"SEASONAL DROUGHT OUTLOOK STRATEGIES FOR APPROPRIATE AND TIMELY DECISION-MAKING IN AGRICULTURE AND WATER RESOURCES"

Proyecto Piloto
Alertas Tempranas
por Sequía en Colombia

Photograph UNGRD – Alta Guajira

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Unidad Nacional para la Gestión del Riesgo de Desastres - Colombia
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GOBIERNO DE COLOMBIA

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ACRONYMS AND ABBREVIATIONS

UNGRD: National Unit for Disaster Risk Management
SNGRD: National System for Disaster Risk Management
GRD: Disaster Risk Management
UNCCD: United Nations Convention to Combat Desertification and Drought.
IDEAM: Hydrology, Meteorology and Environmental Studies Institute
DIMAR: Maritime General Directorate.
IGAC: Agustín Codazzi Geographical Institute
SGC: Colombian Geological Survey
DNP: National Planning Department.
INS: National Health Institute
MADR: Ministry of Agriculture and Rural Development
MADS: Ministry of the Environment and Sustainable Development.
MINVIVIENDA: Ministry of Housing, City and Territory
MINMINAS: Ministry of Mines and Energy
SIATA: Valle de Aburrá Early Alert System
IDIGER: District Institute for Risk Management and Climate Change
CCO: Colombian Ocean Commission
ERFEN: Regional Study of the El Niño Phenomenon
CIIFEN: International Research Center on El Niño Phenomenon.
WMO: World Meteorological Organization
UNISDR: United Nations International Strategy for Disaster Reduction
IRI: International Research Institute for Climate and Society
NOAA: National Oceanic and Atmospheric Administration of the United States
CAR: Regional Autonomous Corporation of Cundinamarca
CENICAFÉ: National Research Center on Coffee
CENICAÑA: Colombian Sugar Cane Research Center
CHEC: Caldas Hydroelectric Power Plant
CORPOCHIVOR Regional Autonomous Corporation of Chivor
CORPOGUAJIRA: Regional Autonomous Corporation of La Guajira
CORPOICA Colombian Agriculture Research Corporation
CORPONOR: Regional Autonomous Corporation of the Northeastern Border
CVC: Regional Autonomous Corporation of Valle del Cauca
EAB: Bogotá Aqueduct Company
EMPOPASTO: Water Works Company of Pasto
EPM: Public Companies of Medellín
FEDEARROZ: National Rice Growers Federation
INVEMAR: Marine Research Institute
PNNC: National Natural Parks of Colombia

PRESENTATION

Through the UNGRD and during past the 6 years, we have managed to change the circumstances of how the resources were distributed, based on the determinations that arose from the new National Policy on Disaster Risk Management, as well as the will of the National Government to transversalize risk management in development policies and plans. We went from concentrating disaster management resources (over 90% in the last decade) to prioritizing disaster risk reduction (currently over 60%).

This big leap has allowed to partly correct old debts that we had left as a Country in many territories, where the recurrence of threats repeated over and over, limiting the total fulfillment of the development plans without being able to advance in other fronts necessary to obtain safe territories, whose aim has always been directed at sustainable development and economic growth. There is still a long way to go with conviction that the trend should be kept during the following years, to have a less vulnerable country with a stronger resilience capacity to face disasters.

If in the past years we have had the opportunity to work on risk reduction, the next decade will be the opportunity for knowledge, visualizing it as a cross-cutting and essential strategy to build the solid foundations of our future as a country and not as a purely academic and a scientists' matter.

We faced this challenge in the National Disaster Risk Management Plan 2015-2025, and in accordance to this, we established that "improving on the knowledge of disaster risk in the country" should not only be the first of five strategic objectives, rather it should be materialized through various strategies which form the basis for decision-making on safe investments, incorporation of sustainability criteria in development planning, land use planning and environmental planning processes.

Climate-sensitive sectors, and specifically those that are affected in one way or another by water deficit, have become aware of the need to adequately share, manage and process the broad flow of information in a comprehensive and interdisciplinary fashion that allows them to reduce the risks of drought effects that have caused so many socioeconomic losses.

This research and technical effort is based on an initiative of a document prepared by the UNGRD and the Ministry of Foreign Affairs where the needs of Colombia were raised based on the discussions generated in the ERFEN Committee, on the follow-up and monitoring of the El Niño phenomenon and the need to strengthen communication between all entities involved, from an "Early Warning Pilot Project for Drought in Colombia", with the aim of promoting, among all sectors, the construction of Seasonal Drought Outlook Strategies for Colombia" as a mechanism of institutional action in the country for decision-makers. This project was accepted by the Secretariat of the of the United Nations Convention to Combat Desertification and Drought – UNCCD and a memorandum of understanding was signed with the National Risk Disaster Management Fund of the Republic of Colombia

This task was undertaken with the conviction of providing useful information to the society, allowing for risk reduction, facilitating disaster management and the implementation of development plans. This document is one of the outputs with a multidisciplinary, interdisciplinary, participatory, and open approach, developed for sustainable development from the interpretation of the contributions made by the experts who participated in the working groups.

I appreciate the support offered by the Secretariat of the United Nations Convention to Combat Desertification - UNCCD for the trust placed in the professionals that lead this project.

I want to thank the group of professionals from the Ministry of Agriculture and Rural Development, Ministry of the Environment and Sustainable Development; Ministry of Housing, City and Territory; Ministry of Mines and Energy, IDEAM, DIMAR, SGC, IGAC, CORPOGUAJIRA, UPME, DNP, EPM, ISAGEN, CIAT, CORPOICA, CAR, FEDEARROZ, FENALCE, FAO, FINAGRO, ECOSAGA, ASOHOFRUCOL, the Superintendent of Public Services, for their inputs and contributions, who with their expertise and lessons learned from the point of view of affectation in their sectors, made the necessary recommendations on the weaknesses and possible solutions to consolidate recommendations for an Early Warning System for Drought in Colombia, which have resulted in this document.

CARLOS IVÁN MÁRQUEZ PÉREZ
Managing Director

INTRODUCTION

Climate prediction in Colombia is gaining importance day by day. Tt allows previously establishing the possible influence of climate variability (intraseasonal, interannual and interdecadal), on the conditions that appear normally in Colombia in their rainy and less rainy seasons.

Lessons learned from the events of the El Niño Southern Oscillation (ENSO), in its heating or cooling phases (El Niño-La Niña, respectively), have shown us the path to follow to carry out studies and research on the influence of these phenomena in Colombia. While "El Niño" brings a reduction in rainfall especially in the Caribbean, Andean, and Pacific regions, "La Niña" results in an increase in rainfall.

When we refer to a seasonal drought outlook for appropriate and timely decision-making in agriculture and water resources, several questions arise. Perhaps the most important one is how to use this information in each user's area of interest and how it can reduce the risk of occurrence of this event when applied.

The latter are the reasons why this document is focused on drought, emphasizing on how the decrease of rainfall associated with the El Niño phenomenon influences the different productive sectors, as well as the health and water sector among others. Strategies that optimize and strengthen seasonal climatic forecasting are hereby propose, integrating information and products from national and international bodies as part of the Drought Warning System process.

Fortunately there is more access to information nowadays, with statistical and dynamic climate models from national, regional and global climate centers that have been adjusted to Colombia's conditions and parameterizations for a better performance.

However, understanding and differentiating climate variability events and climate change are still a major challenge for the country. Beyond the fact that there has been an attempt to establish a certain relationship between El Niño phenomenon and climate change, it must be understood that first of them has a frequency of between 2 and 7 years approximately, which in a way makes it predictable in the long term, whereas climate change allows demonstrating trends in change of the different climate variables with analysis of series of records of over 30 years. Nevertheless, if we consider that climate prediction is associated to periods of a month, three months and six months, we must focus on how to improve these forecasts from the group work carried out in the workshops that were part of the Project on "Early Warning System by Drought-EWS in Colombia", whose results are the base of the strategies that will be set out in this document.

Information is included here on the international efforts made through the World Meteorological Organization-WMO, which supports the Regional Climate Centers - CRC, the climate forums and the CIIFEN[1], which also coordinates this region's climate forums, integrates regional forecasts of Bolivia, Peru, Ecuador, Colombia, Venezuela and Chile.

[1] International Research Center on El Niño Phenomenon.

1. CONCEPTUAL FRAMEWORK

Photograph UNGRD – Alta Guajira

1. SEASONAL DROUGHT OUTLOOK

1.1. The way drought affects the country´s agriculture and water resources

The change in the rainfall pattern in different parts of the country has led to a noticeable decrease in water supply with important implications on farm productivity. Although sometimes water requirements for a particular crop are minimally met, as a consequence, yields are usually quite low, with significant socioeconomic consequences.

Historically, our country has been recognized as on of the areas with the greatest water wealth. Indeed the National Study on Water (ENA) carried out by IDEAM shows an important offer of this resource in the national territory. It concludes, in its latest version, that Colombia has an average water yield that is equivalent to 6 times the global average and 3 times that of Latin America. However, the largest amount of water is concentrated in areas in the Amazon and the Pacific region, with the Andean and Caribbean regions (being the most densely populated) without the water supply required to meet the needs for human consumption, nor to satisfy the requirements of living beings and of the different productive sectors. It is estimated that the Magdalena-Cauca and Caribbean hydrographic areas, where 80% of the national population is located and 80% of the National GDP is produced, only have 21% of the total surface water supply.

Given this condition, it becomes necessary and paramount for the country's agricultural activity to plan and organize the territory based on an efficient use of the water resource. To do this, it is important to encourage irrigation practices that can be available not only to the large agricultural producers, but also to provide tools for small producers to access technology that allows a better exploitation of water resources, seeking to optimize its use. There, the support of regional authorities and environmental and sectoral organizations that contribute to the best methods of irrigation, according to a rational expenditure of water and important outcomes at the level of production, will be preponderant.

1.1.1. Agricultural Sector

It is well-known that when a crop fails to obtain minimum moisture levels it does not meet the needs and requirements for its normal production, reaching the limit of drought.

According to the ENA, the sector with greatest water demand is agriculture with 46.6%, followed by the energy sector with 21.5%, livestock with 8.5% and the domestic sector with 8.2%, which demonstrates the great dependency that agriculture has relative to water supply.

Documents from the Food and Agriculture Organization of the United Nations (FAO) show that millions of people worldwide who depend on agriculture (production, consumption and marketing) can be seriously affected when drought scenarios are perceived. At seasonal level, from small up to large farmers have a high knowledge of climatology of its various regions, expressed in seasons of rain and less rainfall. However, the recurring climate variability phenomena, especially those associated with the presence of El Niño phenomena, increase the risk and vulnerability of the agricultural sector, resulting in economic losses with a degradation of social aspects.

Water requirements vary among the different types of crops, and while some can survive and obtain acceptable yields with small amounts of water, there are others that require higher volumes of the precious liquid. It is also important for some of them to have water evenly distributed within certain

phenological phases, and seeing that it now has more intense rains of short duration, it is assumed that a month's rainfall is concentrated in fewer days.

More exposure to solar radiation should be considered in the presence of El Niño, with not only more hours of sunlight, but also a greater amount of incoming energy to the crop. Due to the reduction in water supply, this makes the situation stressful for the crop. In some cases, agricultural losses caused by drought can be enormous. A notorious reduction in rainfall even affects yields and therefore farmers' investments, beyond the fact that sometimes they try to cushion the problem a little with irrigation practices.

Socio-economically, recurrent drought conditions generate migration problems to areas with a greater water supply that ensure or facilitate an optimum setting for agricultural practices.

1.1.2. Water Sector

When an El Niño phenomenon occurs, the temperature increases significantly with important brightness and solar radiation values due to a decrease in cloudiness. This situation increases the rate of evapotranspiration, which translates into important water consumption from plants, soils and logically the different crops, without specifying that some have higher requirements than others in their different phases. The above also applies to all living beings because levels of dehydration increase, a situation that suggests a greater demand in which water stress scenarios tend to occur, not only in areas that seasonally tend to have little or no rainfall, but also in areas of the country where annual and dryer seasons' rain volumes are not significantly low.

Population growth must be taken into account, both urban and rural. This situation adds negatively to this problem, as demand increases more and more.

An important conclusion of the ENA indicates that the most critical water resource conditions, associated to pressure by use, water pollution, vulnerability to shortages, vulnerability to climate variability and regulatory conditions, encompass 110 municipalities with an estimated population of 17,500,000 inhabitants. It is also noted that 318 municipal capitals may present problems of shortages in dry periods which could affect a population of approximately 11,530,580 inhabitants, among which are municipalities such as Chiquinquirá, Paipa, Floresta, Soracá, Manzanares, Yopal, Neiva, Maicao , Santa Marta, Buga, and Palmira, among others.

Water is a public good that must be protected as part of our social responsibility, and logically it must also be understood as a strategic input in the different productive processes. Taking into account the information compiled by UNGRD[2] in regards to the impact of the most recent El Niño Phenomenon, 296 municipalities in 25 departments were affected with rationing. Of that total, Tolima, Risaralda and Quindío registered over 50% of their municipalities (of the total that integrate this territory) in rationing. In terms of quantity, Antioquia (53 municipalities), Tolima (40 municipalities) and Cundinamarca (36 municipalities) were the departments with the highest number of municipalities in a rationing. Although the incidence of the Niños of moderate to high intensity is much more noticeable in the shortage of water resources, a phenomenon of light intensity to which other phenomena of climate and/or meteorological variability are added may lead to having some municipalities with this problem, especially when there are deficiencies and/or difficulties in the planning and management of the resource.

[2] El Niño phenomenon comparative analysis 1997-1998 // 2014-2016

Another situation that must be considered when a drought is foreseen is the marked decrease in groundwater reservoirs, which further reduces water availability. Considerable periods of time without rainfall, soil moisture decreases to such an extent that the infiltration water that reaches the aquifers is almost null. And of course, it can happen before any effect of a phenomenon like El Niño, that there are areas of the country that have droughts proper to their seasonality, especially referred to the dry season or minimum rainfall, mostly from the north of the national territory. These times may be extended for a longer period of time, or they may begin to be more frequent, in areas where such a condition was not so tangible previously.

Considering the different uses that are given to the water resource and its importance as a source of life and as an indispensable material of many productive sectors, the aforementioned gives climate prediction a relevant connotation, especially when there are conditions that can lead to the occurrence of an El Niño phenomenon that, beyond its possible intensity, must always "set off the alarms" in order to work on prevention tasks, seeking to minimize the recurrent impact when a event of this type is present.

1.1.3. Livestock Sector

Historically, the great negative impact of drought on livestock has been notorious. This is demonstrated by the last El Niño event 2014-2016 with a marked reduction in the sector's production.
In regards to the physical space where cattle is usually at, the prolonged reduction of rainfall with consequent episodes of drought, especially in those areas of the country where the dry season or the season of less rainfall can be seen accentuated, suggest less water availability for irrigation and drinking troughs for cattle. This causes increases in production costs represented in expenses for food supplies, vitamins and others, as well as the demand for agricultural practices that cushion the deterioration of pastures.

Additionally, the increase in the occurrence and propagation of vegetal cover fires when El Niño phenomena take place, increases the grass availability problem. In the face of this situation, drought represents weight loss, dehydration of animals, increased parasites and diseases, and therefore, a decrease in the production of milk and beef, which also means a reduction in birth rate.
The aforementioned context gives rise to the need to implement adequate water management actions in the livestock sector, especially in the months in which rain appears more frequently, beyond being "weakened" by the presence of an ENSO phenomenon in its warm phase.

1.1.4. Energy Sector

The energy sector is perhaps one of the most prepared sectors for the impact generated by drought associated to El Niño phenomena. Lessons learned as a result of El Niño phenomena, especially in the last 25-30 years. For Colombia, the El Niño 1991-1992 marked a milestone because the consequences of the event in terms of rainfall deficit caused a significant level decrease in the different reservoirs, giving rise to what is historically known as the "1992 blackout", or the "Gaviria hour". Indeed, on March 2nd, 1992, "under the presidency of César Gaviria, Colombia was forced to make power outages in the face of the energy crisis, derived from the crude El Niño phenomenon of that time, which caused droughts and affected the levels of power-generating reservoirs" (eltiempo.com). This situation lasted for thirteen months.

The Government announced a series of power cuts throughout the country, so the "Gaviria hour" began on May 2nd of that year. It was a measure that consisted in moving clock forward one hour in

order to take advantage of the most amount of sunlight and thus save more energy. The life of Colombians changed during nine months, where they had to leave for school and work at dawn and arrive home before dusk. Oil stoves reappeared in everyday lives and families had to gather to spend the night around the light of candles. (eltiempo.com)

The most intense El Niño phenomenon, according to the records of the Oceanic Niño Index (ONI), has been the one between 1997 and 1998, that is, the Niño event immediately after the one that generated that difficulty in the sector.

In the scientific community, the 1997-1998, 2014-2016 and 1982-1983 events are recognized as the three strongest El Niño events in history, followed in decreasing sequence of intensity, but still in the range of the strong events, by the 1972-1973, 2009-2010, 1991-1992 el Niño events. The event that generated that great impact has not been the one of greatest intensity, being the event in 1997-1998 the strongest one, it did not generate a similar situation at all, allowing for a good reading and a lesson learned with the "blackout".

As part of the sector's measures, going back to this period after the indicated impasse, the climate factor starts being taken more into account within the energy operation. An increasingly important interaction between the IDEAM and the National Operation Council of the energy sector began to take place and several instances were set in order to reduce the likelihood of an event such as the aforementioned one to the minimum.

Notwithstanding the foregoing, with the last El Niño phenomenon 2014-2016, the strong impact caused in all the country's water bodies, and therefore in the different reservoirs, resulted in the government being very close to energy rationing. Added to such a strong event not only in relation to the ONI, but also to the heavily marked and widespread rain deficit in a large part of the country, the increasing population with the consequent increase in demand is a factor that affects in such a way that whenever a strong event arises, the sector's contingencies must be more efficient and effective.
Being the sector with the most experience in recognizing, practicing and investing in knowledge on climate prediction, based on greater and better inputs for supply and demand models, it will always be important to improve the means and tools necessary to have a prediction that comes close to what can really happen.

1.1.5. Environmental Sector

Many of the effects and implications of an El Niño phenomenon could be grouped within the environmental sector, which have already been mentioned in this document. However, it is important to emphasize the clear incidence that this event has in the notorious increase in vegetation cover fires. The prolonged absence of rain in different areas of the country when El Niño is present allows for the vegetation to acquire favorable characteristics for combustion. Beyond the fact that it is known that over 90% of fires are caused by human activities, there are meteorological and climatic conditions that favor the occurrence and spread of vegetation cover fires.

When favorable conditions for the development of a Niño are set or projected, the increase in fires is always clear and a matter of concern for the SNGRD entities[3]. They are often for these entities the "fronts" of greatest concern and where a series of activities and resources are set as a function of the prevention and mitigation of fire risk.

[3] National System for Disaster Risk Management

Something that the IDEAM has insisted repeatedly on is that an El Niño phenomenon does not disappear during the rainy season, instead what it causes is a reduction in the precipitation volume that normally occurs in the rainy months. When the intensity is low, its influence is less, while in moderate to strong events the incidence in precipitation inhibition is higher.
Exactly in those rainy seasons influenced by a strong Niño, after having very dry soils due to drought conditions associated to the occurrence of the event, sometimes there is strong rain that increases the problems of erosion.

Additionally, it is important to mention that in the presence of a Niño and the consequent reduction of river levels, the favorable conditions of life for water fauna decrease.
An ecosystem that is too fragile before strong Niño events has to do with the country mountain glaciers, which usually increase the loss of their ice cover in length and thickness. The data gathered periodically by IDEAM facing the dynamics and evolution of this strategic ecosystem show the extreme sensitivity of country's glaciers before the presence of an ENSO phenomenon in its warm phase.

1.1.6. Health Sector

The impact on the health sector when an El Niño phenomenon occurs has been associated with an increased incidence of certain diseases due to the long dry season in most parts of the country, as it has been warned in some excerpts.

In the Contingency Plan issued by UNGRD before the probability and subsequent occurrence of El Niño 2014-2016, before the alert issued by IDEAM, the Ministry of Health, the governing body, undertook various actions aimed at controlling the appearance of epidemics of dengue, especially hemorrhagic dengue, malaria and other Vector Borne Diseases, actions that can be described in two phases: Prevention Phase and Response Phase

Preventive actions are highlighted in this document, which focused on inter-institutional coordination activities related to the Ministry of Health's advice to territorial entities on how to address the emergency and the acquisition of specialized machinery and equipment. Functional groups were created in the territorial health institutions that participated in the emergency and disaster programs, environmental cleanliness and epidemiological monitoring established by the Ministry of Health as a permanent strategy for the purpose of prevention.

The indirect effects associated with the impact of the El Niño phenomenon in the agricultural sector give rise to a decrease in the supply of products, which at given moments can cause famines. Similarly, the referred event affects the decline in the supply of municipal and rural community aqueducts, generating a higher concentration of sediments, which sometimes do not have the most suitable management due to insufficient technology and equipment, especially in regards to inadequate water treatment systems. This condition increases the probability of diseases with a higher probability of bacteria.

The lessons learned from the influence of the most recent El Niño phenomena on health have been fundamental for the sector to become increasingly aware of the preventive tasks that should be carried out when the probability of occurrence of a "warm" event is projected. However, work on research, analysis and possible repercussion of "new" diseases associated with its presence needs to continue.

2. PROPOSED STRATEGIES FOR DECISION-MAKING

Photograph UNGRD – Alta Guajira

2. PROPOSED STRATEGIES FOR DECISION-MAKING

According to the results of the consultative workshops that were carried out as part of the "Pilot Project on Early Warning Systems for Droughts in Colombia", strategies were identified that would improve the climate prediction process within the value chain, with timely and effective information so that decision-makers can take actions that reduce the risk of drought identified some strategies that would improve the process of the climate prediction within the value chain, with information timely and effective so that decision makers can take actions that will reduce the risk to a drought. Three strategies will be developed in this document, namely: institutional, technical and communication.

2.1. Institutional Strategy

We believe that this strategy should be addressed interinstitutionally from the integration of national observations, analysis and products with the support of international entities (the international contribution is explained later).

According to the functions already established, IDEAM is responsible for issuing the technical bulletins on climate prediction about a possible drought, based on the probability of an El Niño phenomenon, which is the climate variability event that influences the reduction in rainfall and the increase in temperatures that lead to a water deficit. Together with the National Unit for Disaster Risk Management, they are responsible for declaring the probability of occurrence of an El Niño event in advance, so that national, departmental and municipal entities prepare their contingency plans.

An institutional strategy for seasonal drought outlook must not only consider the participation of the technical entity (IDEAM) and the entity for disaster risk management (UNGRD), but should also consider the participation of all the public and private institutions sensitive to drought in accordance with their responsibilities and their ability to respond with clear goals to reduce risk and make appropriate and timely decisions in agriculture, water resources, energy sector, health, etc.

In regards to joint responsibility, law 1523 of 2012 states that the National Policy for Disaster Risk Management is adopted and coordinated by the UNGRD, and by decree 308, 2016, the National Plan for Disaster Risk Management - PNGRD - in Colombia 2015-2025 is adopted.

The PNGRD contains projects and goals to be developed by state entities aimed at meeting the Plan's strategic objectives, and for each project the entities involved were identified with deadlines (short, medium and long). With the purpose of showing the programs proposed by the workshop participants, the projects that can be considered contributions for the strengthening of the institutional strategy to reduce drought risk have been selected in the following table:

Strategic Objective: To improve disaster risk knowledge in the national territory.

Table 1. Projects that can be considered as contributions for the strengthening of the institutional strategy to reduce drought risk.

Strategy	Project	Goal	Entities involved	Term
	Strengthening of knowledge on threats of hydro-	Performed and shared studies of threats due to	IDEAM INVEMAR DIMAR	MEDIUM

	meteorological and maritime-meteorological nature.	extreme hydro-meteorological and maritime-meteorological phenomena.		
	Identification of the climate variability effect.	Performed and socialized climate variability effect studies (ENSO) on threats due to to extreme hydro-meteorological and maritime-meteorological phenomena.	IDEAM INVEMAR DIMAR	MEDIUM
Strategy 1.1: Disaster Risk Knowledge for Natural Origin Phenomenon	Strengthening of the National Network of Hydrometereological Stations.	Established Integration Protocol of Public and Private Hydrometeorological Stations Network	IDEAM, DIMAR INVEMAR, Research institutes, Corpoica, Territorial Entities, Environmental Authorities, AEROCIVIL	MEDIUM
	Strengthening of thematic mapping information related to soils.	100% of flat areas and areas with slopes lower than 25% of the national territory with information on soils are basic input to be used in disaster risk assessment studies.	IGAC	LONG
	Agro-climatic Early Warning Systems	Agro-climatic Early Warning Systems fostered in the country's productive areas.	Ministry of Agriculture CORPOICA	SHORT
	Regional characterization of risk scenarios due to extreme weather events in production areas.	Characterized and socialized risk scenarios due to extreme weather events in the productive areas of the country.	Ministry of Agriculture Research Institutes IDEAM	LONG
Strategy 1.2: Disaster Risk Knowledge on Socio-Natural Phenomenon	Modeling of basins for knowledge on the threat due to drought and flood.	Hydrologic modeling of 6 basins performed annually	IDEAM	SHORT MEDIUM LONG
	Promotion of the execution of susceptibility studies due to vegetation cover fires.	400 municipalities with susceptibility studies due to man-made forest fires.	Territorial Entities IDEAM Environmental Authorities Ministry of the Environment UNGRD	LONG
Strategy 1.7	Disaster Risk Analysis in	Capital cities and	Territorial Entities	MEDIUM

Research development aimed at Disaster Risk Management	Utility Companies.	municipalities with population over 100,000 inhabitants with risk studies performed.		
	Disaster Risk Analysis in Productive Systems (Agricultural, Livestock and Fishing Sectors).	Studies and risk maps in the agricultural, livestock, forestry and fishing sectors performed.	Ministry of Agriculture	MEDIUM
	Disaster Risk Analysis of protected areas and threatened ecosystems.	Disaster Risk Studies of protected areas and threatened ecosystems.	UASPNN Research Institutes Environmental Authorities	LONG
	Strengthening of threats and vulnerabilities and risks in the country's productive sectors.	Performed and socialized studies on threats, vulnerabilities and risks in the productive sectors of the country due to extreme meteorological phenomena due to climate change.	Ministry of Agriculture	MEDIUM
Strategy 2.2 Disaster Risk Management and Adaptation to Climate Change Measures in the Development Planning and Zoning Instruments.	Incorporation of disaster risk management in the formulation of micro basin environmental management plans.	1 Published methodological guide for the formulation of the Aquifers Environmental Management Plan with built-in Disaster Risk Management component	Ministry of the Environment	SHORT
	Adaptation to extreme hydroclimatic events in the forestry, fishing and rural development sectors.	Implemented adaptation actions to extreme hydro-climate events of the agricultural, forest, fishing and rural development sectors.	Ministry of Agriculture UPRA	LONG

	Incorporation of disaster risk management in the water resource planning instruments.	5 aquifer environmental management plans formulated with technical assistance from MADS, which incorporate the disaster risk management component	Ministry of the Environment	SHORT MEDIUM LONG

2.1.1. How to integrate observations, analysis and products for a good climate prediction in each sector

In Colombia, the information records obtained through the meteorological, hydrological and environmental stations are managed by each public or private entity, which makes it difficult to have a greater density of basic and timely information. If there were integration and automation of all the information available in the country, the reliability of data management by the governing entity would improve, which in this case is the IDEAM, providing better products with spatial and temporal scales with better resolution, which would allow a step by step follow up on the evolution towards a probable drought that serves as a tool for decision-makers to communicate this to different users and thus reduce the water deficit risk. Logically, a rigorous validation and verification process of the quality of the data must be followed so that it can be easily compared, which will result in greater efficiency and effectiveness of the products resulting from the integration.

From the beginning, all sectors must participate so that the efforts respond to their needs. As an example of good practices, the work that is being done every month on the agro-climate working group promoted by MADR, IDEAM and CIAT is noteworthy, where the objective is to generate a special interdisciplinary bulletin translating technical language into understandable languages for its identified users.

Participatory spaces are generated in these agroclimate working groups, with experts from various sector guilds (Fedearroz, Fenalce, Cenicafé, Asocolflores, Cenicaña, among others), where each guild performs its agroclimate analysis based on IDEAM's climatic prediction and makes the necessary recommendations for each geographic area of the crop and communicates it to its users. This helps identify and detect early manifestations of drought, allowing to take precautionary measures in their contingency plans.

All public and private entities that monitor hydro-meteorological and environmental parameters that lead to a state of drought as part of their functional nature and according to their responsibility, should be a part of this institutional strategy.

2.1.2. Contribution of International Entities

In climate variability, scientists working in national, regional and global climate centers have directed their efforts in analyzing the characteristic parameters of an El Niño phenomenon and how it influences the seasonal prediction of rain or temperature behavior, but in the longer term, that can respond to the needs of users for the planning of their sector.

International entities such as the National Oceanic and Atmospheric Administration of the United States-NOAA, the International Institute of Research for Climate and Society-IRI, the Office of Meteorology of Australia, CIIFEN, among others, have been constituted as International references

that monitor the ocean-atmospheric variables to issue the respective alerts about the probable occurrence of an El Niño or La Niña phenomenon.

Other entities contribute to generate capacities, so that each country takes ownership of the information and alerts and adapts them to the characteristics of its seasonality to determine the degree of effect in its territory. Below, mention will be made of how they support national meteorological and hydrological services.

2.1.2.1. World Meteorological Organization-WMO

WMO is a United Nations organization created in 1950 specialized in weather, climate, hydrology and related geophysical sciences that provides the framework of cooperation to all member countries for the development of operational meteorology and hydrology through national meteorological and hydrological services that lead to benefits derived from its application. Colombia has been a part of this Organization since January 5th, 1962 and the Institute of Hydrology, Meteorology and Environmental Studies-IDEAM is Colombia's representative in this organization.

The vision of the World Meteorological Organization-WMO is to be at the forefront of the world in terms of technical knowledge and international cooperation in relation to weather, climate, hydrology and water resources, thus contributing to the security and well-being of all the people in the world and the economic prosperity of all nations. (Taken from the World Meteorological Organization Plan for Disaster Risk Reduction, 2016)

The contribution of WMO, and in particular the National Meteorological and Hydrological Services-NMHSs, which belong to its members, work strongly in the reduction of regional and national disaster risks under a coordination and collaboration among WMO countries, partners and specific communities.

Within the Strategic Plan 2016-2019, disaster risk reduction is one of the organization's seven priorities. For the particular case that is being documented, it is very important to work on improving the accuracy and effectiveness of the predictions taking into account the possible effects and the early warnings of hydrometeorological and environmental threats in order to contribute to the international efforts in matters of disaster risk reduction, resilience and prevention.

The WMO has the global observing system-GOS (see figure 1) that integrates all the information coming from meteorological and hydrological stations, marine buoys, meteorological satellites, marine vessels, radiosondes, etc.

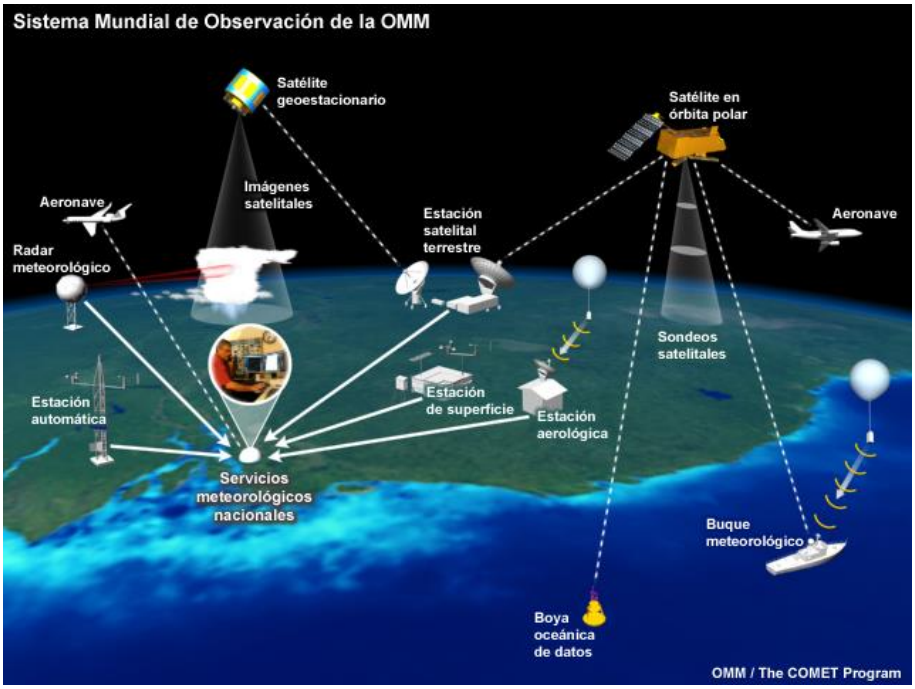

Figure 1. Illustration of the instruments that make up the World Observing System (GOS) of the World Meteorological Organization (WMO). Source: WMO/Comet

There are protocols to send the data produced by observation networks, with established international standards such as schedules, parameters and formats that allow sharing information generated and received from other international networks that are incorporated into each region and nation's hydro-meteorological analysis. Currently, the WMO is focusing on integrating information from the global observing system through the WMO Integrated Global Observing System (WIGOS) in response to current needs in the Global Framework of Climate Services.

Figure 2 shows how the global, regional and national meteorological centers are connected for an effective exchange of information among all member countries, including Colombia, through the Global Telecommunication System-GTS.

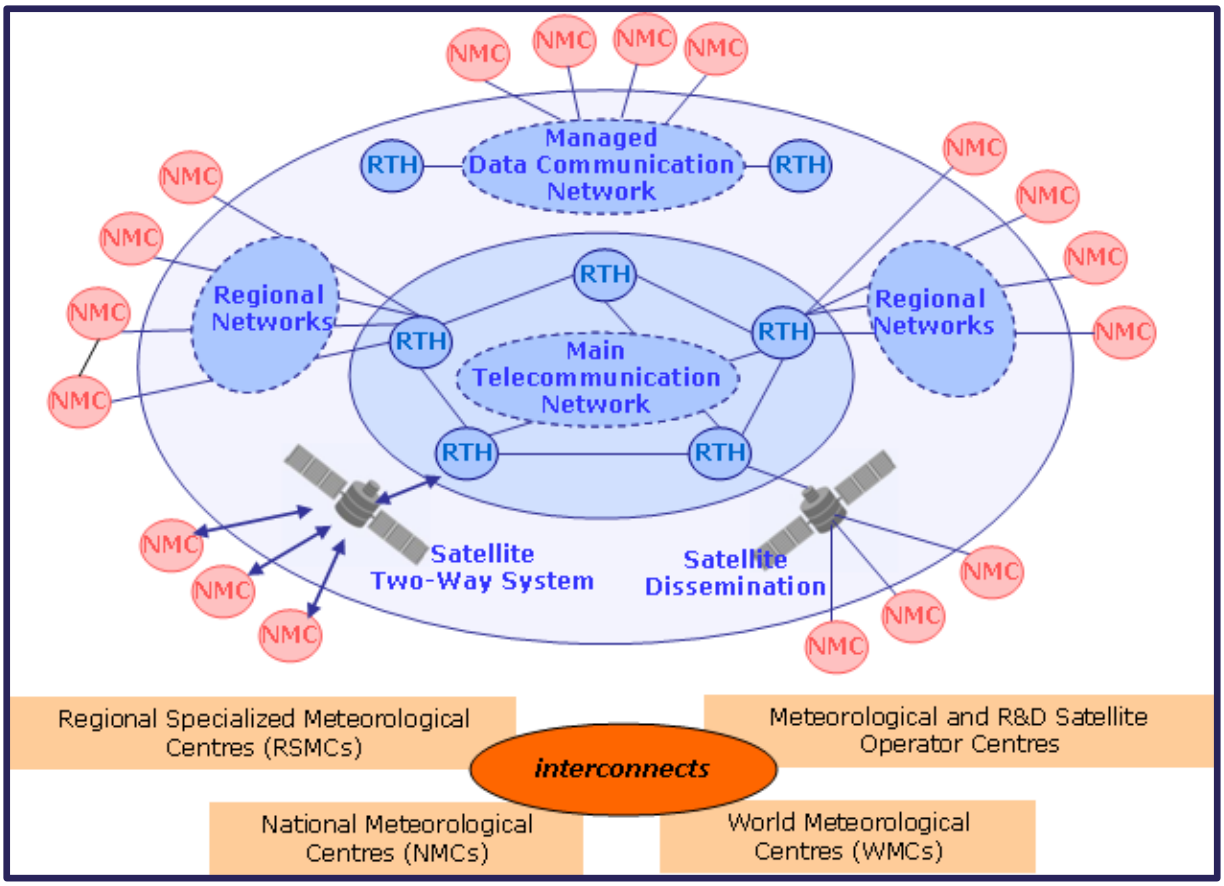

Figure 2. Structure of the Global Telecommunication System

As an institutional strategy and as a contribution of international entities, the WMO has played a preponderant role in promoting climate prediction, not only in integrating the information to be shared, but also with special programs. It has the Public Meteorological Services Program (PMSP) and supports the National Meteorological and Hydrological Services, and the Climate Information and Prediction Services (CIPS) project that promotes the use of new capabilities to predict climate through workshops to exchange new methodologies, use of dynamic and statistical climate models, climate forums with the participation of public and private entities, support for the creation of regional climate centers-RCC, among others, that allow them to issue early warnings of long-term significant seasonal and climate phenomena associated with climate variability phenomena.

2.1.2.2. Regional Climate Centers

The World Meteorological Organization (WMO) has been promoting the creation of the Regional Climate Centers (RCCs) for a few years, and they were created by decision of the WMO World Congress in 2009. Their main role is to generate medium and long term climate information and predictions to improve climate services in support of climate sensitive sectors, decision-makers and all national and regional users. (See figure 3)

Figure 3 shows that there are several regional climate centers. As a reference, in South America there are two regional centers of the World Meteorological Organization-WMO, namely: The Regional Climate Center (RCC) of Western South America, whose mission is to Strengthen the operational capabilities of the National Meteorological and Hydrological Services of Western South America http: //crc-osa.ciifen.org of Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela in order

to contribute to the continuous improvement of their climate services; and the Regional Climate Center for Southern South America RCC-SSA, validated in 2017 as an operational center and integrated by Argentina, Bolivia, Brazil, Chile, Paraguay, Uruguay.

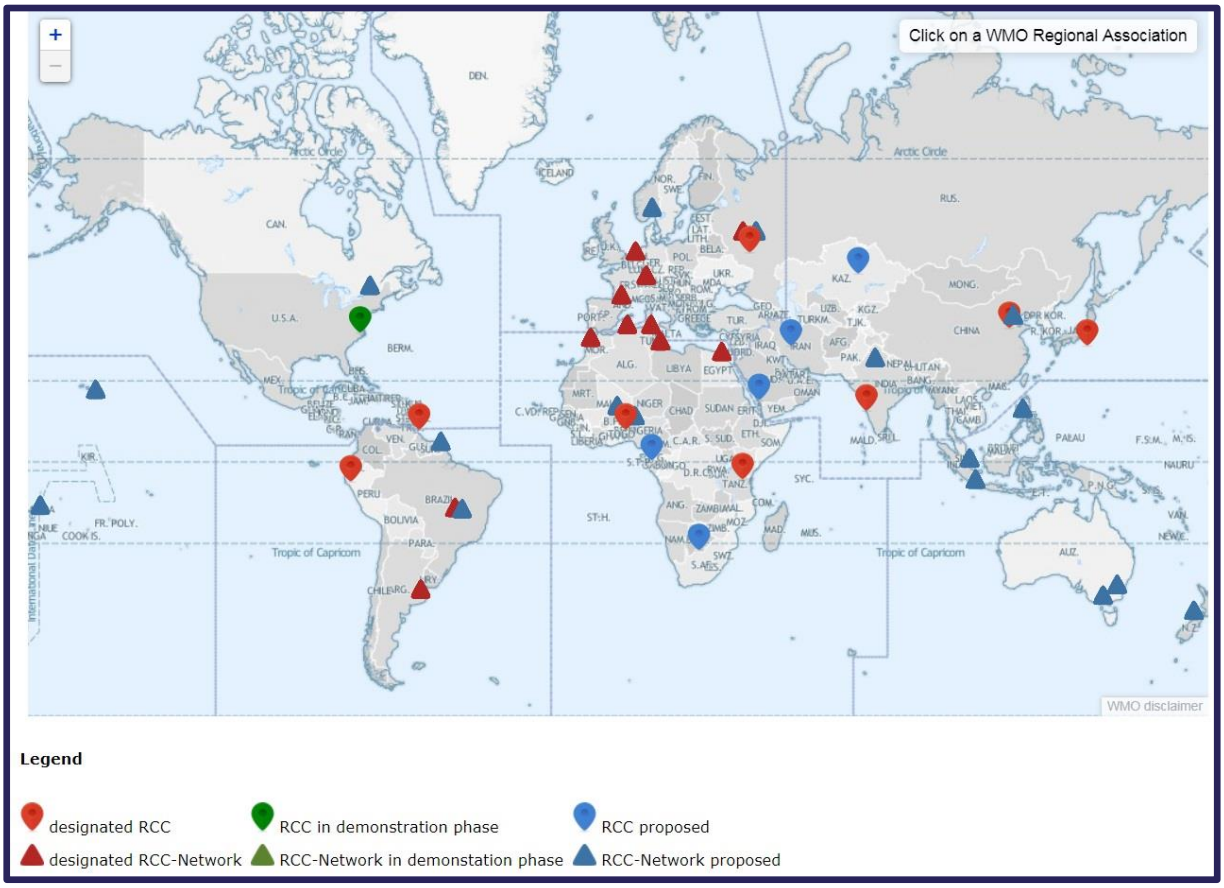

Figure 3. Regional Climate Centers: Source: www.wmo.int/pages/prog/wcp/wcasp/rcc/rcc.php

Its implementation is based on very specific tasks such as strengthening seasonal forecasting capabilities, climate analysis and data management, development of applications, tools and methodologies for disaster prevention in agriculture and water resources sectors, coordinating regional drought initiatives , research on regional impacts of ENSO to mention a few in the technical part; and the resource mobilization and sustainability plan, in order to strengthen the meteorological and hydrological services of the countries that are part of each RCC.

Figures 4a and 4b show some products issued by the two regional centers of South America.

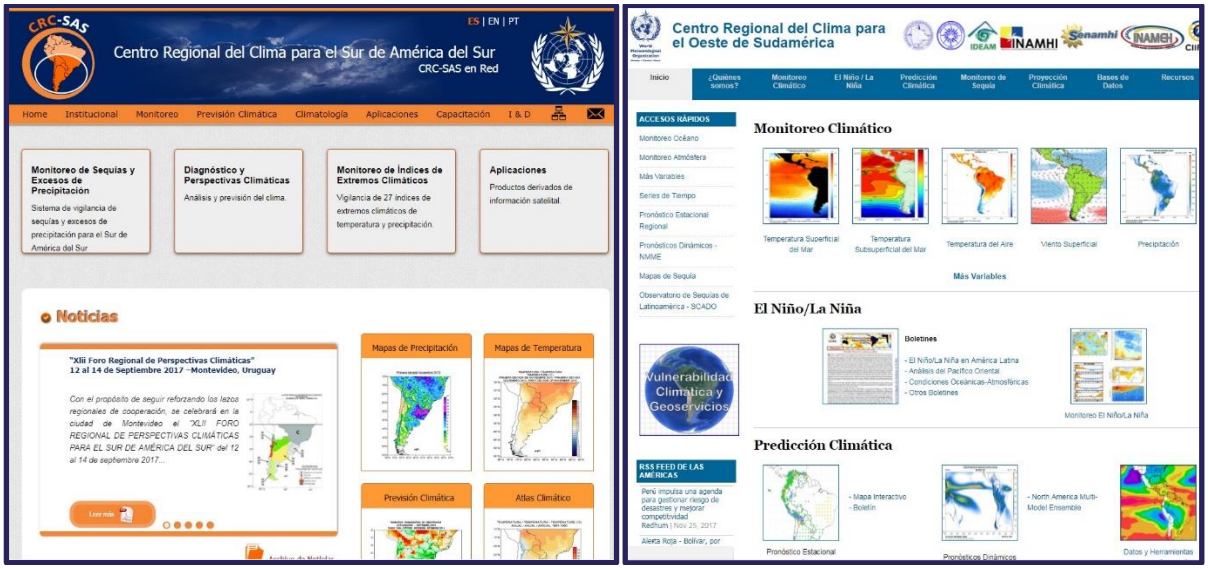

Figure 4. Products issued by regional centers in South America. a) Regional Climate Center - RCC-SSA. b) Regional Climate Center - RCC-WSA

2.1.2.3. Climate Forums

Climate Forums or the Regional Climate Outlook Forums -RCOF were implemented 20 years ago and are sponsored by the World Meteorological Organization-WMO. There are currently 19 operational forums spread around the world (see figure 5).

Bringing together regional experts in climate prediction to exchange knowledge and information, create learning capabilities and generate seasonal predictions for the whole region in terms of precipitation and temperatures became necessary, taking into account factors that influence climate such as the behavior of the ocean, the atmosphere and El Niño-La Niña events in order to contribute to planning in the productive sectors.

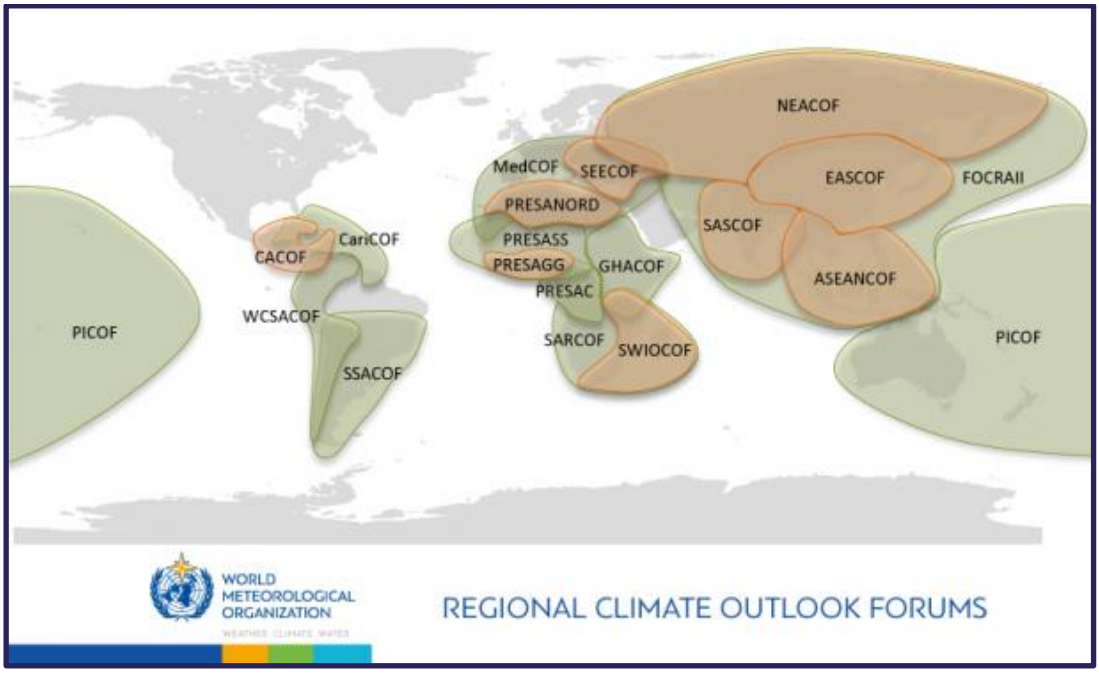

Figure 5. Regional forums Source: WMO

The Climate Forum for Western South America, (COF WCSA) is held once a year and has been coordinated by CIIFEN since 2003, with the support of the World Meteorological Organization - WMO, the National Meteorological Services with the participation of experts from Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela (who are part of the RCC-CIIFEN) to strengthen and revise the methodology to draft the seasonal forecast in a joint and consensual work. Part of each forum includes training for national and regional meteorologists aimed at reinforcing prediction techniques and exchanging experiences and knowledge that contribute to the creation of regional experts' networks for good climate risks management. Representatives of sectors sensitive to climate such as agriculture, energy, health, water resources among others also participate in these forums.

Two of the 16 regional climate forums have been held in Colombia. The first one was the "VI Climate Outlook Forum for Western South America" in Armenia-Quindío between October 31st and November 3rd, 2006, (see figure 6) and the "XIII Western South American Climate Forum" was held in Bogotá-Colombia in November, 2013.

Figure 6. First climate forum in Colombia, year 2006

Participating in these forums were representatives of the National Meteorological Services of Bolivia (SENAMHI), Chile (DMC), Colombia (IDEAM), Ecuador (INAMHI), Peru (SENAMHI), and Venezuela (INAMEH), along with various institutions in the sectors of agriculture, energy, health, environment, disaster prevention, academia, media and the general public.

As part of a feedback, a recent WMO report mentions that an assessment of these forums is being made to technically determine the elaboration, interpretation and dissemination of regional climate trends, as well as the accuracy of the predictions, thinking more about users' need and how this is communicated to them.

2.1.2.4. CIIFEN

CIIFEN has been mentioned in previous sections as fulfilling roles such as Regional Climate Center and organizer of climate forums, but CIIFEN was created from the proposal on immediate actions to assess the feasibility of establishing an International Research Center on the El Niño/Southern Oscillation (ENSO) phenomenon in Ecuador in the Guayaquil declaration of November 13th, 1998, in response to resolution 54/220 of the General Assembly of the United Nations on International Cooperation to reduce the negative impact of the El Niño Phenomenon.

CIIFEN began work on January 10th, 2003, after an entire process of assessment and regional meetings, with the initial participation of WMO, ISDR[4] and the Government of Ecuador and subsequently the CAF[5] in 2004. At the end of 2005, the Government of Spain by way of the State Meteorology Agency of Spain (AEMET) signed the agreement with WMO to join the CIIFEN International Board of Directors[6].

With the support of various donors and organizations in Ecuador and Spain, CIIFEN has implemented more than 45 small/medium projects, mainly in Latin America, but with partners from Europe, United States and Asia.

Without leaving its mission aside "To promote and develop actions to strengthen the science-policy interaction and strengthen the hydro-climate and oceanic services in order to contribute to the risk management and adaptation to change and climate variability", it is important to mention that CIIFEN has been responsible for integrating the seasonal forecasts for the region since 2005. This information is produced monthly based on information coming from meteorological services from Western South America, and is disseminated among all countries as a regional effort to obtain regional products for climate monitoring.

Maps of oceanic and atmospheric monitoring are prepared with NOAA, NCEP and other international data sources (See figure 7).

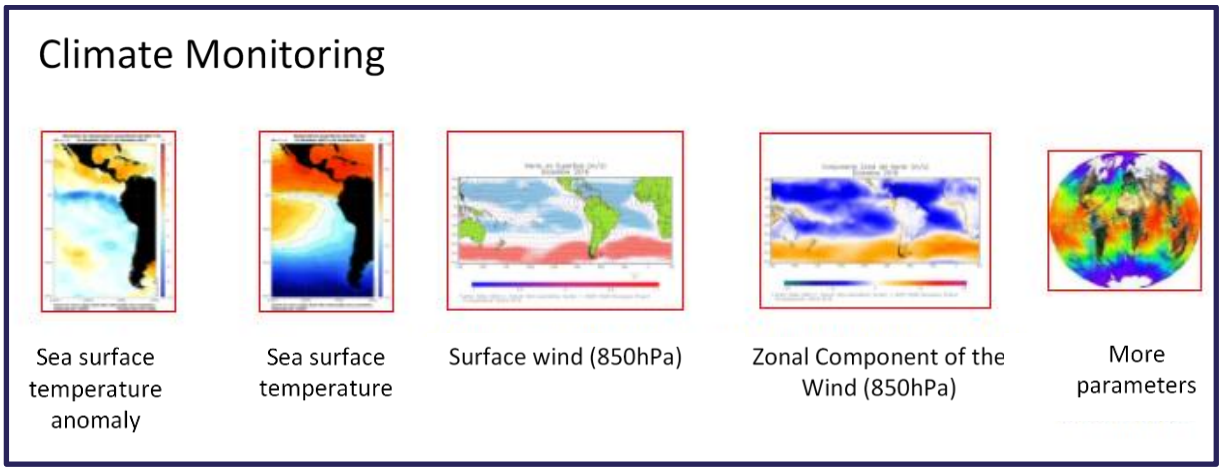

Figure 7. Monitoring Products. Source: CIIFEN

[4] United Nations International Strategy for Disaster Reduction
[5] Development Bank of Latin America
[6] http://www.ciifen.org/index.php?option=com_content&view=article&id=183&Itemid=452&lang=es

They also process precipitation and anomalies maps for three-month periods with NOAA NMME data sources and generate maps such as those shown in Figure 8.

Each month they prepare the report on "Oceanic-Atmospheric Conditions: Evolution and Outlook", where they present and analyze oceanic and atmospheric indices, precipitation anomalies, temperature and seasonal outlooks for South America.

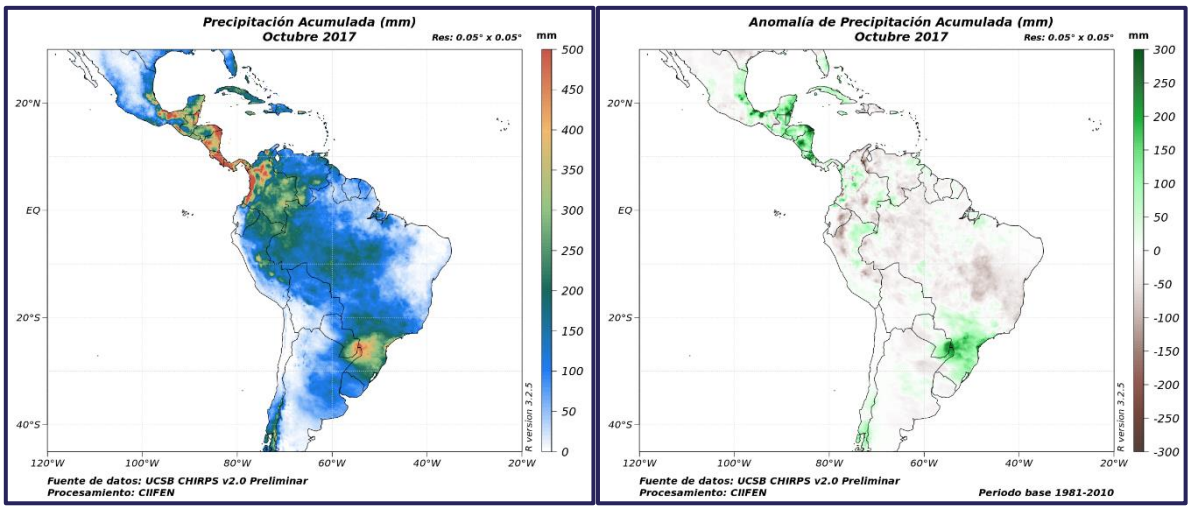

Figure 8. Precipitaction and Anomalies Maps Source: CIIFEN

Additionally, the standardized precipitation index (SPI) is generated for monitoring drought and seasonal forecast for South America with the participation of countries that are part of CIIFEN (See figure 9).

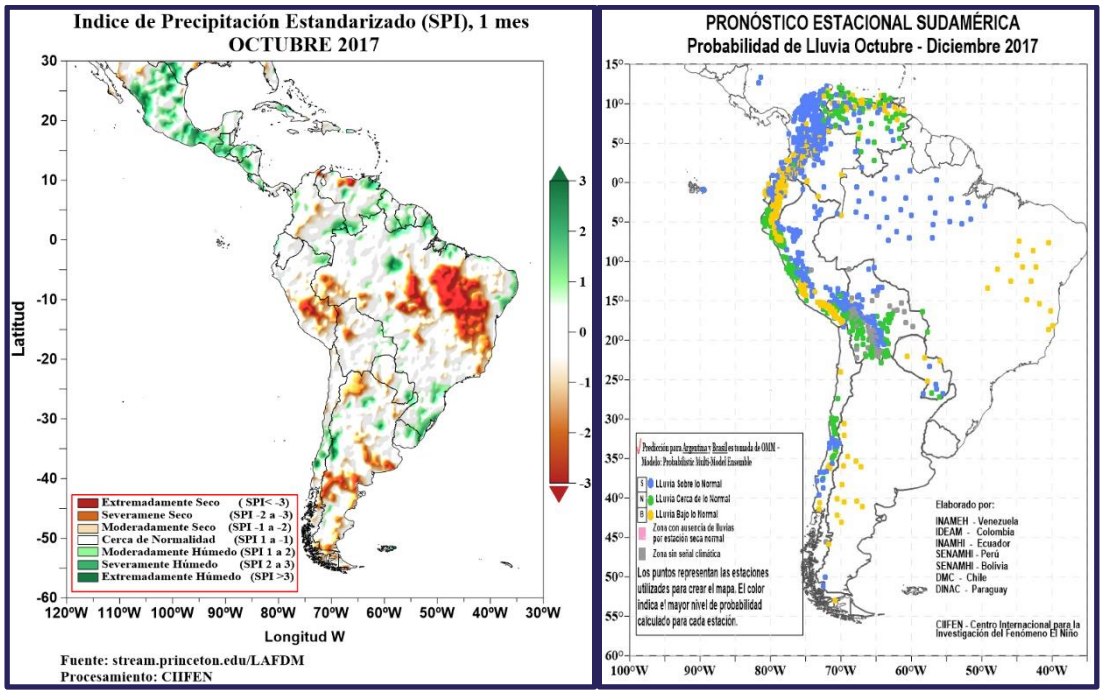

Figure 9. Products for monitoring drought

Each country with its own analysis, with inputs from CIIFEN and information from the world climate centers, adjusts their own climate prediction maps, reports and special bulletins. IDEAM, as the national meteorological authority, prepares the climate prediction bulletins every month, based on a

meeting between the meteorological experts, who with their expertise make the decision after an analysis and review of all the monitoring products and results of the processing of the dynamic and statistical models. This information is socialized in the meetings of the operational technical working groups mentioned in section 3.1.1., so that each sector, in accordance with its internal protocols, disseminates the necessary information on the impact that the weather trends could present and offers the due recommendations to decision-makers who will implement the most effective means of communication and thus reduce climate risk.

In order to see the WMO's contributions more clearly, a scheme of this interrelation is presented (See figure 10).

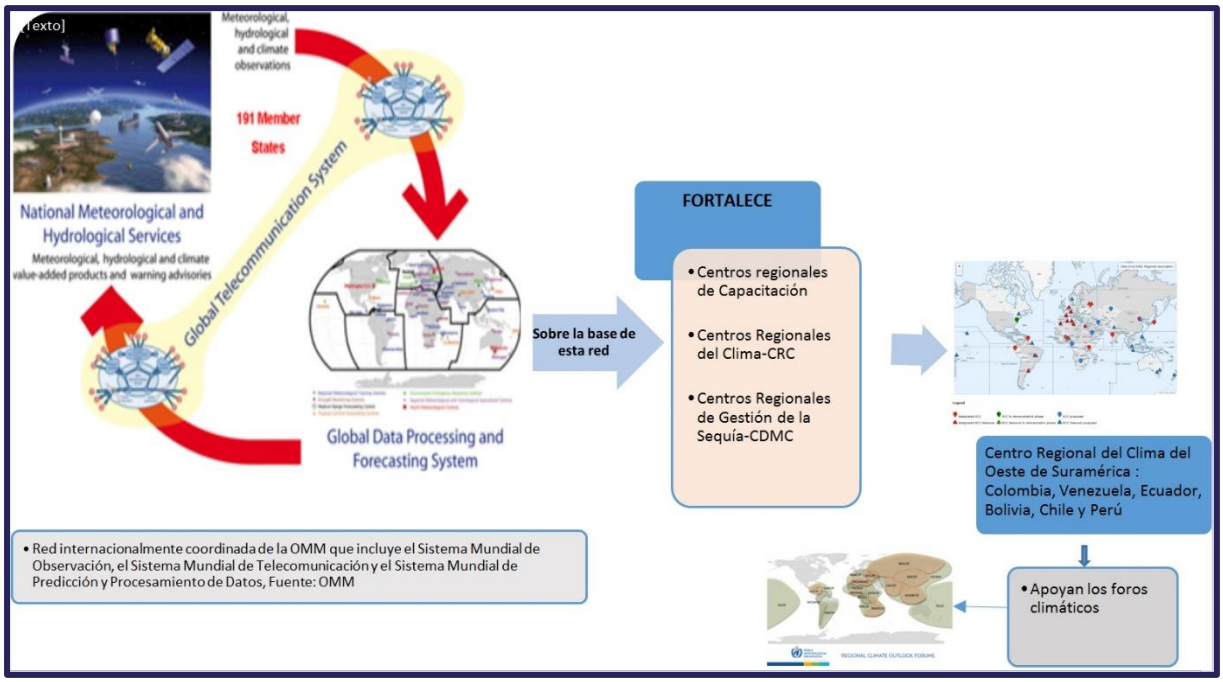

Figure 10. Interrelation in the contribution of international entities (authors' own elaboration based on the international network coordinated by the WMO).

2.2. Technical Strategy

This strategy is proposed as the second step in the value chain to obtain seasonal drought outlooks for appropriate and timely decision-making in agriculture and water resources (See figure 11).

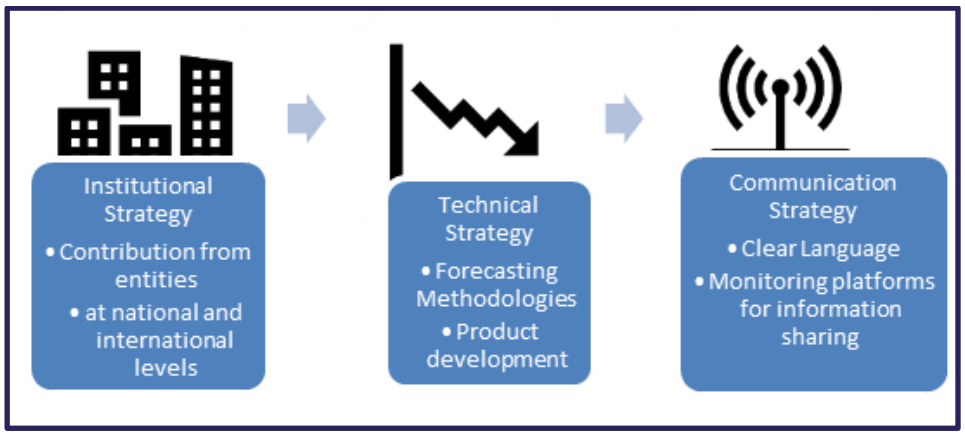

Figure 11. Value chain for the seasonal Outlook

With established the roles in each institution, it should be clear in this strategy what analysis should be taken into account to issue a drought alert based on seasonal prediction.

IDEAM, as the national meteorological authority, has established a methodology with very positive results for some time (see figure 12).

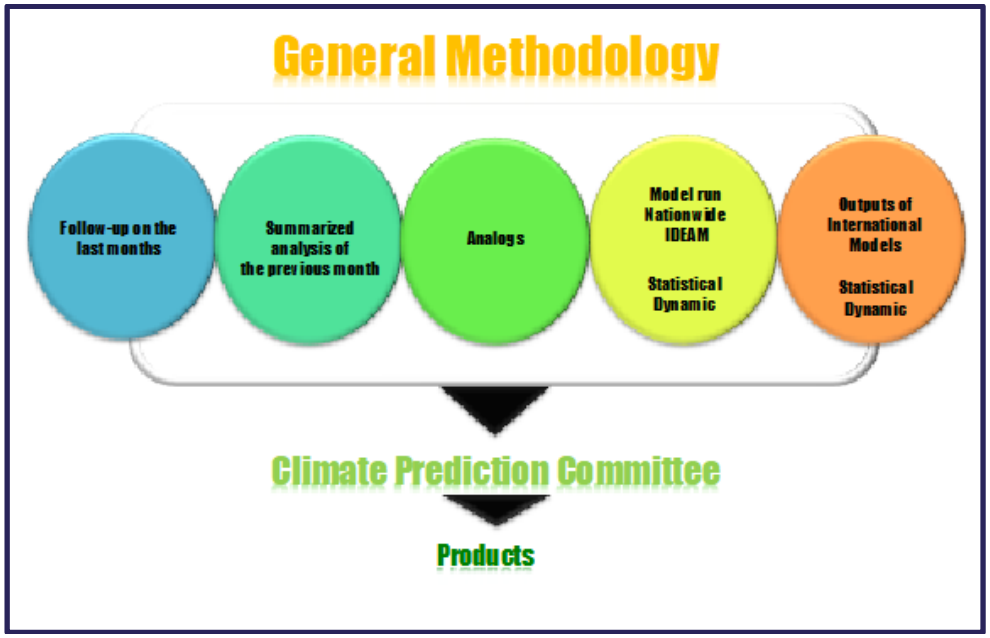

Figure 12. Methodology to carry out the seasonal forecast Source: IDEAM

Following this protocol, meteorologists responsible for monitoring the hydro-meteorological variables run climate models and analyze the outputs of international models, socialize them with the rest of the group of experts and jointly prepare the precipitation prediction maps for one month and three months.

Prediction maps represent the probability that rains are recorded within normal parameters or below or above normal. In terms of determining when drought begins or when it ends, there are still no clear parameters despite the fact that standardized precipitation index (SPI) maps are prepared. An alert is issued due to the El Niño phenomenon and decrease in rain, but no drought alert is issued. It is necessary to establish the technical bases and define monitoring indicators and thresholds, create monitoring platforms for drought, and work jointly with sectors that may be affected that contribute to interdisciplinary knowledge to be able to declare an emergency situation.

2.3. Communication Strategy

A communication strategy should start with minimum and basic requirements to achieve an adequate, understandable and effective language, with communication protocols between technical and risk management entities to facilitate national and regional coordination and exchange information that offers feedback to technical institutions. It is very important to take into account the timeliness with which the information can reach the decision-maker, in order to take appropriate action in a timely and appropriate manner, and not when the drought has already been consolidated. In a way, this means getting ahead of prevention actions.

With the premise that a single institution cannot provide a comprehensive solution throughout the risk management chain for a drought scenario, Colombia has the need to encourage the

participation of all those people, public and private entities, organizations, sectors and others, that feel threatened by these types of events with consequences translated into different levels of effect, so that they work together according to knowledge, developing contingency plans with coordinated approaches that allow facing a possible event with effective, timely and effective actions.

An outline has been drawn (see figure 13) on the communication strategy based on a drought early warning system, where institutional and operational agreements are reached among all the entities involved, so that they share technical information on databases, monitoring products, technical studies and research work on knowledge, and impacts that have been prepared by the entities.

There is also a platform for integrating information for drought monitoring purposes, which is easy to interpret and consult, with suitable products that effectively communicate the trend towards drought.
Lastly, it is important to take community participation into account in the collection of qualitative information and the knowledge that the population has on the region at all levels being a key factor in an EWS, from the perspective of community empowerment on the subject.

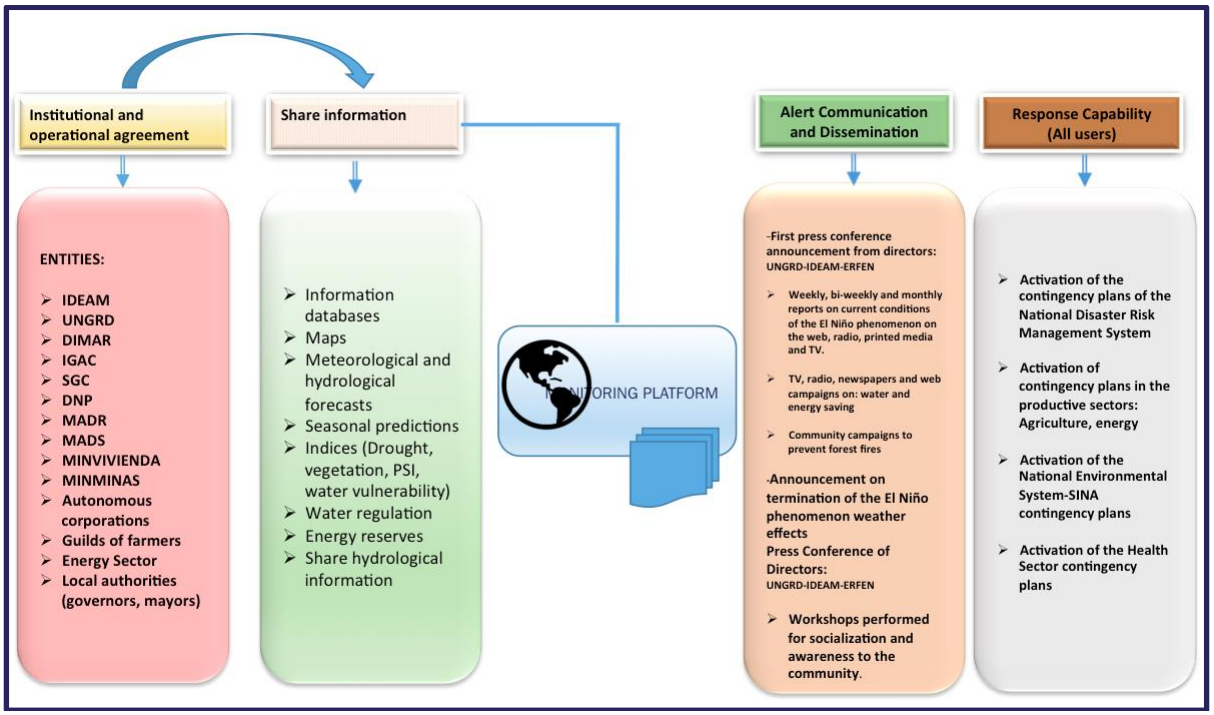

Figure 13. Communication Strategy

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