2003, pg.4. Available at: https://www.researchgate.net/ publication/265012284_SEGURIDAD_ALIMENTARIA_Y_TRAZABILIDAD.

FIGURE 5.7 COLOMBIAN MARKET STRATEGIC CHALLENGES

Source: Presentation Laura Pasculli, 2030 Scenarios Workshop 30 August 2018.

5.5.2 Opportunities and success cases

There are multiple success cases indicating that, with certain conditions in place, an efficient, comprehensive and impactful link between farmers and the market can be achieved (Figure 5.8). These include the experience of the company La Fazenda, which has a self-sustainable business model, linking agricultural production with livestock and their production plants in a direct manner. Replicating this model is feasible because it depends on the alignment of the supply of farmers with the demand of private initiative under a principle of mutual benefit. Another example is the project implemented by Kellogg's and CIMMYT in Mexico to supply the production of yellow maize through sustainable technologies that are, in turn, compliant with the standards of quality and competitiveness required by the company.

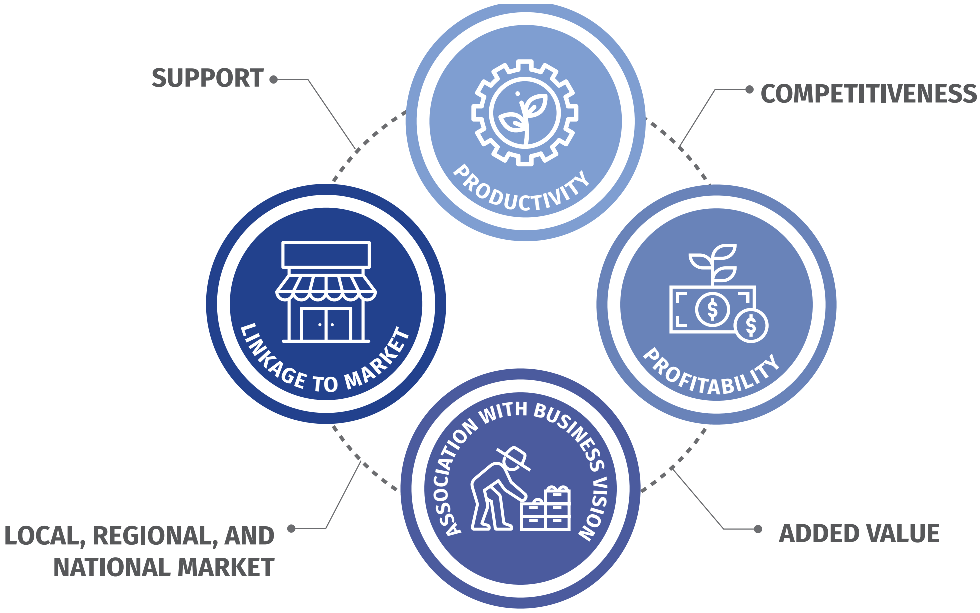


FIGURE 5.8 CONDITIONS FOR LINKING FARMERS TO THE LOCAL, REGIONAL, AND NATIONAL MARKETS

Source: CIMMYT, 2018.

5.5.3 Success case of chain and farmer integration - La Fazenda

One of the emblematic cases in Colombia —and a source of pride for many— is the La Fazenda farm, which in just 10 years managed to sow 32,000 ha, of which 53% is maize and the rest, soybean. The average yield is 7.5 t/ha, although up to 8.8 t/ha[70] have been achieved. La Fazenda, located in Puerto Gaitan, in the department of Meta, is a different model of agricultural development.

This model owes its success to a set of factors inspired in the Brazilian chicken chain, identifying that the production chain should not start "in the concentrates plant with imported grain, as the logistics of bringing it from abroad is very expensive, and reflects in meat and eggs being 30% more expensive than in countries producing their own grain[71]." In addition to the costs, they valued the potential of the Colombian countryside, as well as that of national farmers who are able to increase productivity and, therefore, generate wealth and contribute to the national production chain.

One of the key factors identified in this success case is the ability to plan for the long term. From the beginning, soybean and maize crops were programmed as food for the fattening of pigs handled in La Fazenda (operated by Aliar S.A). A complete chain was developed where the sowing of crops, animals, and processing plants are integrated in the same physical space, leaving out transport costs, thus increasing efficiency. In addition, as part of this planning, a long-term vision was established leading to 2027 —20 years— which envisions the rent of lands, sets goals in terms of the amount of animals (pigs) to be kept in the farm, and defines market sales targets.

70 Guzman Pinilla, John. "La Fazenda, el negocio que cumplió 10 años", Agronegocios, Ganadería, 7 February 2017. Available at: https://www.agronegocios.co/ganaderia/la-fazenda-el-negocio-que-cumplio-10-anos-2622463.

71 Liévano, Jaime. "La Fazenda, éxito de integración de la cadena y productores", Sociedad de Agricultores de Colombia (SAC). 24 August 2016. Available at: https://sac.org.co/la-fazenda-exito-de-integracion-de-la-cadena-y-productores/

Recently, the company developed and launched a cluster where agriculture, animals and plants for concentrate production, slaughter and drying are crossed. Using the existing infrastructure in Puerto Gaitan, Meta this cluster seeks to establish a facility for 2,500 cows in milking. With the support of a group of business advisors from different countries (Costa Rica, Germany and New Zealand), this cattle farming initiative vertically integrates the agricultural model with innovative technologies such as irrigation technology and fertilization, with dairy production and fattening. Not only has the company turned their self-sufficient model into a benchmark, but it also has encouraged the agrifood sector in Colombia to change production models used so far, structurally transforming the way national agriculture functions. "We spread our advice across the community by applying pillars of social, environmental, and economic sustainability without which our business model would not exist," said Jaime Lievano, manager of the company and manager of the La Fazenda farm[72].

5.5.4 Responsible maize sourcing success case - Kellogg's

Another successful model to be replicated is that of "Support for Responsible Supply and Sustainable Agriculture of Maize in Mexico", a project implemented by CIMMYT and the American company Kellogg's to encourage the production of yellow maize through sustainable technologies aiming to increase productivity and protect the environment. Mexico being one of the most important markets for the company and home to 4 plants, a strategic alliance based on growth projections for Latin America was established in late 2016 with CIMMYT. This strategic alliance aims at producing locally and in a sustainable manner a percentage of the yellow maize that the company requires for the development of its products.

Through this collaboration, it is expected that the local yellow maize supply for Kellogg's in Mexico will grow with the aid of conservation agriculture techniques. CIMMYT is responsible for providing technical advice based on the results of scientific methodology to increase the productivity of the land; in doing so, an efficient use of the available natural resources will be made, generating better yields and mitigating the effects of climate change. Technologies promoted among farmers include drip irrigation techniques, pest management, and sensors to reduce fertilizer use.

72 Contexto Ganadero, "La Fazenda implementa clúster que incluye bovina", 13 June 2018. Available at: https://www.contextoganadero.com/ regiones/ la-fazenda-implementa-cluster-que-incluye-ganaderia-bovina

Through this initiative, in 2020, around 300 small, medium and large farmers will produce more than 100,000 tons of this grain with sustainable techniques for producing *Corn Flakes*, a brand with a long tradition in Mexico. In addition, the project seeks to stimulate a closer relationship between farmers and the company, and with new farmers based on trust and reciprocal gain. Through this collaboration, Kellogg's supply and sustainability commitments will be fulfilled, generating a stable purchasing mechanism based on a flexible and resilient production chain with maize quality standards, while meeting consumer demands.

5.5.5 Key messages

While the two success stories mentioned —La Fazenda and CIMMYT-Kellogg's— highlight two different models of organization, both illustrate successful linkages of farmers to the market. Of course, it is worth noting that, in both cases, there are elements of farmer economic organization based on clear rules, dynamized with resources and institutional support services, providing a higher level of certainty to the main stakeholders in the chain. For farmers to feel confident, it is essential to articulate the conditions of both financial and technical support to ensure traceability, as these elements encourage favorable conditions for the successful development of productive activities. Technical support favors the flow of financial and technological support schemes.

In the face of volatile market conditions, it is key to encourage, first of all, the use of instruments aimed at the implementation of low-risk projects, from an integral perspective. Secondly, it is necessary to increase farmers' access to technical support services, training and financing in order to ensure traceability. And finally, complementing and strengthening economic support or incentives is essential to strengthen users' confidence in the short term, so that in the medium term they can access differentiated financing such as marketing, expansion, technologies, among others.

6. 15 Actions: Strategic Plan to Move from Scenarios to Action

The following sections include the 5 drivers of change and the 15 recommended actions for each one of them. These derive from the participatory consultation and institutional validation process of **Maize for Colombia's** strategic planning.

M1	**IMPROVED SEED ADOPTION** **1A.** Document the needs of the seed market. **1B.** Implement financing and incentive schemes that provide support and bring dynamism to improved seed adoption. **1C.** Develop resources for maize breeding research.
M2	**NUTRITIONAL SECURITY** **2A.** Increase the volume of biofortified maize seed production and consumption. **2B.** Identify and address the collection and storage needs of biofortified maize farmers. **2C.** Develop a national dissemination strategy to increase the demand for biofortified maize in the country.
M3	**CLIMATE-SMART AGRICULTURE** **3A.** Develop an agroclimatic information system for better decision-making and use of technologies. **3B.** Scaling up the use of CSA technologies, practices, and tools, including conservation agriculture. **3C.** Implement financing schemes and incentives to increase investment in technologies and systems for climate-smart agriculture.
M4	**FARM ADVISORS INNOVATION NETWORKS** **4A.** Develop a strategy of technical support networks based on diagnosis and regional productive categorization. **4B.** Establish the necessary mechanisms for the implementation of farm advisors innovation networks. **4C.** Incorporate public and private institutional financing mechanisms.
M5	**LINKING COMPETITIVE FARMERS TO THE MARKET** **5A.** Create a Maize Observatory to ease the access to market information. **5B.** Link farmers in the form of marketing associations at local, regional, and national levels. **5C.** Improve existing infrastructure and production systems to ensure market competitiveness.

Driver 1. Improved seed adoption

Goal

Improved seed adoption in 100% of the area under technified systems, and at least in 10% of the area under traditional systems by 2030.

Expected outcomes by 2030

- Assuming that the total area will increase by 2030, plant 100% of the technified system area (933 thousand ha) with improved seed, which includes the current area plus new areas under this system (900 thousand ha), as well as the area that transitions from a traditional scheme to a technified one (approximately 33 thousand ha).
- Promote a national network of seed companies made up of at least 5 Colombian companies.
- Implement a breeding program to release at least 10 hybrids and 2 synthetics adapted to the maize production conditions in Colombia, which are demanded by the market.

IDENTIFIED ACTIONS

Short-term

1A. Document the needs of the seed market.

- Identify the quantities of seed intended for each production system (traditional and technified) and according to the type of consumption (human or animal).
- Develop communication campaigns on the benefits of improved seed (hybrid).
- Identify the value of native maize collections.

Medium-term

1B. Implement financing schemes and incentives that provide support and dynamism to the adoption of improved seed.

Allocate a percentage of public budget to specific components for the development of supply and demand within the seed sector:

Support to farmers for the acquisition of improved seed

Support for investment in productive and distribution infrastructure for seedbeds

Support to supply/demand schemes with consolidated purchasing models, for farmers and suppliers

- Implement, through consolidated programs such as MasAgro in Mexico, strategies for improved seed adoption with differentiated objectives by region and type of maize.
- Coordinate with the Ministry of Finance and Public Credit and the Fund for the Financing of the Agricultural Sector (FINAGRO) financing schemes with competitive interest rates for the development of seed companies.

Long-term

1C. Develop resources for maize improvement research.

- Implement the National Maize Program as part of the National Innovation System Agricultural with short-, medium-, and long-term goals.
- Contribute to the implementation of the National Seed System, including the participation of public and private sectors.
- Create a collaborative digital platform between institutions and seed research centers.

Driver 2. Nutritional Security

Goal

Achieve a national human consumption of 50% of biofortified white maize with high zinc content by 2030.

Expected outcomes by 2030

- Promote the production of zinc-biofortified white maize seed (hybrid and synthetic) to cover at least 50% of traditional and technified production systems.
- Generate dissemination materials on biofortified maize as part of the communication and nutritional education strategy.
- Design monitoring strategies in collection and storage centers to ensure the safety of maize grains in biofortified maize production systems.

IDENTIFIED ACTIONS

Short-term

2A. Increase the volume of biofortified maize seed production and consumption.

- Promote the link with the food industry to introduce local production of biofortified maize.
- Promote the association of small and medium farmers with seed companies in order to encourage the use of biofortified seeds.
- Encourage, by means of extension systems, the use of technified systems for the production of biofortified white maize.

Medium-term

2B. Identify and address the collection and storage needs of biofortified maize farmers.

- Identification of farmers for the use of biofortified maize seed in viable production areas.
- Improve the technical capacities of farmers for the use of biofortified maize through the development of sustainable agrifood systems focused on maintaining the quality and safety of grains.
- Encourage the transfer of storage, handling, and post-harvest control technologies through extension systems and technical training.

Long-term

2C. Develop a national dissemination strategy to increase the demand for biofortified maize in the country.

- Identification of key public, private, and civil society actors to support the creation of a national dissemination strategy.
- Develop and implement a national dissemination plan that will allow informing the population about the benefits of a diversified diet including biofortified products.
- Encourage and disseminate the development and use of biofortified maize through audiovisual material, directed to the rural environment and isolated areas of the country.

Driver 3. Climate-smart agriculture

Goal

Conversion to climate-smart agriculture resilient to variability and change in at least 100,000 hectares of maize production systems by 2030.

Expected outcomes by 2030

- A 6.5 t/ha increase in the average yield of plots that adopt climate-smart agriculture technologies, including conservation agriculture and climate risk reduction.
- Develop climate-smart maize production systems in 100% of the areas under technified systems.
- A 30% increase in the efficient use of nitrogen fertilizers, measured in tons of grain produced per unit of nitrogen applied.
- Install central machinery in at least 30% of the technified area.

IDENTIFIED ACTIONS

Short-term

3A. Develop an agroclimatic information system for better decision-making and use of technologies.

- Collect scientific information to conduct a socioeconomic study that complements and integrates existing databases on short-term and long-term climate risks as well as performance gaps.
- Scale up the use of agroclimatic information and specific agriculture by coverage, integrating platforms such as Aclímate Colombia-Pronósticos, and Siria (AEPS), including the private sector's needs.
- Identify key processes and technologies by region and maize production system to establish sustainable and climate-smart systems.
- Build capacity among technicians and farmers for the collection, analysis, and use of agroclimatic information.

Medium-term

3B. Scaling up the use of CSA technologies, practices, and tools, including conservation agriculture.

- Designate priority areas and target farmer groups.
- Design training modules to be integrated into technical support programs for the adoption of climate-smart agriculture technologies.
- Scale up cyclical research and innovation processes in the field, including Agroclimatic Technical Tables (ATT) and SSF, with a focus on the impact on crop resilience, increase in yields, decrease in production costs, and, in general, greater income generation for farmers.

Long-term

3C. Implement financing and incentive schemes to increase investment in climate-smart agriculture technologies and systems.

- Allocate a percentage of public budget to specific components in order to support the development of key CSA technologies and tools, such as abiotic stress-tolerant varieties (i.e. efficient use of water); conservation agriculture; and soil improvement and efficient use of fertilizers and inputs. Additional tools and actions also include technified irrigation systems and an efficient use of water.
- Sustainability of information systems for data collection and analysis; and participative platforms for agroclimatic risk reduction (e.g. MTA, PICSA).
- Identify geographic areas that are strategic to the technified system and where machinery plants would be required; and facilitate their implementation through financial mechanisms.
- Direct incentives to small and medium enterprises providing farming services as agents of technology transfer.
- Encourage the introduction of local farmers from isolated areas for local trade and identify potential partners that complement the value chain and business strategy.
- Coordinate, with the Ministry of Finance and Public Credit and the Fund for the Financing of the Agricultural Sector (FINAGRO), financing schemes with competitive interest rates for investing in key technologies.

Driver 4. Farm advisors innovation networks

Goal

Coverage of innovation networks as a standard of extensionism and technical assistance in at least 30% of the rural environment.

Expected outcomes by 2030

- Implement technical assistance using the methodology of innovation networks in 100% of areas subject to extensionism, and increase coverage by 20%.
- Adopt 100% of data collection and decision-making systems (ICTs) for follow up, monitoring, and evaluation of farm advising support.
- Generate public-private incentives for the development of the Rural Innovation Fund in support of innovation.

IDENTIFIED ACTIONS

Short-term

4A. Develop a strategy for technical support networks based on regional diagnosis and productive categorization.

- Define the strategy to be used in the extension system based on the geographical area and a productive system oriented towards sustainable, climate-smart production systems.
- Propose the farmers' guild as a leading entity to the extension system, in collaboration with research institutions, and in coordination with a variety of NGOs and private sector.
- Identify and categorize active farmer associations by region in order to facilitate information and knowledge dissemination.
- Identify local innovative farmers as part of a strategy for technology transfer, as well as other key actors who can turn into agents of change within their areas of influence.

Medium-term

4B. Establish the necessary mechanisms for the implementation of farm advisors innovation networks.

- Complement and strengthen the work of extensionists through the use of technologies that facilitate information gathering, storage, and dissemination.
- Develop the skills of agents of change within the technical support network to implement and disseminate production systems through innovation hubs.
- Consider the implementation of the adaptive technology component as an element of extensionism.
- Develop strategies to reduce technology gaps in both traditional and technified maize production systems based on:

    Market conditions and management of risk factors

    Associativity for the purchase and efficient use of machinery and inputs

    Entrepreneurship linked to extension and mechanization services

    Social appropriation of knowledge

Long-term

4C. Incorporate public and private institutional financing mechanisms.

- Create a Rural Innovation Fund with concurrent public funds.
- Develop complementary financing schemes for the implementation of the system by development banks and international organizations.
- Facilitate private investment through tax incentives.

Driver 5. Linking competitive farmers to the market

Goal

Increase trade linkages for competitive farmers from the local, regional, and national market.

Expected outcomes by 2030

- Increase the logistics infrastructure for grain storage by 100%.
- Increase collection centers for maize by 50%, and extension services established for grain storage, by 80%.
- Increase the proportion of associated farmers per production area by 50%.
- Adopt quality standards compliant to the industry's specific requirements for white and yellow maize.
- Support the effective, inclusive and equitable establishment of at least 50 advance sale agreements for local grain and processed products.

IDENTIFIED ACTIONS

Short-term

5A. Create a Maize Observatory to facilitate access to market information.

- Publish a database with market information that allows farmers to consult the prices and quality of white, yellow, and native maize, and monitor the dynamics of supply, demand, and inventories across different market segments.
- Identify critical areas with high potential for productivity that are deficient in terms of storage infrastructure and collection facilities; and systematize associated logistical infrastructure costs.
- Make projections of storage demand and its geographical distribution based on potential scenarios of increased yields; and identify improvements in logistics, as well as in port and transport infrastructure that favor inventory planning and the reduction of logistical costs.

Medium-term

5B. Link farmers in the form of trade associations at local, regional, and national levels.

- Promote economies of scale and associativity among farmers, and disseminate information on supply schemes and consolidated sales.
- Support contract farming schemes for farmers, and ensure the use of minimum clauses to achieve compliance.
- Generate added value for primary products promoting the diversification of crops and processes.

Long-term

5C. Improve existing infrastructure and production systems to ensure market competitiveness.

- Expand the scope of regulatory bodies so that they can support storage traceability and quality in collection centers.
- Link consumption and collection centers.
- Establish incentives for the development of commercial advisory services, logistics, storage, transport and information technologies necessary to access the market.

7. Conclusion

Maize is one of the central crops in Colombia's agrifood system, being the third with the largest cultivation area after coffee and rice. However, the country is the first importer of maize in South America, and ranks seventh in the world with a self-sufficiency level of around 26% —well below the level of agrifood self-sufficiency suggested by FAO (75%).

For this reason, the *Maize for Colombia* strategic plan is paramount for changing the course of the sector. This document consolidates the contributions of statistical information and the direct inputs of a diversity of public, private, and social actors linked to the production chain. This document follows the same planning structure; in other words, the three questions that guided the process itself are used here as reference.

The first question —*Where are we?*— relates to the current situation of the agrifood system —especially that of maize— using historical data to determine the most relevant variables. The first variable is consumption, and the dietary patterns of Colombians that directly relate to maize and to the livestock industry that consumes maize for animal feed; the second variable is production. This last analysis highlights the gap between the technified system and the traditional one in terms of yields and productivity. This section points out that, although the total area of maize production has decreased, the area under the technified system has grown significantly. Nevertheless, the yields of this system, although higher than those of the traditional one (2.0 t/ha vs. 5.4 t/ha), are still below the global average of 5.8 t/ha. Said this, Colombia consumes at a faster rate than it produces, making the country increasingly dependent on imports coming, above all, from the United States.

The following question —*Where are we heading?*— allows us to draw up projections of potential 2030 scenarios if nothing changes, and the same trends in production and consumption continue. The model analyzes prospects that, albeit not forecasts of agricultural production, do suggest potential future scenarios based on system dynamics that help to establish a road map. The results of potential 2030 scenarios are not encouraging. It is expected that, while demand will grow 27.4% based on current trends —to a greater extent due to the growth in demand for yellow maize—, production will only increase by 4%. Therefore, according to these prospects, there will be a deficit of 5.9 Mt by 2030, which implies an increase in imports of 39%, and a decline in self-sufficiency of 26%-21%.

These projected figures for 2030 lead to the third and last question —*How to achieve a better future considering that the status quo scenario to 2030 is not desirable?* This question guided the process of defining strategy proposals —or drivers of change— to achieve positive transformation. These imply modifying production patterns that do not lead to desirable scenarios in the coming years. With this third question in mind, the sum of the work done with the Expert Panel, the Scenarios Workshop, and the validation meetings held with 19 institutions enabled the definition of concrete actions. These, in turn, translated into 5 drivers of change.

Farmers' access to and, above all, adoption of improved seed is a determining factor in increasing crop productivity. Therefore, a future strategy must face this challenge and adapt the experience of MasAgro, in Mexico, in order to increase the national area currently planted with improved seed varieties. This experience, alongside other success stories, show that improved seed together with the right irrigation techniques, the necessary fertilizers, and crop rotation can generate an increase of more than 100% in yields. Synergy between the public and private sectors, and in particular the research sector, will be essential to achieve the goal of this driver of change. Modifications are necessary in each one of the links and mechanisms of the seed value chain —from public research centers, seed multiplication bodies, seed companies, and distributors to farmers themselves.

As to the driver of change on nutritional security, the importance of interventions is highlighted in the regions of Colombia where the challenges of malnutrition due to micronutrient deficiency in the population turn out to be a public health problem —particularly among children and childbearing age women. Consumption of biofortified maize is thus a viable option that could potentially benefit target populations with nutrient-rich foods. The consumption of zinc-biofortified maize is not only an important source of micronutrients, providing even 5 times more zinc than commercial maize (for instance, when consumed in the form of *arepas*), but is also competitive in field productivity. The production and consumption of biofortified maize has great potential. Yet, it requires the participation of different stakeholders (public, private, and civil society) in an alliance to increase the demand for nutritious and productive maize in Colombia.

The adoption of climate-smart production systems and technologies is another determining factor in raising crop productivity in an environment vulnerable to the effects of climate change. The incidence of meteorological phenomena, changes in the distribution of precipitation, and rising temperatures are increasingly frequent and intense. This level of climatic variability affects field productivity. For this reason, CSA principles are fundamental, as they seek to increase food security, improve resilience, and reduce greenhouse gas emissions based on a variety of technological options and practices. These include conservation agriculture, the use of agroclimatic forecasts, and precision agriculture, among others. In this case, the implementation of CSA options will depend on each context, as there is no single recipe.

Innovation networks as a model of extensionism —included in the fourth driver of change— have multiple advantages when compared to traditional schemes. They allow to identify key actors, measure interactions, determine the level of innovation adoption, and develop baseline and final measurement indicators. This is how the experience of MasAgro and that of the hub should be leveraged, whose results show an increase in coverage in 11.3% of production units, compared to 1.3% achieved with traditional methods. In addition, the National Agricultural Innovation System (SNIA) proposed in 2017 presents some mechanisms through which an impact on technical assistance and on the adoption of technological innovations by farmers can be achieved.

The fifth and last driver of change proposes the linkage of competitive farmers to the market as a central element to increase maize productivity and profitability. On the one hand, it proposes to provide farmers with the tools to add an entrepreneurial approach to their productive activity. This is especially beneficial to small farmers, who generally show lower levels of associativity and often become dependent on intermediaries to reach final consumers. The actions formulated in this driver seek to ensure that the link between farmers and the market builds on effective strategies, a good organization of farmers themselves, financing, and specialized advice.

On the other hand, it also endeavors to improve current grain collection and storage infrastructure

in a way that it allows farmers and buyers to promote national production.

Through the objectives, expected results, and short-, medium-, and long-term actions included in the 5 drivers of change, the *Maize for Colombia* strategic plan offers concrete recommendations to build a desirable scenario towards 2030 and a better future for maize in Colombia. In this proposal led by CIMMYT and CIAT, experts and stakeholders from the sector recognize that the country has productive potential to satisfy —in at least 75%— the basic demands of the population and industry in the medium and long term. Moving forward in terms of productivity is entirely feasible. *Maize for Colombia* promotes therefore moving from paper to action. As part of this approach, the actions and objectives on which consensus has been reached in the sector will be implemented to increase maize productivity and profitability in a sustainable manner.

8. Annex 1. Scenarios Workshop Report

FIGURE 8.1 BROCHURE - MAIZE FOR COLOMBIA'S SCENARIOS WORKSHOP - 2030 VISION

The goal of the workshop was to determine whether the scenario Colombia is moving towards —based on projections for 2030— turns out to be a desirable future for stakeholders in the sector and for the country itself. Guided by three key questions, the Workshop was organized in order to generate answers. The first and second questions —*What is the current situation of maize cultivation in Colombia?* and *What are the likely production scenarios by 2030 if there is no change?*— were answered during the first part of the Workshop. This was done through the intervention of Dr. Bram Govaerts, Director of the Integrated Development Program and Regional Representative for the Americas, as well as those of the scientific sector represented by Juan Lucas Restrepo, then Executive Director of AGROSAVIA; Javier Mateo-Vega, Director of Alliances and Communications; and Jeimar Tapasco, Senior Agricultural Economist. Equally important was the participation of the private sector, represented by Laura Pasculli, Director of the Chamber of the Balanced Food Industry of the National Association of Entrepreneurs of Colombia (ANDI).

The answers to these two questions gave rise to the second stage of the Workshop, aimed at answering the central question: *What are the strategies that would lead to a desirable scenario?* In other words, *what actions should be defined to close the gap between demand and production?* This became the focus of the activities in the second and most relevant part of the Scenarios Workshop. The discussion focused on six strategic themes —called drivers of change— initially proposed to develop an objective 2030 maize scenario.

In order to introduce these drivers of change, an Expert Panel was set up, composed by Carlos Galeano, Researcher of the Roots and Tubers Network of AGROSAVIA; Marilia Nutti, HarvestPlus Regional Director for Latin America and the Caribbean; Julián Ramírez, Climate Impacts Scientist;

Henry Vanegas, General Manager of the National Federation of Cereal and Legume Growers (FENALCE); Laura Pasculli, Director of the Chamber of Balanced Food Industry of the National Association of Entrepreneurs (ANDI); and Yadira Peña, Researcher of the Efficient Use of Soil and Land Adequacy team of the Agricultural Rural Planning Unit (UPRA) on behalf of Daniel Aguilar, Technical Director of Efficient Use of Soil and Land Adequacy.

After the experts' presentations, two working sessions with guided group activities to discuss and design potential responses were held with a view to facing shock situations. This was done with the purpose of defining concrete actions to achieve a desirable production scenario, considering that the 2030 scenario is not positive if a number of determining factors maintain the current trend.

A total of 49 participants attended the Scenarios Workshop – Maize for Colombia: 2030 Vision, held on Thursday, August 30, 2018 at the headquarters of the International Center for Tropical Agriculture (CIAT) in Palmira, Colombia, to contribute to building a better future for the Colombian maize sector in 2030. It was a diverse group of representatives of farmers' associations, national research centers, universities, balanced food companies, industries dedicated to the production of poultry, pork and beef, among other key public and private sector stakeholders directly related to the production and use of maize in Colombia.

8.1 What is the future of maize in Colombia?

8.1.1 Current Situation and 2030 Projections. Where are we heading?

To answer this question, Javier Mateo-Vega, CIAT Director of Partnerships and Communications, gave a presentation highlighting the alliance between CIAT and CIMMYT as centers united for the development of the Colombian countryside and the current situation of maize production. Also, he underlined the importance of building an initiative such as *Maize for Colombia.*

Afterwards, Laura Pasculli, Director of the Chamber of Balanced Food Industry of the National Association of Entrepreneurs of Colombia (ANDI), gave her presentation and shared an industry perspective on the relevance of maize cultivation.

In turn, Juan Lucas Restrepo, Executive Director of AGROSAVIA, introduced the participants to the Government's perspective, inviting them to work as a team and support maize as an income-generating grain for peasant families.

Afterwards, Jeimar Tapasco, CIAT Senior Agricultural Economist, presented the climate change and maize scenarios for Colombia, emphasizing the opportunities and challenges for the sector.

Finally, Dr. Bram Govaerts, CIMMYT Director of the Integrated Development Program and Regional Representative for the Americas, presented the *Maize for Mexico* strategic plan —the first of its kind— which inspired the launch of Colombia's initiative. In addition, he presented a scenarios model developed by the CIAT team, where the most relevant variables affecting maize in Colombia are projected leading to 2030. The panorama towards 2030 gave way to the second part of the event, considering that the scenario projected for the coming years is neither desirable nor favorable for Colombia's maize sector. Hence, the following activity focused on identifying possible strategies that could change the course of things.

8.2 How to achieve a better future? Drivers of change

The second part of the keynote presentations consisted of six interventions by the Expert Panel. Each expert presented an overview of their area of expertise, linking drivers of change with opportunities for improvement of the current and future maize situation in Colombia, and quoting evidence of success cases.

Each expert presented the context and problems related to the topic they were assigned. In their interventions, alternative solutions were explored based on key actions identified in the aforementioned success cases. Also, implementation challenges to adopt actions supportive of a better future for the maize sector in Colombia were addressed.

The Expert Panel's presentations served as an introduction to the breakout discussions held in the last part of the Workshop. As follows, the order in which the experts presented their assigned topics:

8.3 Working tables

FIGURE 8.2 MAIZE FOR COLOMBIA'S EXPERT PANEL AND THEIR ASSIGNED DRIVER

Maize Expert Panel for Colombia	
Improved seed adoption	**DRIVER 1** **Carlos Galeano** *PhD Researcher* Roots and Tubers Network AGROSAVIA
Post-harvest and nutrition	**DRIVER 2** **Marilia Nutti** *Regional Director for Latin America and the Caribbean* HarvestPlus
Climate-smart agriculture	**DRIVER 3** **Julián Ramírez** *Climate Impact Scientist* International Center for Tropical Agriculture (CIAT)
Farm advisors innovation networks	**DRIVER 4** **Henry Vanegas** *General Manager* National Federation of Cereal and Legume Growers (FENALCE)
Linking competitive farmers to the market	**DRIVER 5** **Laura Pasculli** *Director* Chamber of Balanced Food Industry National Association of Entrepreneurs of Colombia (ANDI)
Infrastructure and rural development	**DRIVER 6** **Yadira Peña** *Researcher* Directorate of Efficient Use of Soil and Land Adequacy Agricultural Rural Planning Unit (UPRA)

Following the experts' presentations, facilitator Sophie Álvarez summarized the goals of the *Maize for Colombia* strategic plan, and highlighted the importance of the Expert Panel's interventions as an introduction to the two group activities developed to prompt discussion; this, in turn, aimed at triggering the design of effective actions to achieve a desirable 2030 maize scenario in Colombia.

The design of the activities detailed below was based on the "war room" methodology, which results from the intersection of four basic concepts: strategic thinking; language as action; ontological design as a generator of possibilities with broken value and responses; and systemic thinking. The methodology consists of a "physical or virtual space where powerful and effective actions are designed and assigned, shared by decision-makers and aligned with an adaptive strategy. The purpose of these actions is to sort out the moves of other stakeholders or overcome sudden changes in the environment, and to advance in the construction of political viability to a project of change[73]." In using this methodology, it was sought that conversations do not revolve around traditional processes, but rather look at innovative, high-impact possibilities for a renewed road map and for the yielding of expected results in the maize sector moving forward.

With this in mind, each table had the participation of one of the Panel's experts, who guided the discussion on the corresponding topic. In addition to the expert, tables had the support of a rapporteur —an employee of CIAT or CIMMYT— whose task was to fill out the formats, based on the discussions, as well as to document the most relevant topics dealt with in each group.

Attendees were assigned to the different tables ensuring that representatives from almost all sectors were included in each group. The distribution of topics by working group and experts in charge was as follows:

a. Activity 1: Intervention Strategies

TABLE 8.1 DISTRIBUTION OF BREAK-UP TABLES

No. Table	Theme of the table	Person in charge
1	Access to improved seed	Carlos Galeano
2	Post-harvest and nutrition	Marilia Nutti
3	Climate-smart agriculture	Julián Ramírez
4	Farm advisors support networks	Henry Vanegas
5	Linking competitive farmers to the market	Laura Pasculli
6	Infrastructure and rural development	Yadira Peña

In the first exercise, participants were asked to assume that each table was a group of advisors. The advisors would receive an intervention strategy proposal and, based on each table's specific theme, they were supposed to issue a recommendation on its potential application to the Ministry of Agriculture and Rural Development. Prior to the discussions, general context was given to all tables intending to inform their decisions. The general problems presented to the participants were the following:

Maize production increased 76% between 1961 and 2016, whereas the demand for it grew at

73 Diseño de Cuarto de Guerra, Luiz Raúl Mateos, The Graduate School of Political Management, The George Washington University, July 2014. Available at: http://andreselias.com/main/wp-content/uploads/2018/10/DISE%C3%91O-DE-UN-CUARTO-DE-GUERRA-LUIS-RA%C3%9AL-MATOS.pdf

a faster rate than production. In 2016 alone, 74% of domestic demand was imported. If this trend continues, production is expected to grow by around 6% and demand by 9% between 2018 and 2030. Despite this, Colombia has great potential to significantly increase maize production by stepping up productivity —the potential yield in many areas is 10 t/ha— and through the use of new available areas to plant maize, among other actions.

In addition to the general context given, specific context was given to each table in relation to the driver of change they had been previously assigned. The specific context triggered discussion with the purpose of determining actions and best strategies to change the course of things. The first task of each of the "advisory" tables was to validate, reject or improve the intervention, making recommendations guided by the following questions:

a. Expected outcomes Describe the expected results of the intervention strategy, such as "*increasing the capacities of X% of the target population*" or "*increasing yields by 10%*";
b. Who is leading the strategy? Identify the entity or entities that should advance the intervention strategy agenda in the short- and medium-term;
c. In what time frame can results be observed? *Indicate the time needed for the first activities of the intervention strategy to take place and within what timeframe results could be obtained;*
d. How is the budget for this strategy to be calculated? *Describe spending concepts and indicative amounts based on your experience;*
e. Where to start? *Indicate 3 key actions in the short-term*. Describe the main actions to be carried out during the first 6 months to 1 year of the intervention;
f. Indicate 3 risks faced by this strategy.

In each of the tables, the appointed expert was responsible for guiding the group's discussion and responding to participants' queries. The 2030 goals set out in the sheets discussed by each of the tables were predetermined based on the Expert Panel's advice. The objectives of each of the tables were as follows:

1. *Access to improved seed:* Improved seed adoption in 100% of the area operating under technified system, and at least 10% of the area under traditional system by 2030.
2. *Post-harvest and nutrition:* Achieve 50% of national human consumption of zinc-rich, biofortified white maize by 2030, and increase the grain storage logistics infrastructure by 100%.
3. *Climate-smart agriculture:* Conversion to sustainable agriculture adapted to climate variability and change in at least 100,000 hectares of maize cultivation by 2030.
4. *Farm advisors innovation networks:* Coverage of innovation networks as a standard of extensionism and technical assistance in at least 30% of the rural environment.
5. *Linking competitive farmers to the market:* Increase fair trade linkages for farmers from the local, regional, and national market.
6. *Infrastructure and rural development:* Increase maize production in highly vulnerable rural areas by at least 15% by 2030.

As follows, the results of each table:

DRIVER 1:
IMPROVED SEED ADOPTION

Background

The use of improved maize seeds allows crops to withstand high temperatures, droughts, pests, and other biotic stresses, and it also allows for higher nutritional content —particularly zinc and vitamin A. The average yield in Colombia is 3.6 t/ha, although 73% of the cultivated area has below average yields. Around 50% of the cultivated area operates under traditional systems, with an average yield of 2 t/ha. In that sense, a system of hybrid seeds and breeding programs would allow, both in traditional and technified systems, higher yields that increase adaptability across a variety of agroclimatic regions.

Goal of the Strategy leading to 2030

Improved seed adoption in 100% of area operating under technified systems, and in at least 10% of farms operating under traditional system.

Expected outcomes

- Adoption of technified system: 100% of farmers. Increase of 20% in the national average corresponding to the technified sector, to go from 5 to 6 tons.
- Adoption of traditional system: 10% of the traditional sector with 50% of improved or selected seed. Go from 2 to 3 tons by using improved varieties.

Who leads the strategy?

- Public-private partnership
- MADR and FENALCE
- Industry
- AGROSAVIA-CIMMYT
- Universities

In what time frame can results be observed?

- Signing of partnerships – 1 year.
- For the technified sector: (1) Generation of hybrids – genetically modified organisms (GMOs) – 6 months; (2) Adoption of first hybrids – GMOs – 5 years.
- For the traditional sector: (1) Generation of hybrids and conventional varieties – 1 year; (2) Adoption of conventional hybrids – 5 years.

How is the budget for this strategy to be calculated?

- Improvement programs.
- Linkage building strategies.
- Seed production.

Where to start? Indicate 3 key actions in the short-term

1. Improvement programs.
2. Linkage building strategies.
3. Seed production.
4. State policies favoring importation.
5. Market fluctuation.
6. Biotic and abiotic effects.

Indicate 3 risks faced by this strategy

7. State policies favoring importation.
8. Market fluctuation.
9. Biotic and abiotic effects.

DRIVER 2:
POST-HARVEST AND NUTRITION

Background

In Colombia, the demand for white maize is mainly for human consumption. Annual consumption per capita is 30 kg. Zinc deficiency among Colombians is a problem that affects 22% of the population, while in some departments it exceeds 60%. The dissemination of white maize —both synthetic and hybrid— with high zinc content is being promoted as a strategy to contribute to the solution of hidden hunger in priority areas of Colombia. Likewise, in order to bring this maize to the processing and consumption centers, it is necessary to generate infrastructure that provides the necessary conditions.

Goal of the 2030 Strategy

Achieve a national human consumption of 50% of biofortified white maize with high zinc content by 2030 and increase the logistics infrastructure for grain storage by 100%.

Expected outcomes

- 80% of the Colombian population is aware of the benefits of zinc-rich foods.
- 50% increased of zinc-biofortified maize seed production.
- 50% of the demand for zine-rich white maize used in food production.
- 50% of medium farmers unionized by production area.
- 50% of collection centers linked to the production area and industry.
- 80% of extension services established for grain storage.

Who leads the strategy?

- Ministry of Health and Ministry of Agriculture (national and department level) with support from institutions.
- FENALCE and industry, among others.

In what time frame can results be observed?

- Seed production: results in 4 years.
- Grain consumption and demand: from the 8th year onwards.
- Aggregation and collection centers: from the 5th year onwards.
- Extension services: from the 2nd year onwards.

How is the budget for this strategy to be calculated?

(No record by the rapporteur)

Where to start? Indicate 3 key actions in the short-term

1. Collaborate with the food industry.
2. Collaborate with the seed companies.
3. Consumer marketing.
4. Mapping of critical zones for infrastructure implementation.
5. Capacity building and extension of storage technologies.
6. Expansion of the scope of regulatory bodies.

Indicate 3 risks faced by this strategy

1.a. Traceability (Chain of Custody).

1.b. Availability of grain to meet demand.

1.c. Price competitiveness.

2.a. Non-compliance with good storage practices.

2.b. Decoupling from the market.

2.c. Competitiveness of prices and transport infrastructure.

.

DRIVER 3:
CLIMATE-SMART AGRICULTURE

Background

Climate change projections indicate that by 2030 there will be a general increase in temperature throughout the country (with greater intensity in the south). In addition, they show an increase in annual precipitation rates, mainly in the central and eastern regions, and a reduction in the Caribbean and Amazon regions. Maize production, and especially that at small scale, suffers from high yield gaps and is highly sensitive to climatic variability. On average, yield gaps are estimated at 2 t/ha, with some areas reaching up to 4-5 t/ha. The impacts of climate variability are estimated at 168 billion pesos annually. Therefore, in the absence of adaptation and mitigation, major challenges are expected for the Colombian maize sector in the face of climate change. Among the most important impacts are reductions in areas harvested and suitable for growing maize, and decreases in productivity. These impacts can only be addressed through the development of climate-smart systems that include climate-smart seed programs, climate information systems, irrigation technology, and best practices in conservation agriculture.

Goal of the 2030 Strategy

Conversion to sustainable agriculture adapted to variability and climate change on at least 100,000 hectares of land cultivated with maize in 2030.

Expected outcomes

- A 6.5 t/ha increase in the average yield of plots that adopt climate-smart agriculture technologies, including conservation agriculture and climate risk reduction.
- Develop climate-smart maize production systems in 100% of the area under technified systems.
- Increase the efficient use of nitrogen fertilizers, measured in tons of grain produced per unit of nitrogen applied, by at least 30%.
- Install central machinery in at least 30% of the technified area.

Who leads the strategy?

- CIAT
- FENALCE
- AGROSAVIA
- Others: guilds, public universities, and advisors
- Ministry of Health and Ministry of Agriculture (national and department level) with support of institutions
- FENALCE and industry, among others

In what time frame can results be observed?

- Research: 6-8 years.
- Extension: 2 years.
- Policies: 5 years.

How is the budget for this strategy to be calculated?

(No record by the rapporteur)

Where to start? Indicate 3 key actions in the short-term

1. Collect information developed in research and carry out a socioeconomic study.
2. Identify areas and technologies to work with and make a diagnosis.
3. Adoption of materials and platforms such as Aclímate Colombia-Pronosticos.
4. Link leaders by sector.
5. Socialize the extension policy.

Indicate 3 risks faced by this strategy

1. Market (imports).
2. Lack of interest from the State.
3. Policy implementation.
4. Competitive clash in research with the development of transgenics.

DRIVER 4:
FARM ADVISORS INNOVATION NETWORKS

Background

Extensionism is a practice in which professionals from the agricultural sector —called extensionists— promote and favor the transfer of knowledge and productive processes for rural development. The creation of extensionist networks enables regions to increase their capacities and learn to use cutting-edge techniques for their crops. Through interactions, extensionism improves the level of innovation and generates higher yields as opposed to networks that simply establish links among farmers. An example of extensionism and efficiency in the adoption of technology are the 427 thousand hectares of maize planted in coffee-producing areas between 2003 and 2011, for which the National Federation of Coffee Growers (FNC), FENALCE, and CIMMYT joined forces.

Goal of the 2030 Strategy

Coverage of innovation networks as a standard of extensionism and technical assistance in at least 30% of the rural environment.

Expected outcomes

- Regulation of Law 1876 of 2017: a law that obliges all entities implementing actions in the field to collaborate.
- Implement technological platforms and systematize contents developed by institutions so that they reach extensionists and support the optimization of technology transfer.

Who leads the strategy?

- The rural extension of Colombia guided by the leading guild in the maize sector
- Research associations for the development and marketing of products
- Universities

In what time frame can results be observed?

(No record by the rapporteur)

How is the budget for this strategy to be calculated?

(No record by the rapporteur)

Where to start? Indicate 3 key actions in the short-term

1. Identifying and categorizing active farmer associations by region would be an appropriate strategy.
2. The Local Innovative Farmer (PILO) technology transfer strategy, addressed to farmers constantly seeking to improve their crop and their farming by means of appropriate technologies.
3. Complement with training in information gathering, storage, and dissemination to strengthen the work of the extensionist.

Indicate 3 risks faced by this strategy

1. Implementation of the law with a territorial approach
2. Resource management

DRIVER 5:
LINKING COMPETITIVE FARMERS TO THE MARKET

Background

Maize imports into Colombia have increased rapidly as a result of rising domestic demand. As to yellow maize, in 2016, consumption amounted to 5.3 Mt, which was covered in 81% with imports mainly from the United States (U.S.), Argentina, and Brazil. With the Colombia-U.S. Free Trade Agreement signed in 2006 and implemented in 2012, a maize import of 3.4 Mt is expected by 2022 at a tariff of 2.1%. From 2023, the tariff will be eliminated. Therefore, it is necessary to increase the profitability of maize cultivation in Colombia in order to make it sufficient and competitive, while encouraging the development of markets at national, regional, and local levels.

Goal of the 2030 Strategy

Increase fair trade linkages for farmers from the local, regional, and national market.

Expected outcomes

- Creation of a sustainable local maize market for all parties involved.

Who leads the strategy?

- Independent entity that brings together private sector, government representatives, industry, farmers, and researchers, and is initially led by CIMMYT.

what time frame can results be observed?

- 4 years.

How is the budget for this strategy to be calculated?

- Insurance.
- Credit.

Where to start? Indicate 3 key actions in the short-term

1. Contract farming development model.
2. Land usufruct guarantee.
3. Works for taxes.

Indicate 3 risks faced by this strategy

1. Legal protection.
2. Resistance to change.
3. No business sustainability.
4. Guarantee of compliance.

DRIVER 6:
INFRASTRUCTURE AND RURAL DEVELOPMENT

Background

The current situation of Colombia, in the face of the Peace Agreements offers the opportunity to serve 344 prioritized municipalities where maize cultivation plays an important role in the production system, together with other cereals, cocoa or coffee. The main solutions proposed, as part of the Comprehensive Rural Reform of the Peace Agreements, contemplate a structural transformation of agricultural production, land use, infrastructure, as well as the substitution of illicit crops. The challenge the country faces is, on the one hand, to develop actions and strategies for the implementation of these changes to boost sustainable agricultural productivity; on the other hand, develop communications and transportation infrastructure; and increase storage capacity, among others, to connect maize producing areas with regional and national markets.

Goal of the Strategy leading to 2030

Increase maize production in highly vulnerable rural areas by at least 15% of the identified area by 2030.

Expected outcomes

- Production for self-consumption and food security.
- Generation of local processed products to add value and close the gap to the market.

Who leads the strategy?

- Regional entities.
- Ministry of Agriculture through municipal secretariats

In what time frame can results be observed?

- Activities are expected to take place within 10-12 years.

How is the budget for this strategy to be calculated?

- Development of road infrastructure and storage.
- Consumables – training and extension.
- Post-harvest and processing infrastructure.
- Intermediation and marketing costs.

Where to start? Indicate 3 key actions in the short-term

1. Technology transfer.
2. Agricultural and post-harvest technical assistance.
3. Technical assistance for livestock and pigs.
4. Identify the advantages of infrastructure with passable roads, for the areas furthest away from centers of consumption and collection.
5. Improve the presence of control entities.

Indicate 3 risks faced by this strategy

1. Lack of confidence in farmers to adopt the crop and government policies.
2. Market uncertainty. How to replace a crop as highly profitable as illicit crops.
3. Lack of viability markets/marketing – access to markets. Incorrect crop competitiveness analysis for international markets.

b. Activity 2: Shock scenario. What to do in a crisis situation?

The objective of the second activity was to design possible sectoral responses in the event of a shock scenario. In the same way as the first exercise, this activity was based on the war room methodology, through the simulation of a potential disruptive event that could impact the production of national maize. The aim was to surprise the participants and give a twist to the discussions held up to that moment.

The shock scenario presented was as follows:

> Within the framework of the Peace Agreements, one of the core areas is rural development. The goal is to improve the conditions of rural inhabitants affected by the armed conflict, by means of large-scale initiatives for the reconstruction of their communities and the increase of the country's agricultural competitiveness and productivity. We must remember that the National Government estimated that the cost of implementing the Peace Agreements over the next 15 years would be $129.5 billion. Of this figure, a total of $110 billion will have to be invested in a comprehensive rural reform.
>
> The government of Ivan Duque has announced a series of actions to promote the comprehensive development of the country and, in particular, that of the agricultural sector. The World Bank has offered to support the new government with a loan of $2 billion pesos per year for the next 3 years within the framework of the Peace Agreements for rural development. Of that budget, $1 billion pesos (50%) per year has been earmarked for the implementation of actions focused on maize cultivation, in particular for field modernization strategies, that encourage productivity through the appropriation of new technologies and innovations.
>
> President Duque's cabinet has asked his advisors for their recommendation to accept the bank's offer and prepare a proposal identifying priority actions that the World Bank's budget could focus on.
>
> Possible priority action options:
>
> A. Improved seed and breeding program
> B. Investment program in precision agriculture and irrigation technology
> C. Systematization of an extensionist network at the national level
> D. Program to link farmers to regional and national markets
> E. Seed biofortification program for maize cultivation

Faced with this situation, the president of Colombia has 24 hours to respond to the request of the Presidency on whether the government should accept the contribution of the World Bank. If that is the case, how and with what priority should the budget be allocated to the proposed actions?

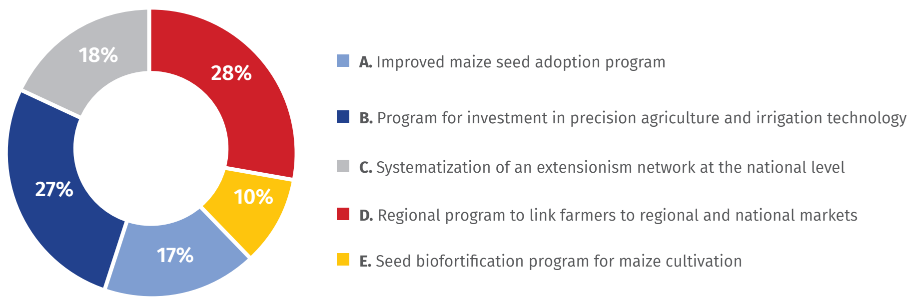
An Excel file was given to each table to answer the request.

TABLE 8.2 DISTRIBUTION OF PROPOSED BUDGET BY TABLE

Priority Areas	Budget
A. Improved maize seed adoption program	$
B. Program for investment in precision agriculture and irrigation technology	$
C. Systematization of an extensionist network at the national level	$
D. Program to link farmers to regional and national markets	$
E. Seed biofortification program for maize cultivation	$
TOTAL	$1,000,000,000,000 Colombian pesos

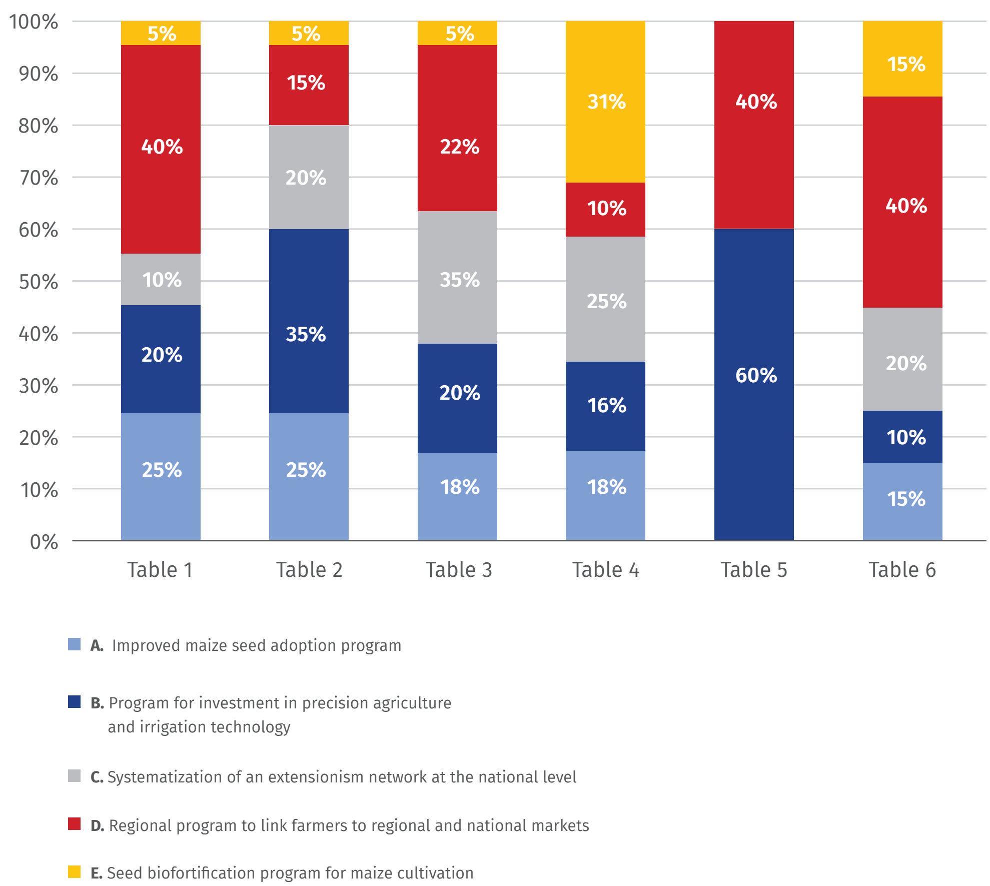
Once the content of the budget distribution tables was obtained and analyzed, the results were made known to all attendees to the Workshop. In aggregate terms, the item with the largest budget was the regional program for linking farmers to regional and national markets, with 28%, followed by the program for investment in precision agriculture and irrigation technology, with 27%.

Graph 8.1 shows the percentage distribution (aggregated of all tables) of the World Bank's offering for each of the items:



GRAPH 8.1 BUDGET ALLOCATION PERCENTAGES TO PRIORITY ACTIONS BY FIELD.

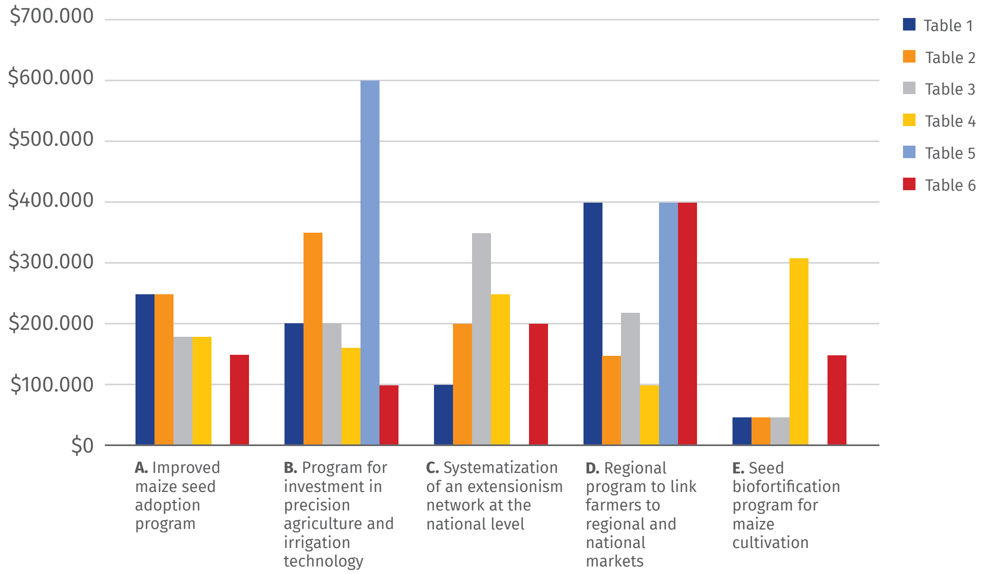
It should be noted that, although the budget distribution table was the same for all working groups, the budget allocation established by each of them was highly dissimilar: tables 3 and 4 were the only ones to allocate budget for providing additional income to mitigate an increase in price. Table 6 earmarked most of the budget for the systematization of an extensionist network at the national level. Tables 1 and 7 behaved similarly, distributing the budget among all options (with the exception of item A, Additional income to mitigate an increase in price). Finally, tables 2 and 5 allocated budgets to only three options in equal proportions. The following graphs show the budget distribution by table.



GRAPH 8.2 BUDGET ALLOCATION PERCENTAGES TO PRIORITY ACTIONS BY SECTOR

As mentioned in the aggregate, the strategy with the largest budget allocated was the regional program for linking farmers to regional and national markets, followed by the program for investment in precision agriculture and irrigation technology. Thirdly, the systematization of an extensionist network at the national level. However, from Graph 8.3, it becomes clear that preferences were different in each table. Such is the case of table 5, which worked on the issue of infrastructure and rural development and, although it allocated 60% of its budget to the systematization of an extension network at the national level, it earmarked the remaining 40% to the seed biofortification program for maize cultivation. Meanwhile, table 3 on climate change, for example, underlined the importance of an extensionism program

GRAPH 8.3 ALLOCATION OF BUDGET FOR PRIORITY ACTONS BY TABLE (BILLION COP)



Scenarios Workshop Survey

As part of the Workshop activities, participants were asked to complete the survey referred to in Figure 8.3, to identify the main risks in the agrifood sector associated with the increase of maize production in Colombia. Firstly, the survey revealed that 44% of the Workshop attendees were representatives of the research sector, 39% of the private sector, and 6% of the public sector.

FIGURE 8.3 RISK SURVEY APPLIED TO THE PARTICIPANTS IN THE SCENARIOS WORKSHOP

MAIZE FOR COLOMBIA 2030 Vision

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Phone: +57 2 4450000
Ext: 3025
E-mail: CIMMYT-Maize-for-Colombia@cgiar.org

SURVEY ON THE MAIN RISKS BY 2030

The answers will be used to show the overall results at the end of the workshop.

Goal: Identify the main risks for maize in Colombia

1. Mark with a cross the sector you represent:

- Agricultural farmers
- Livestock farmers
- Financial sector
- Consumable suppliers
- Public sector associations
- Government
- Research
- Other, specify: ______________________

2. Identify the 5 most significant risks that you believe the maize sector will face in 2030, numbering them from 1 to 5. Please, use number 1 for the highest risk and 5 for the lowest among the options chosen.

- Market: instability, price uncertainty, volatility in the face of growing demand
- Lack of inclusion, non-alignment with the demands of the sector
- Lack of long-term vision (training of decision-makers)
- Public expenditure inefficiency: large % of public budget implemented with no clear objectives or poorly invested
- Lack of access to knowledge: capacity building and human capital (specialists, capable technicians, researchers)
- Pests and diseases in crops
- Land depletion, soil degradation
- Climate change: temperature change
- Water Scarcity
- Development of specific markets: product specialization
- High or low consumable costs (social and economic instability)
- Monopolization of the market
- Demographic pressure: growing demand exceeding production capacity
- Security and organized crime
- Generational handover
- Resistance to change, lack of adaptability (at all levels, institutional, technical, farmer, etc.)

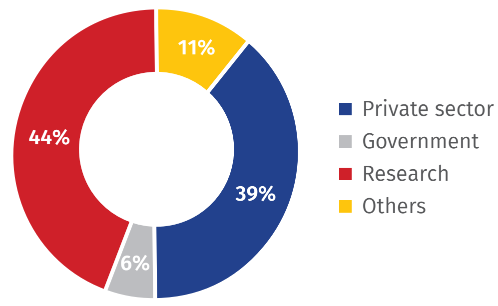
3. Identify the 3 institutions or actors that you believe have the greatest capacity to successfully face or mitigate these risks, numbering them from 1 to 3. Please, write number 1 for the highest risk and 3 for the lowest among the options chosen.

- Ministry of Agriculture
- Federal Government
- State Governments
- Associations of companies and farmers in the agrifood sector
- General Civil Society
- Universities and research centers
- Army
- Multilateral institutions (United Nations, World Bank, etc.)

CIAT International Center for Tropical Agriculture
Since 1967 *Science to cultivate change*

CIMMYT International Maize and Wheat Improvement Center

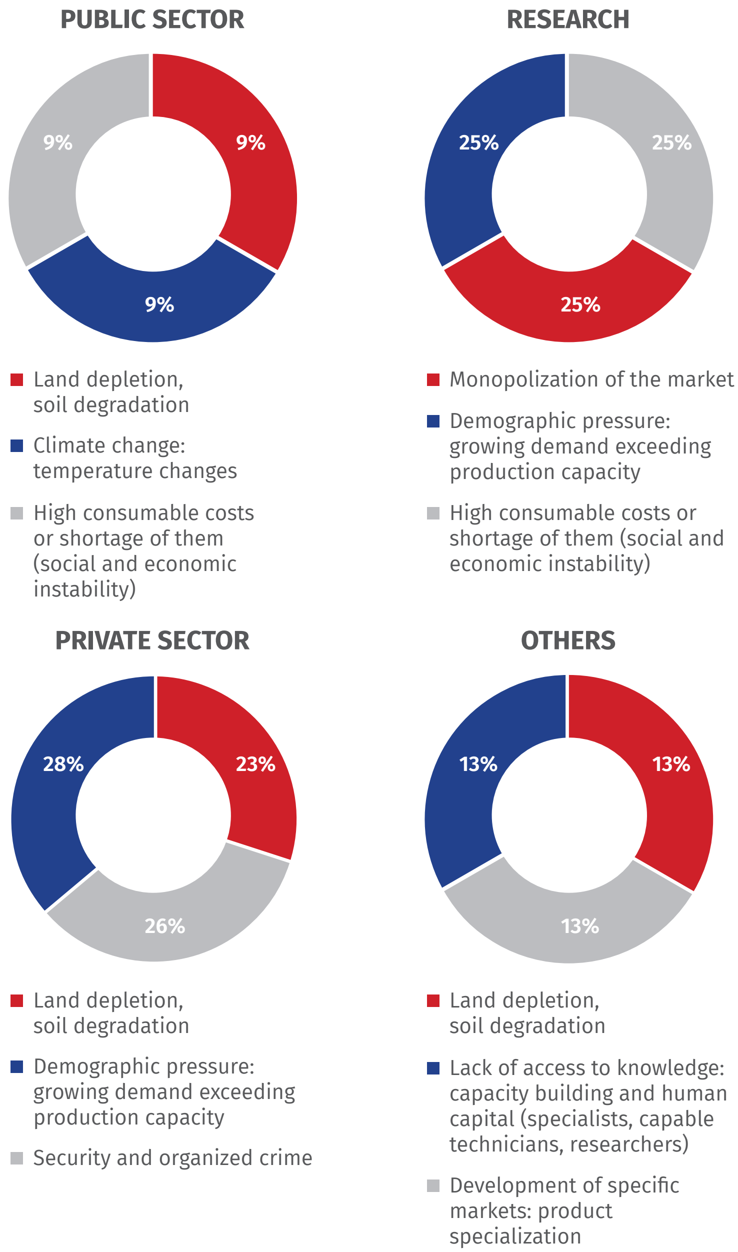
GRAPH 8.4 WORKSHOP PARTICIPANTS PER SECTOR



The results of the risk survey yielded a score per participant related to the 5 most significant risks based on their perspective of the sector. Each participant rated the most important risk number 1, and 5 for the lowest risk. The risks were assessed as shown in Table 8.5, the main ones identified being (1) lack of long-term vision in the government or among decision-makers; (2) by tied vote, the conditions of a volatile market: instability, price uncertainty, volatility in the face of growing demand; and (3) inefficiency in the use of public spending, that is, a significant budget percentage allocated without a clear objective or simply badly invested. However, the risk of market uncertainty was selected by the largest number of people attending the Workshop.

TABLE 8.3 TOP 10 IDENTIFIED RISKS FOR MAIZE PRODUCTION IN COLOMBIA

Ranking	Risks / Threats	Topic	Total points	Total number of people who included it in their Top 5
1	Lack of long-term vision (training of decision-makers)	Capacities	13	24
2	Market: instability, price uncertainty, volatility in the face of growing demand	Markets	10	28
3	Public expenditure inefficiency: large % of public budget implemented with no clear objectives or poorly invested.	Public policies	10	12
4	Climate change: temperature change	Environment	8	21
5	Lack of inclusion, non-alignment with the demands of the sector	Markets	5	11
6	Lack of access to knowledge: development of capacities and human capital (specialists, capable technicians, researchers)	Capacities	5	13
7	High or low consumable costs (social and economic instability)	Markets	3	9
8	Generational handover	Socioeconomic and cultural	2	11
9	Resistance to change, lack of adaptability (at all levels, institutional, technical, farmer, etc.)	Capacities	2	15
10	Pests and diseases in crops	Environment	1	6



GRAPH 8.5 TOP 3 RISKS PER SECTOR

On the other hand, if we analyze the risks selected by the participants according to the sector to which they belong, we can also see that the public sector attributed the risks of maize production in Colombia to land depletion and soil degradation, climate change and social and economic instability. In turn, the private sector considers that the greatest risks by 2030 will be demographic pressure in the face of a growing demand that exceeds production, as well as security and organized crime in the country.

TABLE 8.4 SCORE OF 16 RISKS BY CATEGORY

Topic	Total points	Percentage of total (%)
Capacities	20	33%
Markets	19	32%
Public policies	10	17%
Environment	9	15%
Socioeconomic and cultural	2	3%

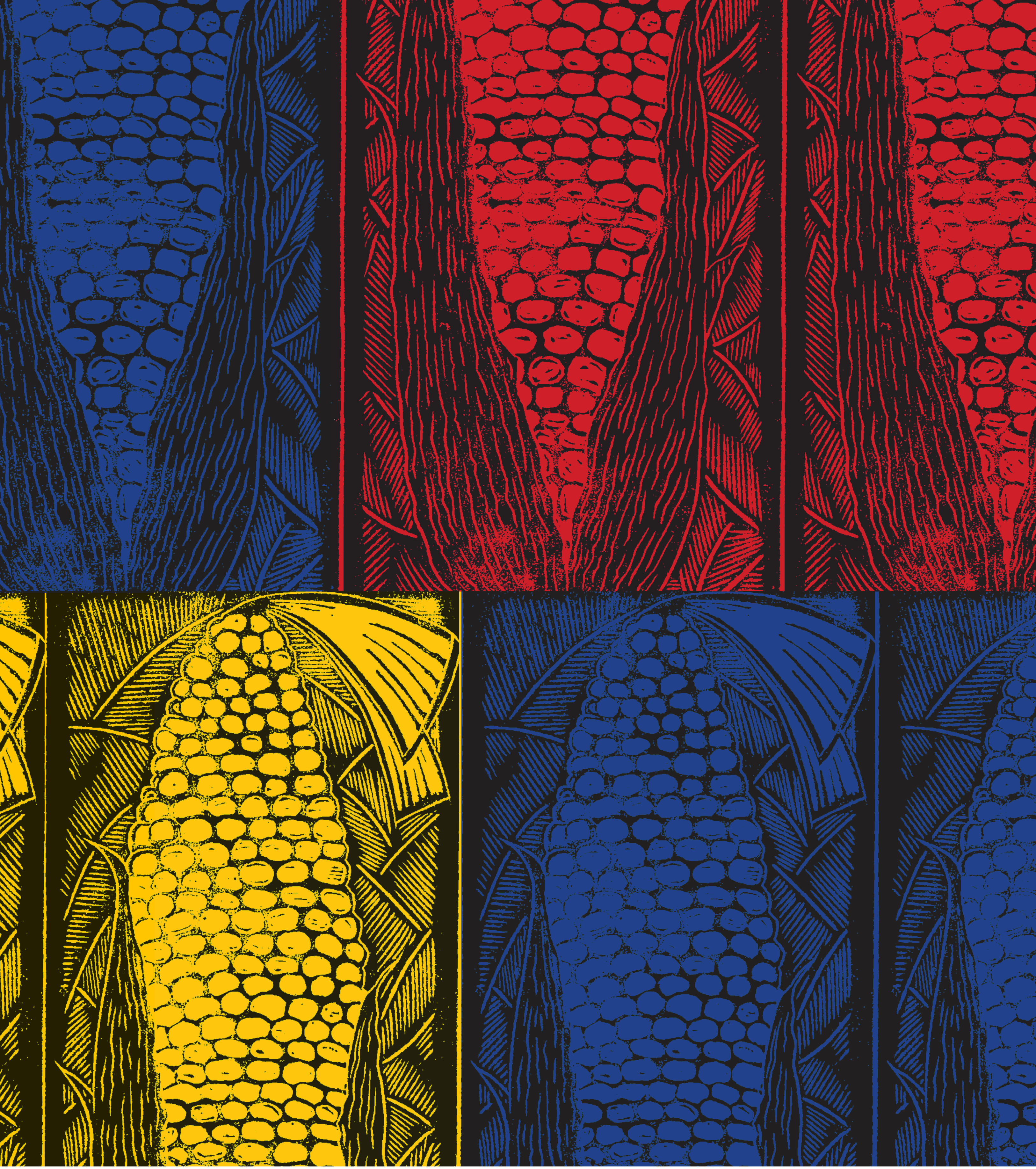
Once the risks by sector and thematic category were identified, an analysis was run to identify stakeholders responsible to mitigate risks moving forward, focusing on existing capacities and markets. This exercise yielded a total score of 65%. From this analysis, boosting maize production was identified as a responsibility of the Ministry of Agriculture of Colombia by 36% of the participants, as well as a duty of the National Government by 25% of them —which accounts for 61% of the attendees to the 2030 Scenarios Workshop.

GRAPH 8.6 WHO SHOULD MITIGATE THE RISK?

Participants list- Scenarios Workshop

No.	Name	Organization	Position
1	Leonardo Alberto Ariza	Colombian Association of Seeds and Biotechnology	General Manager
2	Magda Liliana Murcia	Colombian Association of Seeds and Biotechnology	Technical Director
3	José Jaime Tapia	AGROSAVIA	Master Researcher
4	Julio Ramírez Durán	AGROSAVIA	Head of Seed Department
5	Luis Fernando Chávez	AGROSAVIA	PhD Researcher
6	Manuel Alejandro Guzmán	AGROSAVIA	PhD Researcher
7	Sergio Mejía	AGROSAVIA	PhD Researcher
8	Juan Lucas Restrepo	AGROSAVIA	Executive Director
9	Carlos Galeano	AGROSAVIA	Researcher
10	Eduardo Graterol	Latin American Fund for Irrigated Rice (FLAR)	Executive Director
11	Helder Yecit Girón	Colombian Agricultural Institute (ICA)	Manager (E)
12	Miguel Lengua Linares	Maxi Semillas SAS	Manager
13	José Joaquín Marulanda	Semillas Valle SA	Research Manager
14	Ever Andrés Vargas	National University of Colombia	Plant Breeder
15	Carolina González	HarvestPlus	Deputy Director HarvestPlus LAC
16	Luz Adriana Jiménez	HarvestPlus	Market Analyst
17	Meike Andersson	HarvestPlus	Product Development Specialist
18	Deissy Martínez Barón	CIAT	Regional Coordinator for Latin America
19	Wietske Kropff	CIAT	Coordinator - Digital Agriculture
20	Javier Crespo	Agrarian Bank of Colombia	Union Coordinator
21	Napoleón Viveros	Casa Toro	Manager
22	Carolina Navarrete	CIAT	Regional Director for Latin America and the Caribbean
23	Yadira Peña	Agricultural Rural Planning Unit (UPRA)	Specialized Professional
24	Javier Mateo-Vega	CIAT	Director, Partnerships and Communications
25	Henry Eduardo Vargas	FENALCE	Director, Department of Economic Research
26	Henry Vanegas	FENALCE	General Manager
27	José Ever Vargas Sánchez	FENALCE	Plant Breeder
28	Marilia Nutti	HarvestPLus	Regional Director for Latin America and the Caribbean
29	Jeimar Tapasco	CIAT	Senior Agricultural Economist
30	Steve Prager	CIAT	Senior Scientist
31	Daniel Jiménez	CIAT	Data Scientist
32	Natalia Palacios	CIMMYT	Nutrition Specialist
33	Anna Camila Nader	Semillas Valle SA	Plant Breeder
34	Julio González	CONTEGRAL	International Business Manager
35	Ricardo Mejía	CONTEGRAL	Agriculture Manager
36	Yeiro Muñoz	Alimentos Polar	Logistics Manager
37	Elizabeth Castañeda	Alimentos Polar	Technical Manager
38	Juan Pablo Estrada	PorkColombia Asoporcicultores	Raw Material Advisor
39	Clara Esperanza León	AGROSAVIA	Innovation Agent Transitory Crop Network and Agribusiness
40	Eduardo Barragán	AGROSAVIA	PhD Researcher
41	Heriberto Guerrero	Semillas Guerrero Asociados	Manager
42	Augusto Castro	CIAT	Researcher
43	Juan Guillermo Jaramillo	Solla S.A.	Vice President Purchasing and Logistics
44	Ana Jael Villa	Solla S.A.	
45	Laura Pasculli	ANDI	Director of the Balanced Food Industry Chamber
46	Carlos Madrid	Corteva Agriscience	Regional manager of government and industrial affairs
47	Luis Narro	CIMMYT	Scientific Consultant CIMMYT - Colombia
48	Wilson Celemín	CIAT	Administrative Analyst
49	Bram Govaerts	CIMMYT	Director of the Integrated Development Program and Regional Representative for the Americas


LINEA 2
2.28 ton/ha
CIMMYT
Rendimiento potencial de maíz
Genética
Ambiente
50 %
50 %
Semilla
(Variedad, Híbrido)
Densidad de Siembra
Fertilización
Control de Plagas
Sistema de Cultivo
MAÍZ PARA COLOMBIA
Cadena de valor
Políticas
CIMMYT



CIAT
International Center for Tropical Agriculture
Since 1967 Science to cultivate change

CIMMYT[MR]
International Maize and Wheat Improvement Center