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ARTICLE

The Drivers of Child Mortality During the 2012–2016 Drought in La Guajira, Colombia

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Abstract During the 2012–2016 drought in La Guajira, Colombia, child mortality rates rose to 23.4 out of 1000. Most of these children belonged to the *Wayuu* indigenous community, the largest and one of the most vulnerable in Colombia. At the municipal level, this study found a significant positive correlation between the average child mortality rate and households with a monthly income of less than USD 100, the number of people without access to health insurance, being part of the indigenous population, being illiterate, lacking sewage systems, living in rural areas, and large households with members younger than 5 years old and older than 65 years old. No correlation was found with households without access to a water source. The stepwise regression analysis showed that households with a monthly income of less than USD 100, no members older than 65 years old, but several children younger than 5 years old, account for 90.4% of the child mortality rate. This study concludes that, if inhabitants had had better incomes or assets, as well as an adequate infrastructure, they could have faced the drought without the observed increase in child mortality.

Keywords Child mortality · Climate change · Drought · Socioeconomic vulnerability · Water management · *Wayuu* indigenous community

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1 Introduction

Poor people in Latin American countries such as Colombia, Guyana, and Honduras are overexposed to droughts and high temperatures. Droughts are likely to become more common and severe in places where they already occur (Hallegatte et al. 2016). Between 2012 and 2016, a long drought took place in La Guajira, Colombia due to El Niño phenomenon. The monthly average precipitation in the high Guajira dropped from 30 mm in 2012 to as little as 5 mm in 2015 (Bonet-Morón and Hahn-De-Castro 2017). The water scarcity reduced crop production and led to food insecurity within the department (Contreras et al. 2016), stopping the decreasing tendency of child mortality in La Guajira and even increasing this tendency again in some of the municipalities of the department (Avilés 2019).

Colombia is divided into 32 departments, one of which is La Guajira in the far northeast, between the Caribbean Sea and Venezuela. The department with a total area of 20,848 km^2 is divided into 15 municipalities (Fig. 1), with Riohacha on the coast as the capital. The department is located in three natural subregions: high, middle, and low Guajira, as shown in Fig. 2. The high Guajira is a semi-desert area, where the vegetation is scarce. The middle Guajira consists of semi-desert zones with tropical dry forest but also with agricultural potential. Nevertheless, areas with the best conditions for agriculture are in the low

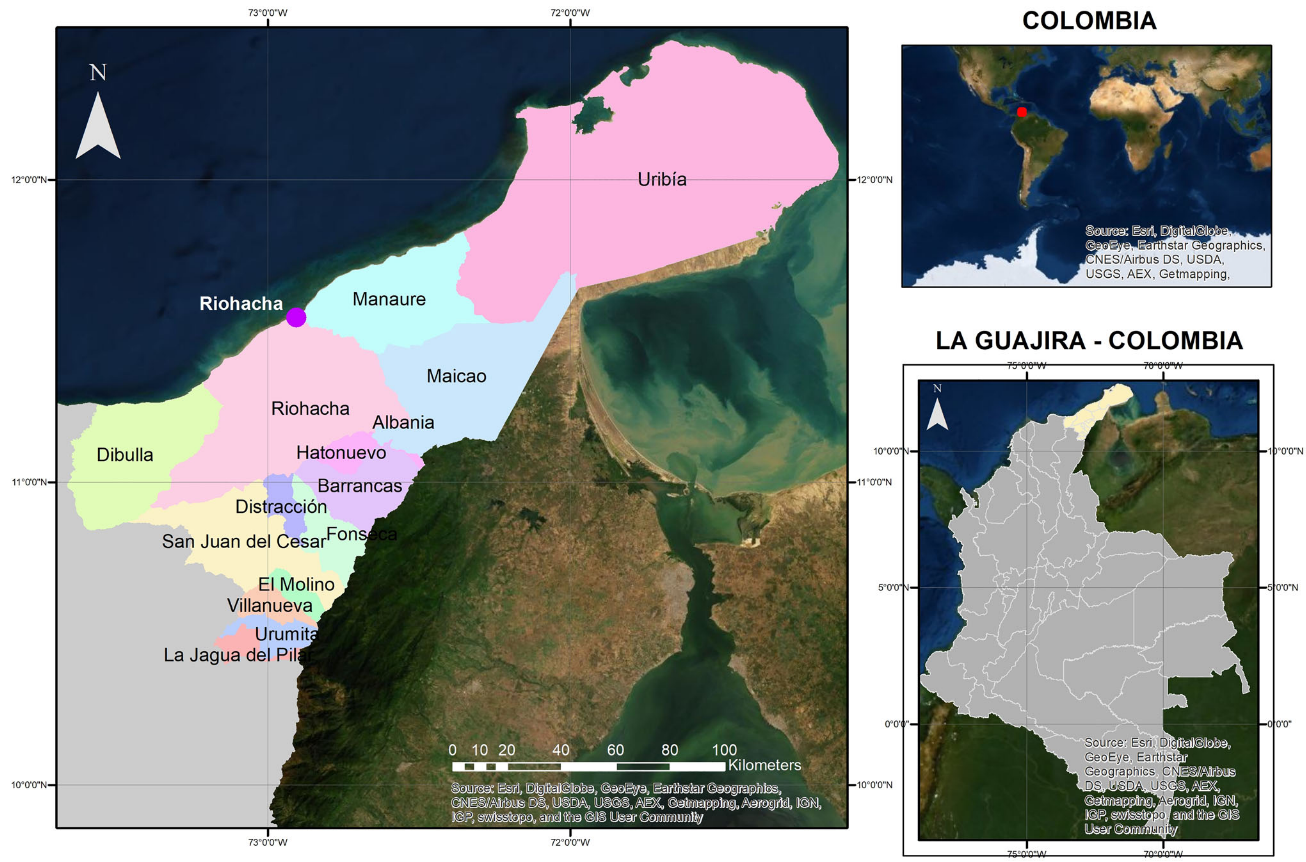

Fig. 1 Location and municipalities of La Guajira Department, Colombia

Guajira due to its closeness to Rancheria and El Cesar Rivers (CCG 2017).

The precipitation in La Guajira is less than 500 mm per year, and temperatures vary between 35 and 42 °C throughout the year (IDEAM et al. 2017). Based on the 2005 population census projections (2005–2020), about 44.9% (454,804 inhabitants) of the total population in La Guajira (1,012,926 inhabitants) are indigenous people from four communities: *Wayuu*, *Kogi* (*Kaggaba*), *Wiwa* (*Arzario*), and *Arhuaco (Ijka)* (CCG 2017). The *Wayuu* are the largest indigenous community in La Guajira and in Colombia, and one of the most vulnerable. They account for 20% (381,123 *Wayuu* population) of the total indigenous population in Colombia (1,905,617 indigenous population). The *Wayuu*'s ancestral land includes the high and middle Guajira and the northwestern part of Venezuela (Fig. 3); therefore, they have both the Colombian and Venezuelan citizenships and free transit between the two countries.

The people of the *Wayuu* indigenous community can largely be divided into two groups based on their activities: *apaalanchi* (fishers) and *arumewi* (shepherds). However, during the dry season they migrate to Riohacha to work in the construction industry or any low-skill jobs, to look for grass for their cattle in the low Guajira or to secure jobs in the extraction of salt (Hostein 2012) in Manaure still in the high Guajira. During the eighteenth and the nineteenth centuries, members of the *Wayuu* indigenous community already migrated to Venezuela during the dry season to work on the cocoa, coffee, and indigo plantations. This migration further intensified in the twentieth century with the demand for a labor force to work in various oil facilities (Hostein 2012). Smuggling was one of the other economic activities since the Spanish conquerors' arrival in this region, and it remained prevalent until the 1970s when the traffic of marihuana became an alternative source of income for the region until the beginning of the 1980s (Contreras et al. 2016). Due to its isolated geographic position, La Guajira is a favorable territory for all kinds of illicit trafficking, including drug running. The latter has become an essential source of income for the *Wayuu* population (Hostein 2012), but also a source of conflict in the department.

Factors such as water scarcity, high temperatures, and soil salinization contribute to a desertification process and together with the dredging of the sandbank of Lake Maracaibo make the exploitation of marine resources difficult, making it challenging to find sources of livelihood in

Fig. 2 Natural subregions and rivers in La Guajira Department, Colombia

this region (Hostein 2012). The members of the *Wayuu* indigenous community are known for their coping capacity and adaptation strategies to survive in the desert (Hostein 2012) with their herds of goats and rams (Castro-Aniyar 2016), subsistence crops, crops with medicinal properties to sell, and weaving bags and hammocks. Nevertheless, famine among *Wayuu* children was already recorded as early as 1776 by members of the Spanish army (Guerra 2016), in 1920 by the Swedish researcher Gustaf Bolinder and 1973 by the French ethnologist Michel Perrin (Bonet-Morón and Hahn-De-Castro 2017). More recently, between 2012 and 2016, a long drought took place in La Guajira due to an El Niño event. The monthly average precipitation in the high Guajira dropped from 30 mm in 2012 to as little as 5 mm in 2015 (Bonet-Morón and Hahn-De-Castro 2017). In addition to the drought, the water scarcity in La Guajira is caused by controversial water management. The water supply system covers 87% of the urban areas, but only 22% of the rural areas of the department, while in the rest of Colombia, the water supply system covers 97% and 73%, respectively (CCG 2017). The El Cercado dam was built on the main river in the department. The dam was completed in 2010 with the purpose to mitigate the effects of the cyclical droughts in La Guajira, to supply water to the aqueducts of nine municipalities, and to provide irrigation for agriculture. But the pipes to conduct the water lead nowhere. The flow barely makes it past the rice crops, cattle ranches, and El Cerrejon (Avilés 2019), the tenth-largest open-pit coal mine (by reserve) in the world (Mining Technology 2013), all of which tap into the river below the dam. By the time the flow of the river reaches the middle Guajira (Contreras 2019), it is reduced to almost a trickle (Guardian 2015; Contreras et al. 2016). While the *Wayuu* indigenous community does not have access to the basic requirement of 2 l of water per person per day for cleaning and for preparing food (Guillén 2016), the coal mine uses 17 million liters per day (Correa 2015; Avilés 2019). Additionally, a 3.6 km section of the Arroyo Bruno (Bruno Stream), a tributary of the Rancheria River, was diverted into a new channel in 2016 to extract 35 million tons of coal located under it (Silva 2016).

Our hypothesis was that the high child mortality rate between 2012 and 2016 in La Guajira was triggered by the lack of access to water sources due to the drought caused by the El Niño event. The child mortality rates in La Guajira rose to 23.4 per 1000 in this period (CCG 2017).

The next section reviews the literature on the concept and the indices to measure drought, water scarcity, and

Fig. 3 Data collection areas and landmarks in La Guajira

food insecurity in the world, Latin America, and the Caribbean. The third section describes the methodology of the study, including data collection and statistical analysis. The fourth and fifth sections describe and discuss the results, respectively. Section sixth addresses the conclusion of the research and section seventh the recommendations.

2 Literature Review

Between 1994 and 2013, more than one billion people were affected by drought worldwide (UNISDR and CRED 2015). There are two common definitions of drought in the literature: a conceptual definition and an operational one (Pedro-Monzonís et al. 2015). The conceptual definition describes droughts as a natural hazard that results from a reduction in precipitation, which turns into an insufficient amount of water to meet the needs of human activities or ecosystems (Estrela and Vargas 2012). The operational definition focuses on identifying the beginning, end, and severity of droughts. According to the conceptual definition, there are four kinds of droughts: meteorological, agricultural, hydrological, and socioeconomic (Mishra and Singh 2010). Delbiso et al. (2017), describe drought as a slow-onset natural cyclical event that worsens gradually, and, if not addressed properly, ends in destitution, starvation, and death. The continued shortage of precipitation is defined as a meteorological drought. It usually triggers other kinds of droughts and affects large areas. Agricultural drought is a moisture deficit in the root area that fails to meet the needs of crops, while hydrological drought is considered a period of low flows and below-normal flows in watercourses, lakes, and low groundwater levels. Socioeconomic drought is linked to the effect of water scarcity on people and economic activity, thus causing social and environmental impacts (Mishra and Singh 2010). There are several indices to quantify, monitor, and analyze drought, such as the standardized precipitation evapotranspiration index (SPEI), the standardized precipitation index, and the Palmer drought severity index (Delbiso et al. 2017).

Early warning systems (EWS) are defined as the timely provision of information through recognized institutions that allow individuals exposed to a drought hazard to act and reduce its impact and prepare for effective responses (Wilhite and Svoboda 2000). An early warning system is one of the behavioral anticipated climate change adaptation (CCA) options to help farmers make informed decisions for harvesting crops. Early warning systems enable farmers to predict droughts, take preventive measures, and adopt coping strategies (FAO 2013). Nhamo et al. (2019) assessed the spatiotemporal changes in water resources over time in southern Africa to measure the changes in aridity and rainfall patterns to justify the need for an EWS.

Water availability depends on precipitation, seasonal cycles, snow peaks, and evaporation rates. Local climate and the evolution of droughts will vary with location. Water scarcity is due not only to lack of rain, but also due to human actions (Jaeger et al. 2013). The scarcity of water in a region must be understood in the spatial and temporal context. Availability of water resources is defined as the ability to obtain water to fulfill basic needs, taking into account the time and distance to collect the water, rights to access, and costs (Desalegn et al. 2006). Water scarcity is a general problem in arid and semiarid regions such as the Yellow, Jordan, Murray-Darling, Colorado, and the Rio Grande rivers. The impacts of climate change will exacerbate water scarcity and make droughts more frequent (Kahil et al. 2016).

Allouche (2011) emphasizes that the stress on water and food systems can be induced by war or conflict, economic crisis, or climate change. About 70% of global freshwater is used for agricultural purposes. International commissions have recommended increasing investment in irrigated agriculture in Sub-Saharan Africa to improve food production, livelihoods, and the resilience of communities to climate change. In rural communities in Namibia, for example, user associations administer and set the rules for water management practices. The rules regulate boundaries and define contributions from members and outsiders. Research by Schnegg and Bollig (2016) demonstrated that during the 2012–2014 meteorological drought in Namibia, kinship and reciprocity took priority over formal agreements.

Undernourishment in Latin America and the Caribbean has increased in recent years. In 2016, around 42.5 million people (6.5%) from a total of 653,962,331 inhabitants did not have enough food to cover their daily calorie intake needs. These official figures represent an increase of 6% compared to the previous year (FAO and PAHO 2017). The increase can be explained by the unfavorable economic conditions faced by Latin America and the Caribbean in the last few years (FAO and PAHO 2017). The country with the greatest proportion of undernourishment in the region is Haiti, where 47% of the population is unable to cover its minimum dietary requirements. Other countries that show recent increases in the prevalence of undernourishment in Latin America and the Caribbean are Argentina, Ecuador, El Salvador, Grenada, Peru, and Venezuela. The most significant increase has been observed in Venezuela (FAO and PAHO 2017). Nevertheless, organizations such as the Food and Agriculture Organization of the United Nations (FAO) and the Pan American Health Organization (PAHO) (2017) state that the food production of the region can cover the food needs of its population. Raleigh and Urdal (2007) indicated that climate change will influence the food-producing capacity in many areas of the world. They consider that resource scarcity is the consequence of the interaction of three factors: population growth, resource degradation, and the unfair distribution of resources among individuals and groups. Developing countries are more sensitive to resource scarcity.

Food security is considered to exist when everyone has access to sufficient, safe, and nutritious food at all times to maintain an active and healthy life (Cook 2002; Coleman-Jensen et al. 2013); this is a suitable environment in which to raise a child. Food security includes availability, accessibility (Poblacion et al. 2014), utilization, and stability of food for a healthy and active life (FAO et al. 2015). Healthy and affordable food must be on the market (Poblacion et al. 2016). The Intergovernmental Panel on Climate Change (IPCC) classifies areas with acute food insecurity into five phases: minimal, stressed, crisis, emergency, and famine (FAO/FSNAU 2006). Food insecurity (FI) is defined as the limited or uncertain access to nutritious food or to a diet sufficient in the quantity necessary for productive and healthy life (Pérez-Escamilla and Segall-Corrêa 2008; FAO 2012) in socially acceptable ways due to financial constraints (Pérez-Escamilla and Segall-Corrêa 2008). Food is important to maintain the function of body systems, especially in children (Poblacion et al. 2016).

Per capita or household income is an indicator of financial resources to purchase food and other goods and services. Variables such as type of water system, sewage system connection, and construction materials indicate housing quality, which is also related to the affordability of food at the household level (Poblacion et al. 2014). Household FI affects children's nutritional status by compromising the quality and quantity of dietary intake, producing undernutrition, and affecting parents, who do not have enough energy to provide care, prevent illness, and develop stimulation; this can also lead to depression (Weinreb et al. 2002; Hadley et al. 2008; Pérez-Escamilla et al. 2009; Poblacion et al. 2016) and stress (Fischer et al. 2014; Weigel et al. 2016). Food-insecure households consume less nutrient-dense foods due to lack of financial resources, increasing their risk of undernutrition and hospitalization (Perez-Escamilla et al. 2012). Improving the income of food-insecure households is essential to increase the consumption of vegetables, fruits, and meat (Bortolini et al. 2012). Living in a food-insecure household hinders human and socioeconomic development and contributes to the cycle of underdevelopment and malnutrition (Poblacion et al. 2016).

Food insecurity is prevalent in many low- and middle-income Latin American countries (Ribera 2012; Rodriguez et al. 2016; Smith et al. 2017; Sperandio et al. 2018; Espinosa-Cristia et al. 2019; de Sousa et al. 2019). One of the indicators to benchmark the severity of a crisis is the official child mortality rate, which also represents the general health of the population in a country (Working Group for Mortality Estimation in Emergencies 2007). The health impacts of drought are long-lasting and complex. Drought is linked to high mortality due to health problems related to undernutrition, micronutrient deficiency, and food- and water-borne diseases. Drought also aggravates chronic diseases, decreases crop and livestock production, contributes to the inflation of food prices, and leads to migration (Reuveny 2007; Jülich 2011). Poverty, deficient health infrastructure, and poor sanitation make the impacts of drought even worse (Stanke et al. 2013; Ebi and Bowen 2016). Limited household resources make children vulnerable to difficult health outcomes (Cook et al. 2004).

3 Methodology

The methodology section is divided into two subsections: data collection and data analysis. The data collection is from primary and secondary sources at the municipal level. The data analysis subsection explains the method of the socioeconomic vulnerability assessment and addresses the statistical analysis: correlation and regression.

3.1 Data Collection

Primary and secondary data were collected for the region of La Guajira. The primary data were collected in fieldwork through interviews (14), meetings (12), and workshops (3) (Contreras 2019). Between January 2017 and September 2018, 14 interviews with community members including social leaders, fishers, farmers, *Wayuu* indigenous, colombians who returned from Venezuela, and people relocated due to the mine activities took place in the city of Riohacha and the townships of Atnamana-I, Chancleta, Camarones, and Garrapateros. The location of these places is plotted in Fig. 3. We visited Camarones because we were aware of the coping capacities and adaptation strategies of the fishers living there. Atnama I, Chancleta, and Garrapateros were visited following the suggestions of the nongovernmental organization (NGO) named Peace's Fabrics working in the case study area. In Atnamama I we could observe the problems of the farmers with the drought and their adaptation strategies. In the case of Chancleta, we noted the social uprooting due to the forced relocation caused by the mine activities (Avilés 2019). Garrapatero was visited to observe the resettlement of Venezuelan immigrants in a nature reserve that receives monetary compensation due to its environmental services. Additionally, 12 meetings were held with representatives of governmental institutions such as National Natural Parks and Unit of Risk due to Disaster Management (UNGRD for its acronym in Spanish), NGOs such as Diocese of Riohacha, Action Against Hunger (ACH), Food and Agriculture Organization of the United Nations (FAO), World Food Program (WFP)/PMA, Peace's Fabrics, Malteser International, and United Nations Office for the Coordination of Humanitarian Affairs (OCHA), and National Department of Planning (DNP for its acronym in Spanish). Three workshops also took place: two with community groups, the first workshop took place in Camarones and the second one in Garrapatero where the participatory assessment of climate and disaster risks methodology (PACDR) was applied by Diaz and Rubiano (2018). The third workshop took place in Riohacha with representatives of NGOs working in the case study area, governmental institutions, and the University of La Guajira to present the results of the assessment of climate change evaluation strategies in La Guajira, the application of the PACDR (Keller and Künzler 2014) methodology in Camarones and Garrapatero, and to design an action plan with the participants. Most of the activities were conducted within the framework of the project sponsored by the Swiss NGO Disaster Risk Reduction (DRR) platform and undertaken jointly with Caritas Switzerland (CACH) to assess the impact of climate change in La Guajira, Colombia and opportunities for adaptation.

The primary data are qualitative in nature and were collected from a combination of unstructured and semistructured interviews recorded in audio and video. The interviews were focused on assessing the socioeconomic vulnerability conditions, and the existing coping and adaptation strategies of the inhabitants in La Guajira in the face of the challenges imposed by the impact of increased drought on the region.

The secondary data comprise the child mortality rates at the municipal level for the period from 2012 to 2016 published by the National Department of Statistics of Colombia (DANE 2017). Table 1 and Fig. 2 show the child mortality rates in La Guajira for under 1 year out of 1000 live births. The highest child mortality rates are observed in the municipalities of Uribia and Maicao.

The selected socioeconomic variables by municipality were identified from the interviews, meetings, and workshops involving the attendants of the workshops in Camarones and Garrapatero, the officials from governmental institutions, NGOs, and the University of La Guajira. Table 2 and Fig. 3 show a summary of the selected

Table 1 Child mortality rates by municipality in La Guajira, Colombia. *Source* DANE (2017)

Number	Municipality	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
1	Riohacha	24.0	23.0	21.9	21.3	28.5	28.5	26.6	24.1	25.6	26.7
2	Albania	31.9	31.9	31.9	31.7	26.8	24.1	24.1	23.9	24.1	24.6
3	Barrancas	28.8	28.1	27.3	26.8	23	23	22.4	20.2	19.2	21.6
4	Dibulla	28.1	26.8	25.5	25.5	18.3	16.5	15.1	15.1	14.7	15.9
5	Distracción	24.5	23.4	22.2	20.4	25.1	22.6	21.8	21.8	21.9	22.6
6	El Molino	28.7	27.5	26.3	25.1	17.7	15.9	16.9	17.7	17.3	17.1
7	Fonseca	20.6	19.7	18.7	17.7	25.5	23	24.5	24.4	24.8	24.4
8	Hatonuevo	29.2	27.9	26.5	25.5	19.1	17.2	17.2	18.4	17.9	18.0
9	La Jagua del Pilar	21.0	20.1	19.1	19.1	26.1	23.5	22.7	21.8	22.2	23.3
10	Maicao	30.1	29.6	29.0	29.0	48.8	48.8	47.7	49.6	47.9	48.6
11	Manaure	54.4	54.4	54.4	54.3	19.1	18.8	18.5	19.2	18.9	18.9
12	San Juan del Cesar	19.9	19.3	18.6	17.2	17.2	15.5	15.9	15	15.2	15.8
13	Uribia	53.8	53.8	53.8	53.8	53.8	48.4	45.4	48.9	48.5	49.0
14	Urumita	14.8	14.1	13.5	12.1	12.1	11.3	11.4	10.1	10.9	11.2
15	Villanueva	17.0	16.2	15.5	13.9	13.9	12.5	13.7	14.1	13.7	13.6

Deaths of children under 1 year out of 1000 live births, 2012–2016

variables by municipality in La Guajira and the level of socioeconomic vulnerability in La Guajira, respectively.

3.2 Data Analysis

3.2.1 Socioeconomic Vulnerability Assessment

We normalized the values of the variables to estimate the level of socioeconomic vulnerability per municipality using Eq. 1. Later the normalized values of these socioeconomic variables were integrated summing them using equal weight. The total of this sum was also normalized using again Eq. 1 and the outcoming values were classified into five nominal categories: very low, low, medium, high, and very high.

$$Z_i = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad (1)$$

where Z_i is the normalized value, x_i is the index of the variable, x is the raw value of the variable

3.2.2 Correlation Analysis

Pearson's correlation was used in this study to measure the relationship between the child mortality rate at the municipal level for the period 2012–2016 and the socioeconomic indicators presented in Table 2. According to the literature review and the fieldwork observations, these variables can be associated with child mortality during the drought.

3.2.3 Regression Analysis

Since correlation only suggests the strength of a relationship and not the causality between indicators, it is still necessary to perform a regression analysis to test the predictive power of the indicators chosen. A stepwise regression analysis considered the average child mortality rate at the municipal level between 2012 and 2016 as the dependent variable, and the socioeconomic variables were used to remove the weakest correlated variables and identify those that best explained the distribution, avoiding collinearity between the independent variables (Fig. 4).

4 Results

This section is divided into three subsections: socioeconomic vulnerability assessment, correlation analysis, and regression analysis.

4.1 Socioeconomic Vulnerability Assessment

The result of the socioeconomic vulnerability assessment shows the highest level of vulnerability in the north and middle of the department, while the lowest levels of vulnerability are observed in the south (Fig. 5).

4.2 Correlation Analysis

Between 2012 and 2016, at the municipal level, a statistically significant positive correlation can be observed in La

Table 2 Variables of socioeconomic vulnerability in La Guajira, Colombia. *Sources* REDATAM - CCG (2017). Study on the territorial economic performance of La Guajira. Retrieved from http://www.camaraguajira.org/publicaciones/informes/estudio-economico-de-la-guajira-2017.pdf

Number	Municipality	Total population	Rural population	Number of people per household	Population younger than 5 years old	population older than 65 years old	Households with less than us$100 monthly income	Households without access to a water source	Households without a sewage system	Population without health Insurance	Illiterate population	Native indigenous population
		Number	Number	Number	Number	Number	Number	Number	Number	Number	Number	Number
1	Riohacha	277,868	41,054	8	24,850	7145	833	11,062	15,151	53,078	29,545	31,991
2	Albania	27,589	13,852	7	3885	555	69	935	2015	5601	4320	5583
3	Barrancas	36,134	17,572	7	4369	1143	184	2290	2146	6543	5633	8309
4	Dibulla	35,404	29,651	8	4354	861	111	823	3858	6964	7406	5282
5	Distracción	16,484	10,933	7	2118	583	170	817	1109	4760	3340	4852
6	El Molino	8940	2782	7	1043	454	163	506	557	2474	1731	1329
7	Fonseca	34,286	12,004	6	3988	1325	171	2627	2576	11,620	5352	4760
8	Hatonuevo	26,782	11,666	9	2681	481	51	1083	1163	5557	4074	5378
9	La Jagua del Pilar	3289	953	8	552	125	13	167	158	531	596	503
10	Maicao	162,118	50,968	10	20,663	3540	1016	4964	11,116	43,004	25,067	40,720
11	Manaure	112,103	63,501	7	13,400	3410	335	980	9750	21,949	28,035	46,357
12	San Juan del Cesar	38,351	12,996	6	4039	1731	277	3452	3160	11,032	5992	7191
13	Uribia	186,532	173,143	10	17,694	6418	1685	1072	18,612	73,264	68,426	105,979
14	Urumita	18,792	7710	7	2393	720	34	1237	1159	4453	3733	4519
15	Villanueva	28,254	8599	6	3462	1445	104	2941	1252	6420	5370	4579

REDATAM is a friendly and interactive computer system that facilitates the processing, analysis, and web dissemination of information from population censuses, surveys, administrative records, national/regional indicators, and any other sources

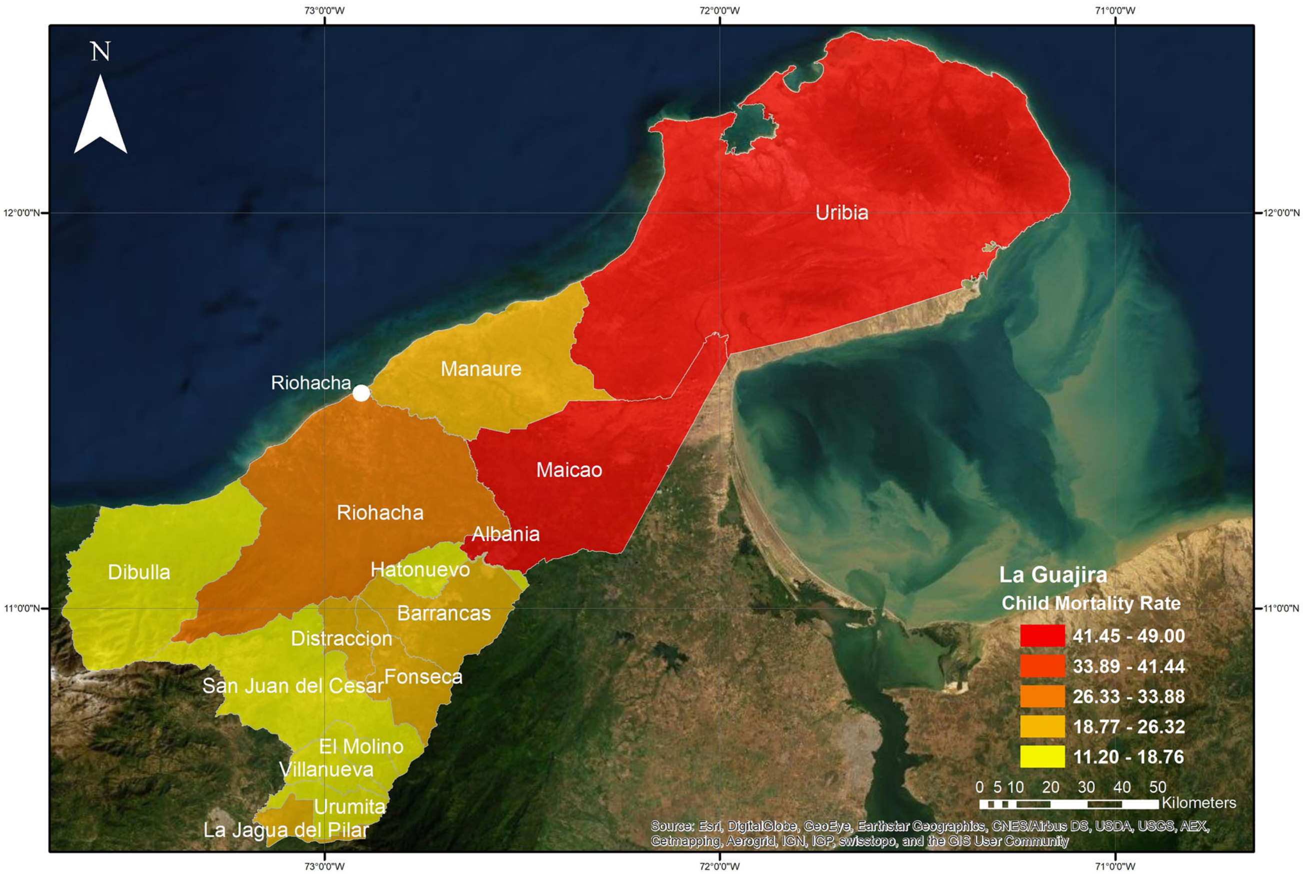

Fig. 4 Five year average (2012–2016) child mortality rates by municipality in La Guajira, Colombia

Guajira between the average child mortality rate and households with a monthly income of less than USD 100 ($r = 0.868$** and $p = 0.000$), the number of people without health insurance ($r = 0.803$** and $p = 0.000$), and the size of the native indigenous population ($r = 0.763$** and $p = 0.001$). There is also a significant positive correlation between the average child mortality rate and the number of illiterate people ($r = 0.746$** and $p = 0.001$), the number of households without a sewage system ($r = 0.734$** and $p = 0.002$), the size of the rural population ($r = 0.729$** and $p = 0.002$), the number of people per household ($r = 0.712$** and $p = 0.003$), and the number of people younger than 5 years old ($r = 0.690$** and $p = 0.004$). There is no correlation between the number of households without access to a water source ($r = 0.226$ and $p = 4.18$) and the average child mortality rate in contrast to expectations. The results of the correlation analysis are presented in Table 3.

4.3 Regression Analysis

The regression analysis considers the average child mortality rate at the municipal level between 2012 and 2016 as the dependent variable, and it takes all the socioeconomic variables as independent variables. Those that best explain the distribution were households with a monthly income of less than USD 100, the number of people older than 65, and the number of people younger than 5 years old.

Table 4 presents a summary of the model provided by SPSS 25. Table 4a lists the variables selected for the final model. Table 4b includes the value of the correlation coefficient, or R, and the derived R^2 for the model considering only the variables listed in Table 4a. Table 4c lists the excluded variables due to their degree of collinearity. According to Table 4b the average child mortality rate against the socioeconomic variables selected, R has a value of 0.951, and R^2 is 0.904. This shows that belonging to a household with a monthly income of less than USD 100, with no members older than 65, but several children younger than 5 years old, accounts for 90.4% of the child mortality rate at the municipal level for the period 2012–2016 in La Guajira, Colombia.

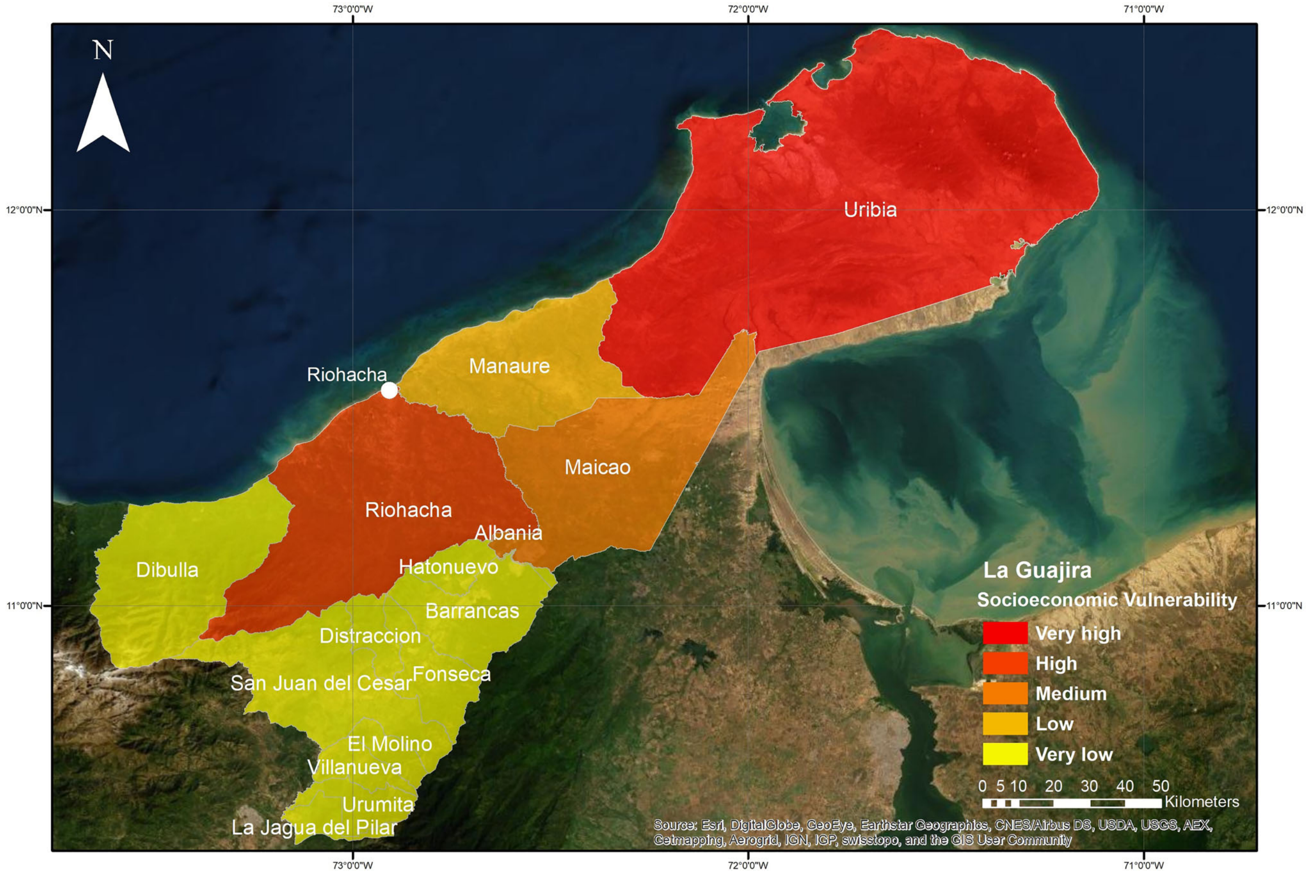

Fig. 5 Socioeconomic vulnerability in La Guajira, Colombia

5 Discussion

The very high, high, medium, and low levels of socioeconomic vulnerability correspond with the driest natural subregions of the department—the high and middle Guajira, while the lowest level of socioeconomic vulnerability is identified in the low Guajira, the natural subregion with more agriculture potential and water availability. Based on this finding we can assume that the most affected by the drought due to their location are the *Wayuu* indigenous community. Besides the drought, a factor that could have contributed to reducing the income of the *Wayuu* families, especially in the municipalities of Uribia and Maicao, is the intermittent closing of the borders with Venezuela due to the political turmoil and the shortage of basic products in Venezuela, and the lack of connection of La Guajira's economy with the rest of Colombia (Contreras et al. 2016). Uribia and Maicao are located on the border with Venezuela, their inhabitants have coped with drought with seasonal migration and smuggling. Nevertheless, the closing of the border by the Venezuelan army did not stop the migration from Venezuela to Colombia. The *Wayuu* in Venezuela flee hunger, hyperinflation, and political repression in Venezuela to claim their rights to land and settle in Colombia. These rights are justified by the presence of the remains of their ancestors resting in the *Wayuu* cemeteries in La Guajira. The arrival of the Venezuelan *Wayuu* has generated conflict with the Colombian *Wayuu* clans already living in those territories, not only due to some cultural differences, even though they are also *Wayuu*, but also because of the additional pressure that their presence represents on scarce resources such as land, water, and food. These facts have generated xenophobia, and the Venezuelan *Wayuu* are, for example, accused of bringing illness, which could be the result of the poor condition of the healthcare infrastructure in Venezuela (Casey and Iguarán 2019). The low-skill jobs that in the past used to be a source of income for the Colombian *Wayuu* during drought are now sometimes occupied by migrants from Venezuela, and the humanitarian aid to respond to the hunger among the *Wayuu* population had to be extended to include the migrant population of Venezuela (Contreras 2019). This population usually arrives in exceptionally poor health conditions due to hunger in Venezuela and the long walking journey to reach the Colombian border, which involves risking their lives when they cannot go through legal immigration control due to the lack of passports.

Table 3 Pearson's two tailed bivariate correlation between the average child mortality in 2012–2016 and selected social vulnerability indicators in La Guajira, Colombia

Socioeconomic variables	Average child mortality between 2012 and 2016	Rural population	Number of people per household	Population younger than 5 years old	Population older than 65 years old	Households with less than US$100 monthly income	Households without access to a water source	Households without a sewage system	Population without health insurance	Illiterate population	Native indigenous population
Average child mortality between 2012 and 2016											
Pearson correlation	1	0.729**	0.712**	0.690**	0.619*	0.868**	0.226	0.734**	0.803**	0.746**	0.763**
Sig. (2-tailed)		0.002	0.003	0.004	0.014	0.000	0.418	0.002	0.000	0.001	0.001
N	15	15	15	15	15	15	15	15	15	15	15
Rural population											
Pearson correlation	0.729**	1	0.600*	0.656**	0.759**	0.900**	0.060	0.867**	0.870**	0.976**	0.984**
Sig. (2-tailed)	0.002		0.018	0.008	0.001	0.000	0.830	0.000	0.000	0.000	0.000
N	15	15	15	15	15	15	15	15	15	15	15
Number of people per household											
Pearson correlation	0.712**	0.600*	1	0.528*	0.410	0.619*	0.010	0.568*	0.590*	0.591*	0.618*
Sig. (2-tailed)	0.003	0.018		0.043	0.129	0.014	0.973	0.027	0.021	0.020	0.014
N	15	15	15	15	15	15	15	15	15	15	15
Population younger than 5 years old											
Pearson correlation	0.690**	0.656**	0.528*	1	0.937**	0.825**	0.714**	0.936**	0.906**	0.786**	0.739**
Sig. (2-tailed)	0.004	0.008	0.043		0.000	0.000	0.003	0.000	0.000	0.001	0.002
N	15	15	15	15	15	15	15	15	15	15	15
Population older than 65 years old											
Pearson correlation	0.619*	0.759**	0.410	0.937**	1	0.869**	0.674**	0.966**	0.951**	0.876**	0.817**
Sig. (2-tailed)	0.014	0.001	0.129	0.000		0.000	0.006	0.000	0.000	0.000	0.000
N	15	15	15	15	15	15	15	15	15	15	15
Households with less than US$100 monthly income											
Pearson correlation	0.868**	0.900**	0.619*	0.825**	0.869**	1	0.379	0.928**	0.973**	0.943**	0.928**
Sig. (2-tailed)	0.000	0.000	0.014	0.000	0.000		0.164	0.000	0.000	0.000	0.000
N	15	15	15	15	15	15	15	15	15	15	15
Households without access to a water source											
Pearson correlation	0.226	0.060	0.010	0.714**	0.674**	0.379	1	0.515*	0.517*	0.252	0.151
Sig. (2-tailed)	0.418	0.830	0.973	0.003	0.006	0.164		0.050	0.049	0.364	0.591
N	15	15	15	15	15	15	15	15	15	15	15

Table 3 continued

Socioeconomic variables	Average child mortality between 2012 and 2016	Rural population	Number of people per household	Population younger than 5 years old	Population older than 65 years old	Households with less than US$100 monthly income	Households without access to a water source	Households without a sewage system	Population without health insurance	Illiterate population	Native indigenous population
Households without a sewage system											
Pearson correlation	0.734**	0.867**	0.568*	0.936**	0.966**	0.928**	0.515*	1	0.978**	0.945**	0.909**
Sig. (2-tailed)	0.002	0.000	0.027	0.000	0.000	0.000	0.050		0.000	0.000	0.000
N	15	15	15	15	15	15	15	15	15	15	15
Population without health insurance											
Pearson correlation	0.803**	0.870**	0.590*	0.906**	0.951**	0.973**	0.517*	0.978**	1	0.946**	0.910**
Sig. (2-tailed)	0.000	0.000	0.021	0.000	0.000	0.000	0.049	0.000		0.000	0.000
N	15	15	15	15	15	15	15	15	15	15	15
Illiterate population											
Pearson correlation	0.746**	0.976**	0.591*	0.786**	0.876**	0.943**	0.252	0.945**	0.946**	1	0.990**
Sig. (2-tailed)	0.001	0.000	0.020	0.001	0.000	0.000	0.364	0.000	0.000		0.000
N	15	15	15	15	15	15	15	15	15	15	15
Native indigenous population											
Pearson correlation	0.763**	0.984**	0.618*	0.739**	0.817**	0.928**	0.151	0.909**	0.910**	0.990**	1
Sig. (2-tailed)	0.001	0.000	0.014	0.002	0.000	0.000	0.591	0.000	0.000	0.000	
N	15	15	15	15	15	15	15	15	15	15	15

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Table 4 Results from the stepwise regression analysis between average child mortality from 2012 to 2016 and selected socioeconomic indicators in La Guajira, Colombia

Model	Variables Entered	Variables removed	Method
(a) Variables selected			
1	Households with less than US$100 monthly income		Stepwise (Criteria: Probability-of-F-to-enter <= 0.050, Probability-of-F-to-remove > = 0.100)
2	Population older than 65 years old		Stepwise (Criteria: Probability-of-F-to-enter <= 0.050, Probability-of-F-to-remove > = 0.100)
3	Population younger than 5 years old		Stepwise (Criteria: Probability-of-F-to-enter <= 0.050, Probability-of-F-to-remove > = 0.100)

Model	R	R square	Adjusted R square	Std. error of the estimate	Change statistics				
					R square change	F change	df1	df2	Sig. F change
(b) Model summary									
1	0.868	0.754	0.735	0.016422388264325	0.754	39.830	1	13	0.000
2	0.911	0.829	0.801	0.014235514872487	0.075	5.301	1	12	0.040
3	0.951	0.904	0.878	0.011164160710079	0.074	8.511	1	11	0.014

Model	beta in	t	Sig.	Partial correlation	Collinearity Statistics		
					Tolerance	VIF	Minimum tolerance
(c) Excluded variables							
Model 1							
Number of people per household	0.282	1.733	0.109	0.447	0.617	1.620	0.617
Population younger than 5 years old	− 0.084	− 0.334	0.744	− 0.096	0.319	3.133	0.319
Population older than 65 years old	− 0.555	− 2.302	0.040	− 0.554	0.245	4.082	0.245
Households without access to a water source	− 0.121	− 0.799	0.440	− 0.225	0.856	1.168	0.856
Households without a sewage system	− 0.523	− 1.476	0.166	− 0.392	0.138	7.244	0.138
Population without health insurance	− 0.782	− 1.360	0.199	− 0.365	0.054	18.590	0.054
Illiterate population	− 0.651	− 1.690	0.117	− 0.438	0.112	8.963	0.112
Native indigenous population	− 0.306	− 0.818	0.430	− 0.230	0.139	7.218	0.139
Model 2							
Number of people per household	0.188	1.191	0.259	0.338	0.551	1.815	0.162
Population younger than 5 years old	0.783	2.917	0.014	0.660	0.122	8.225	0.093
Households without access to a water source	0.237	1.238	0.242	0.350	0.371	2.693	0.106
Households without a sewage system	0.454	0.696	0.501	0.205	0.035	28.568	0.035
Population without health insurance	2.022	1.640	0.129	0.443	0.008	121.902	0.008
Illiterate population	− 0.417	− 1.105	0.293	− 0.316	0.098	10.178	0.098
Native indigenous population	− 0.266	− 0.818	0.431	− 0.239	0.138	7.240	0.102
Model 3							
Number of people per household	0.001	0.005	0.996	0.002	0.408	2.454	0.062
Households without access to a water source	0.053	0.301	0.770	0.095	0.302	3.312	0.080
Households without a sewage system	− 0.191	− 0.332	0.746	− 0.105	0.029	34.649	0.029
Population without healthinsurance	1.282	1.218	0.251	0.359	0.008	132.180	0.008
Illiterate population	− 0.090	− 0.265	0.796	− 0.084	0.083	12.019	0.070
Native indigenous population	− 0.070	− 0.257	0.802	− 0.081	0.128	7.828	0.087

Dependent variable: Average child mortality between 2012 and 2016

1. Predictors: (Constant), Households with less than US$100 monthly income

2. Predictors: (Constant), Households with less than US$100 monthly income, Population older than 65 years old

3. Predictors: (Constant), Households with less than US$100 monthly income, Population older than 65 years old, Population younger than 5 years old

Illiteracy in La Guajira must be understood as the inability to read or write Spanish. A significant proportion of the *Wayuu* population only speaks *Wayuunaiki*, the official *Wayuu* language (Hostein 2012; CC 2015), and they are not able to communicate in Spanish. This is confirmed by the strong correlation between the size of the illiterate population and the native indigenous population ($r = 0.990^{**}$ and $p = 0.000$). This explains the strong correlation between the average child mortality rate and illiteracy: when *Wayuu* mothers arrive at healthcare facilities with highly undernourished children, they cannot understand the medical diagnosis and treatment recommendations and are unable to follow the proper treatment (Pirry 2014; CC 2015).

The strong correlation between the size of the rural population and child mortality can be explained by all the challenges that communities in rural areas, and mainly indigenous communities ($r = 0.990^{**}$ and $p = 0.000$) in Uribia, Manaure, Maicao, and Riohacha, have to face, such as a monthly income of less than USD 100 ($r = 0.984^{**}$ and $p = 0.000$), the lack of a sewage system ($r = 0.867^{**}$ and $p = 0.000$), and a lack of health insurance ($r = 0.870^{**}$ and $p = 0.000$. Another factor is the lack of birth control among the *Wayuu* communities, which explains the strong correlation between the size of the rural population and the number of people per household in rural areas ($r = 0.600^{**}$ and $p = 0.018$), as well as the number of people younger than 5 years old ($r = 0.600^{**}$ and $p = 0.018$). There is also a highly significant correlation between the size of the rural population and the number of people older than 65 years old ($r = 0.750^{**}$ and $p = 0.001$).

According to Raleigh and Urdal (2007), in arid environments water scarcity is the consequence of the unfair distribution of water resources. The results of the correlation analysis dismiss lack of access to a water source as the primary reason for child mortality ($r = 0.226$ and $p = 0.418$). This lack of correlation can be explained by the fact that, although there is no infrastructure for water supply in Uribia and Maicao, the municipalities with the highest rates of child mortality, the government and the private sector supply drinking water to these municipalities using water tanker trucks.

The explanatory power of the average child mortality between 2012 and 2016 due to the number of households with less than USD 100 monthly income is justified because of the reduction in the income of the families due to the political and economic problems of Venezuela and the lack of connection of the La Guajira with the rest of Colombia. The negative explanatory power of the number of people older than 65 years old for child mortality can be understood as the presence in the household of a person with assets such as animals and savings accumulated through his/her life that can be used for consumption or to purchase food during drought, which reduces the probability of child mortality in that specific household.

6 Conclusion

Taking into account the correlation analysis, it can be concluded that the drivers of child mortality during the 2012–2016 period were the high socioeconomic vulnerability conditions. The level of socioeconomic vulnerability of the inhabitants in La Guajira is in turn determined by the natural subregion where they live. The agriculture potential and the availability of water in the low Guajira allow to have crops and raise animals, hence to have an income greater than USD 100 to cover basic needs and even make profit, which in turn contributes to having the lowest child mortality rates in the department. Unfortunately, *Wayuu* indigenous community inhabits the driest subnatural regions—high and middle La Guajira, which make them more vulnerable.

The hypothesis that the high child mortality rate between 2012 and 2016 in La Guajira was triggered by the lack of access to water sources due to the drought caused by the El Niño event is rejected in the sense that variables such as households with a monthly income of less than USD 100, the number of people older than 65 years old, and the number of children younger than 5 years old were determined by the stepwise regression analysis as the explanatory variables of this phenomenon.

If the *Wayuu* indigenous community had an income to cover their basic needs; health insurance adapted to their traditions, with medical doctors and nurses able to speak their language and involving traditional *Wayuu* healers in their prevention campaigns; and adequate interdependent infrastructure such as paved roads, water and sewage systems, electricity, and communications and healthcare facilities in the rural areas, they could have faced the drought without the observed increase in child mortality rates. Rather than water scarcity, the real problem could be the lack of basic sanitation due to the lack of sewage systems, which results in the contamination of the water stored by communities or taken from the *jagüeyes* (open-air water reservoirs); this mainly affects children (Avilés 2019). This could be the reason for the acute diarrheal disease that is usually linked to undernourishment in La Guajira.

The existence of an effective EWS in La Guajira could have prevented or at least reduced the level of child mortality among the *Wayuu* population, allowing the government to design a plan based on a spatial planning support system (SPSS) to distribute food supplements and drinking water and monitor health condition among children.

7 Recommendations

It is essential to reduce the socioeconomic vulnerability in La Guajira, and mainly in the municipalities located in the high and middle Guajira. This would allow the communities to be prepared for the challenges imposed by climate change and would increase their resilience through adaptation measures rather than coping capacities.

It is vital to train the inhabitants of La Guajira on the importance of techniques to diversify income risk or to earn off-farm income, for instance with ecotourism (Contreras et al. 2016) and ethno-tourism. It is important to implement adaptation strategies based on ecosystem services as an alternative source of income involving tourist guides, fishermen, the *Wayuu* indigenous community, the National Natural Parks of Colombia, and the Ministry of Business, Industry, and Tourism (Contreras 2019). Some such activities already exist, such as birdwatching in the township of Camarones and windsurfing in El Cabo de la Vela. It is necessary to increase the coverage of health insurance by providing more facilities, increasing the capacity of the existing ones, and/or strengthening the already existing mobile health brigades. It is essential to improve basic sanitation in the *Wayuu* settlements. Moreover, new methods should be considered to collect water such as surface runoff rainwater harvesting and fog water harvesting through nets (Nash 1992; Abdul-Wahab and Lea 2008; Fessehaye et al. 2014; LeBoeuf and de la Jara 2014; Dodson and Bargach 2015; Harb et al. 2016).

According to Desalegn et al. (2006), there should be a network of EWS for drought so that farmers can be prepared and reduce the next drought's impact on them and their region. It is necessary to enhance the existing EWS in La Guajira developed by the UNGRD and FAO to be prepared for the next drought.

Another recommendation is to resort to a government drought relief program, which would act as a safety net to obtain financial services, such as access to microinsurance (Hallegatte 2016), supplemental feed, or water (Nagler et al. 2007; Coppock 2011; Wilmer 2016; Shrum et al. 2018), or programs such as "cash for work" pioneered by the FAO.

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[2] PNUD (Programa de las Naciones Unidas para el Desarrollo/United Nations Development Programme – UNDP) https://www.undp.org/.

[3] MADS (Ministerio de Ambiente y Desarrollo Sostenible/Ministry of Environment and Sustainable Development) https://www.minambiente.gov.co/.

[4] DNP (*Departamento Nacional de Planeación*/National Planning Department) https://www.dnp.gov.co/DNPN/Paginas/default.aspx.

[5] CANCILLERIA (*Ministerio de Relaciones Exteriores*/Ministry of Foreign Affiars) https://www.cancilleria.gov.co/.

[6] FMAM (*El Fondo para el Medio Ambiente Mundial*/The Fund for Global Environment Facility – GEF) http://www.fao.org/gef/es/.

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