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Assessing the impact of climate change on agriculture in Norte de Santander, Colombia

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Abstract. Agriculture in the Andean region of Colombia is vulnerable to climate change and warrants the evaluation of its impact on the small agricultural family home to the mountain. The objective of this investigation was to evaluate the economic, environmental and social impact of climate change on the agricultural sector of the Bochalema municipality, Norte de Santander Department, using the methodology of the Integrated Relevant Criteria to identify and assess impact in order to provide essential input to support the decisions of local development agencies. This investigation reveals high fragility in the sector and underinvestment in public policies, strategies, plans and programs. Keywords: agriculture, climate change, assessment, impacts. JEL classification: Q51, Q54.

1. Introduction

The preview determinations of the environmental impact [1-3], on physical-natural or communal environment, represents a foresight tool useful to prevent, mitigate or adapt developments permitted within the environmental sustainability parameters. The Environmental Impact Assessment (EIA) of climate change on agriculture and livestock sector, takes as its central focus the prevention, mitigation and adaptation of activities that can be positive or negative to the environment [2-4] and [5].

However, because the agricultural sector is a vital means to the population because of its significant contribution to food security [6,7], it is urgent to assess the effects that currently causing climate change by being predominantly agro-dependent environmental condition systems (temperature, precipitation, soil, solar radiation) of which climate change is causing negative impact on product yields, profitability and food quality.

In the methodologies for assessing the impact of climate change it is important to consider four basic concepts related to risk: vulnerability, exposure, mitigation and adaptation [8]. The first refers to how sensitive natural and human ecosystems are to high and moderate risks of climate change; the second refers to the level of protection that people and their resources have when faced with extreme events; the third refers to the technical-administrative measures to reduce impacts on the environment; the fourth, to the mechanisms so that ecosystems and communities can adapt to emerging conditions of temperature and precipitation conditions within the survival limits.



The objective of the research was to evaluate the economic, environmental and social impacts of climate change on the agricultural sector of the Bochalema municipality, Norte de Santander Department (Colombia), and in this article are presented the most important findings in agriculture

2. Materials and methods

The EIA was based on a climatic, environmental, social, economic and agricultural characterization realized at an earlier stage of the research project. The methodology of the Integrated Relevant Criteria proposed by Buroz (1994) for assessing environmental impact started from a technical analysis to identify environmental impacts through the checklist [2,4,9,10]. This allows an analysis of causality between a given action and its possible effects on society, the economy and the environment. The checklist data was divided into blocks of influence, according to the aspect involved ("La Niña" Phenomenon and its low temperatures; "El Niño" Phenomenon and its high temperatures, climate mitigation and adaptation policies). In each block the environmental impact was determined with their respective impacted environmental factor (social, economic and environmental) a result of the climate change occurred in the agricultural sector.

Once the long list of results was obtained, we proceeded to develop a short list of environmental impacts through the cause-effect matrix Interaction, called Matrix Repeatability and Relevance [2] which identified and evaluated the environmental impacts generated by said actions or activities, with qualitative results that emerged from the Ad Hoc group experience or expert group [2,5]. For the assessment of impacts a weighing of each impact of the short list (obtained Matrix Repeatability and Relevance) to rank them with a minimum of subjectivity was established by Equation (1):

$$M = I \times \rho(0,4) + D \times \rho(0,2) + E \times x\rho(0,4) \quad (1)$$

Denotations: Environmental impact magnitude (M); Environmental impact intensity (I); Environmental impact duration (D); Extension of the Environmental Impact Assessment (E); Reversibility of the impact (RV); Risk impact (RG) and; Weighting factor (ρ)

After the estimated magnitude of the impact was obtained, we proceeded to determine the Environmental Impact Value (EIV) as a result of the weighted sum of the criteria evaluated (Equation (2)):

$$EIV = M \times \rho(0,66) + RV \times \rho(0,22) + RG \times \rho(0,17) \quad (2)$$

The EIV relevance levels as well: Severe or high (> 8); Strong or high (6.0 to 7.9); Medium (4.5 to 5.9) and Mild or low (<4.4).

3. Results and discussion

In assessing the effects of climate change, 43 environmental impacts were characterized in the agricultural sector; this article presents 10 impacts which got the highest scores during the estimation. (Table 1). The table presents the impacts classified by the Value of the Environmental Impact Assessment (EIV) and the level of relevance obtained from the results of the research project carried out in the Bochalema Municipality, Norte de Santander Department.

Within the "serious" category (3) three impacts were evaluated. The first refers to the prevalence in small tracts of land in family farms, being invasive and dependent on natural resources with a population in poor socioeconomic conditions that make them vulnerable to climate change. This finding reinforces the observations reported by other studies, which indicate that globally more than 85% of agricultural land are made up of small tracts of land [11-13], about 15 million households in Latin America (cited in [12]), exclusively dependant on environmental conditions, with low levels of technology, high levels of poverty and involved in family farming [14].

The second and third impact correspond to the increased intensity of the use of fragile mountain ecosystems, effects on the habitat of wild plants species like moss, cress, "Guinchos", Linnet, figs,

wild ferns, among others because of deforestation and mining activities. In this sense [15] reports that accelerated erosion due to drought, deforestation or agricultural practices can inhibit soil development and consequently limiting edaphic balance processes in the future by decreasing vegetation cover and increasing soil vulnerability [16]. Also, heat affects the crop characteristics and ripening conditions of coffee, specifically in the physical and chemical expressions of green coffee, by the effect of the combination of heat waves and water stress that affect development of vegetation [17].

Table1. Assessment of the impacts of climate change on agriculture.

No	Climate change impacts	Value of Environmental Impact Assessment (EIV)	Level of relevance
1	Small tracts of invasive family lands, dependent on natural resources and a population in poor socioeconomic conditions.	8.4	Serious
2	Increase in the intensive use of fragile mountain ecosystems.	8.3	Serious
3	habitat of wild flora and moss species affected, cress, “Guinchos”, “pardillos”, figs, wild ferns, among others due to deforestation and mining activities.	8.2	Serious
4	Temperature rise by 1.1 ° C and decrease in precipitation by 34.7% (data of Blonay station within seven (7) years of study), is reflected in the decrease in water supply.	7.9	High
5	Social conflicts over water use for drinking and irrigation resulting from the decrease in the flow of the main sources, caused by intense droughts.	7.8	High
6	Poor culture and knowledge in the local producers for environmental prevention.	7.7	High
7	Fading of productive associative practices of the locals such as medicinal plants, vegetables and animals.	7.7	High
8	Risk and vulnerability in the population due to soil slippage in cultivated areas, or road obstruction.	7.5	High
9	Limited use of clean and modern technologies for agricultural production.	7.5	High
10	Changing patterns of crops (cocoa, citrus, avocado) instead of traditional (coffee, leafy vegetables, and “lulo” tall fruit trees) due to variations of climate change.	7.1	High

In the same way, emerging research results match with findings of a greater impact of climate change in species such as insects and vertebrates, in relation to vascular plants [18]. Another research by Hatfield and Dold [19] states that weather variations affects water availability, temperature and concentration of CO₂ influencing plant growth and; the spatial distribution pattern of animals and pests [20].

A score of ‘serious’ was given to the use of fragile mountain ecosystems and the habitat of native wild flora species due to deforestation activities, mining and the migration of species of fauna in the area, in line with the findings of various researchers, including: Deb et al. [21] in the negative effects of the involvement of wildlife species with endangered animals; Anjos and Toledo [22] demonstrated that forests have less resistance to climatic stress than prairie and savanna ecosystems; Burns et. al. [18] reported in their studies that intensive agricultural activities, combined with climate change, affected the three major taxonomic groups evaluated (insects, vascular plants and vertebrates). This category revealed the high fragility of mountain ecosystems to anthropogenic forcing, in this case family agriculture and the impacts of climate variations by alternating periods of drought and heavy rains [23] that increase vulnerability and risk to the ecosystem.

Likewise, the impact of certain risk of accidents to producers happened by landslides and overflowing streams occurred by high rains were assessed as severe; increasing epidemics in rural areas by effects of heat or heavy rains. Among the numerous studies that find correlation with this finding are those by [24] in Pakistan and they suggest that risk management, public health and water

conservation measures are urgent; disruption of agricultural and operational work [25]; cultivated land and damaged agricultural infrastructure [26]; the incidence of pests and diseases on the health of the rural population [27] and; the low income of producers aggravates poverty of families [28,29]. In summary, there is a direct relationship between extreme climatic phenomena with the health and poverty of farmers. It is evidenced by the impact of the former on the surrounding physical environment and the basic conditions that guarantee the development of the daily life of rural cultures.

4. Conclusions

The context of the action: The purpose of the evaluation focuses on a region with high natural wealth anchored in the Colombian Andes, in small agricultural units subject to artisanal mining of coal production. The complexity and high vulnerability of the site showed significant negative effects of climate variability on water sources, soil, biodiversity and production systems, which raises alarms in some emerging indicators of evaluation.

Weather pressure: The 7-year analysis of climatological records indicate that the studied region has experienced an increase of 1.1 °C in the annual average temperatures and a decrease of 34.7% in annual rainfall, with disturbances in the bimodal cycle and rain. This climate variability has influenced, together with the anthropic action, prolonged droughts and heavy and untimely rains that have caused, among major effects: a) Damage to production (marginalization of low areas, crop migration, intensification and migration of pests and diseases, loss of crops and low yields); 2) Loss of biodiversity (deforestation, vegetation, forest fires, extinction of wild flora and fauna); 3) Damage to infrastructure and agricultural services in farms and related areas (landslides, floods, destruction of irrigation systems and roads); 4) Impairment to a farm families' health (new or intensification of the incidence of pests and diseases, heat waves, effects on comfort and shortage of drinking water); 5) The effects on food security by reducing the quantity, quality and price of food in extreme periods of rain or drought.

Anthropic pressure: The temperature increase is forcing farmers to change farming patterns or animal husbandry, seeking whatever appropriate for their agribusinesses weather conditions. Thus, traditional coffee growers of low altitudinal are starting to plant cocoa (or coffee planting in upper parts of farms); appears on the scene warm floors crops such as cocoa, banana, citrus and pineapples.

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