







Neily (Coto 49) limits the total comparison by periods. It is worth mentioning that rainfall that tends to fall does not represent a drought in the territory; however, special attention should be paid to this trend [11].

According to the National Meteorological Institute (IMN) and the Regional Committee for Hydraulic Resources (RCHR) [13]; in fact, there is an increasing trend of extreme dry events (see figure 3).

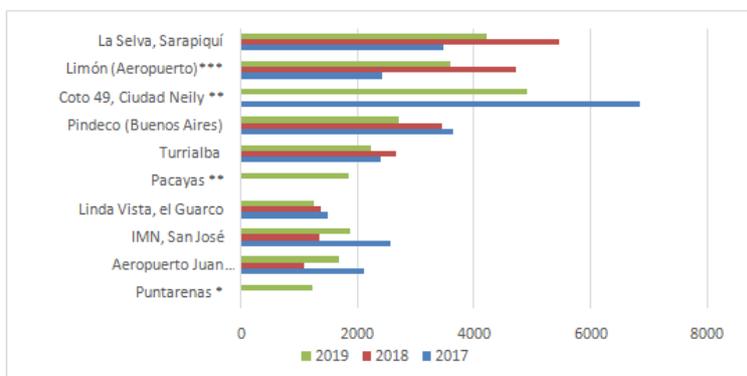


Fig. 2: Costa Rica: Annual precipitation, according to the season, 2017-2019 (in millimeters). Source: Based on the data of INEC [12]. \* The data for the Puntarenas station, to date, is not complete. \*\*\*\* The Pacayas and Ciudad Neily stations have months with missing data. \*\*\* For 2019, the Juan Santamaría and Limón Airport stations correspond to stations 84233 and 81013, respectively.

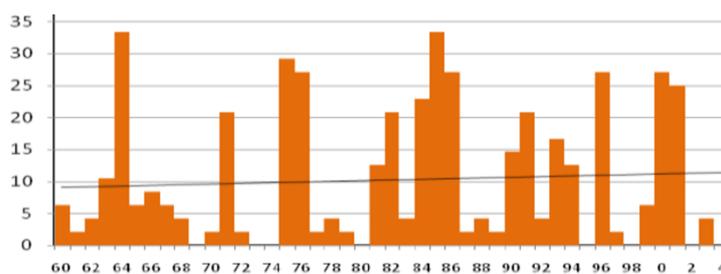


Fig. 3: Costa Rica: Frequency of extreme dry events (%). Source: Comité Regional de Recursos Hidráulicos [13].

On the contrary, the forest cover of different types is composed of the mature forest representing coverage of 1,548,583.38 ha, followed by grass with 1,219,425.65 ha trees; the secondary forest has

an area of 940,820.31 ha; there are 74,596.85 forest plantations (see figure 4) [14].

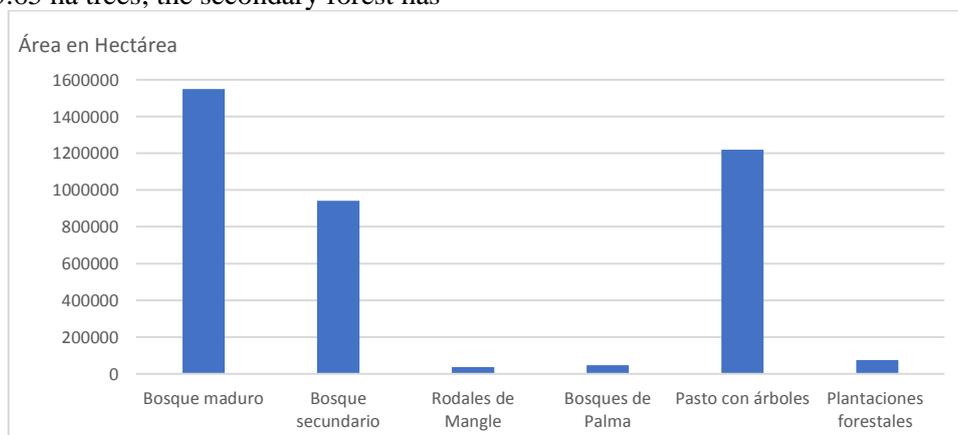


Fig. 4: Costa Rica: Type of Forest in hectares (Ha). 2015. Source: Adapted from Programa REDD/CCAD-GIZ - SINAC [14].

Suppose the relationship between precipitation and forest cover is taken as a basis. In that case, it could be considered that the Atlantic area of the country does not have drought problems and, on the contrary, the northern area has the most significant droughts.

The challenge of drought in the country is associated, in part, with the significant changes throughout national history in the agricultural sector due to institutional policies and the behavior of the national and international market. Regarding institutional policies, the sector's increased agricultural productivity has been promoted through value-added programs.

It should be noted that the cultivation and export of bananas, pineapple, African palm, and coffee account for 48.5% of the added value in the sector [15]. Therefore, any hydrometeorological event directly affects the national economy, as happened in 2015 when the sector's contraction occurred mainly due to these events [15].

Despite the fact that between 2014 and 2017, an average of 1 304 558 million colones was allocated in both sectors, even though there have been critical natural phenomena such as: “(...) *drought in the Pacific, floods in the Caribbean, eruptions of the Turrialba volcano, Hurricane Otto and Storm Nate*” [15].

In addition to the presence of droughts and the characteristics of the soils, mainly sloping land, and physical and chemical aspects [9], the lack of technology makes it difficult to diversify production systems, limiting competitiveness in international markets [9].

In a Senara report [16], it is stated that "climate change generates water scarcity in Guanacaste," and Miranda [17] underlines that "Central America is only responsible for 0.5% of greenhouse gas emissions and the region it is considered one of the most vulnerable to the global environmental crisis" and with the problem of food security [18]. It should be noted that experts from the UCR affirm that the province of Guanacaste, in which critical agricultural activities are carried out, is drier than the rest of the Central American countries that belong to the CSC [19]. In summary, "climate change has direct and indirect impacts on ecosystems and biodiversity" [20].

To address the drought in Guanacaste, the State has developed the Arenal Reservoir with which the dry areas of the region are irrigated. Currently, “ (...) *the waters from the Arenal reservoir are used three*

*times by the Costa Rican Institute of Electricity (ICE) for electricity generation, to later be used for agricultural irrigation in the cantons of Liberia, Cañas and Bagaces*” [16].

On the other hand, Muñoz and Nicaragua relate the drought problem to the lack of systems for improving land use. This is due to communication and information systems shortcomings, combined with the digital literacy gap [twenty-one]. In this sense, the lack of knowledge of the impact generated by the alliance of agribusiness with the oil and chemical industries, which "offers food at low prices but with 'enormous' ecological, economic and social externalities" [22].

As a reflection to address the challenge of drought in the country, it not only requires investment in infrastructure for irrigation, investment in production processes and international markets in the agricultural sector, improvement in land use, or recognizing the gaps in the communication and information system. The challenge of the drought in Costa Rica lies in recognizing the dynamics of the CSC to guide sustainable development policies.

## 4 Discussion

Based on the impact of the drought, the discussion precisely includes all sectors, since, when one link of the production system is affected, the rest suffer the impact, in some cases such as water supply, production costs increased considerably. In others, such as the impact produced by burning due to droughts, it is invaluable from the loss of ecosystems.

Other factors can alter the impacts that drought brings, such as population growth or territorial development policies. As the population increases, the pressure on the water resource is more significant, while the demand for drinking water and the need for environmental sanitation systems increase.

On another line, drought can be controlled by expanding forested areas. Given this statement, the UN highlights that the best managers of forests in Latin America are indigenous peoples [23].

In Costa Rica, the population of native peoples is made up of 8 indigenous peoples (Bribri, Cabécares, Borucas or Bruncas, Chooteegas, Huetares, Malekus or Guatusos, Ngöbes or Guaymies, Térrabas or Teribes) and they have 24 indigenous territories distributed throughout the country [24]. It is determined that most of the territory is located in the southern zone (see figure 5).



Fig. 5: Costa Rica: Indigenous territories in 2011.  
 Source: INEC [25]

The basic principle of caring for the forest is education, in other words, the ability to transmit the value of forest conservation from generation to generation: "Our grandmothers kept telling us that if we did not take care of her, Iriria would get sick. That is what is happening outside our territories", comments Edith Villanueva Reyes, one of the leaders of the Association of the Commission of Indigenous Women of Talamanca (Acomuita) [26]. This development of training capacities has allowed indigenous peoples to implement sophisticated conservation and interaction systems

with the forest and ensure the very existence of the population. The conception of natural resources transcends the extractive and exploitative approach of resources, their value, perhaps not found in commercial principles but the essence of preserving the ecosystem and the environment as a whole. Another activity that has been implemented in the country is reforestation. Through the Payment for Environmental Services (PES) project, the country has increased the amount of forest cover in the Territory (see figure 6).

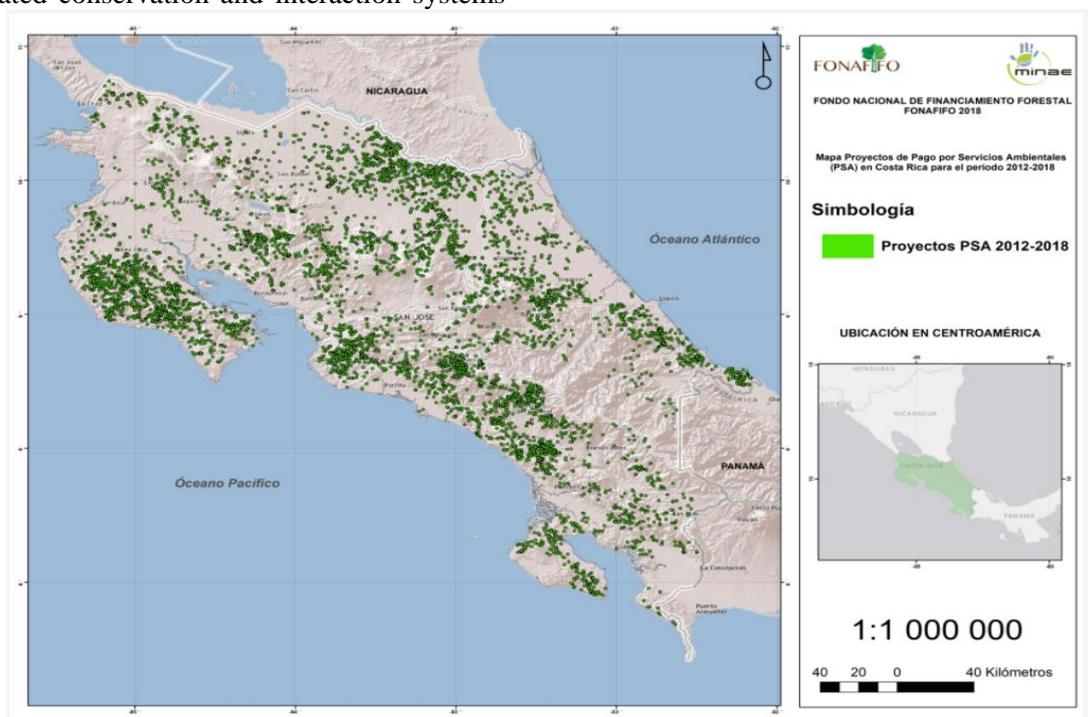


Fig. 6: Costa Rica: Map of Payment Projects for Environmental Services in 2012-2018.  
 Source: BioCosta Rica [27].

The increase in coverage areas in the territory has had positive results; however, it is not enough to correct the problems of droughts in the national territory. The productive sectors such as

agriculture, livestock, and aquaculture require strategic and contingency plans to address the environmental, economic, and social risks that the phenomenon of drought brings with it. These plans

must strengthen the value-added chains and their differentiating attributes to develop the proposed strategic plan.

## 5 Conclusions

The conviction that the environmental policy regarding the increase of forest cover has left tangible results, such as the territories dedicated to reforestation, conservation, protection, and recovery of wildlife refuge areas. However, the challenges of decreasing rainfall in most of the country and the presence of more extended periods of droughts are urgent to be incorporated into national sustainable development agendas.

Another element that must be taken up promptly is the production chains, which must be attended to integrally. For this, it must be provided with the necessary resources to accompany it in the application and adoption of sustainable production systems.

## 6 Study Limitations and Prospective Research Lines

This research advances our knowledge and sensibility about this global relevant issue - once it directly influences the territory of Costa Rica and indirect impacts worldwide due to the critical ecosystemic role in the world's biodiversity. Nevertheless, and bearing in mind that the current work is only preliminary research, several research prospects remain. In this regard, for example, if more advanced statistics were used, the results could be more exciting and accurate. Also, if more variables and different fields within the sustainable development [28-40] concept were considered, a better view we obtain over all these issues impacts.

Nevertheless, future lines of research must necessarily consider the social, political, and natural aspects to carry out the comprehensive analysis required by the challenge of drought. It is impossible to understand drought only as a phenomenon that occurs in the CSC; it is essential to recognize the presence of the human being and the natural baggage that interacts on the site. Likewise, it is crucial to rethink the possibility of carrying out research in maritime-terrestrial areas, which are already affected by droughts. It is also correct to discuss the current and future resources to face the drought.

As final remarks, similar studies should be carried out in other territories and geographies to allow some comparisons between countries; therefore, it will enable to find common solutions regarding this increasing problem easily.

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All the authors contributed equally to the development of the present paper. All phases of the paper development have been properly discussed and worked on by the authors. All authors have read and agreed to the published version of the manuscript.

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