September 2017
Volume: 14, **No**: 3, pp. 384– 396
ISSN: 1741-8984
e-ISSN: 1741-8992
www.migrationletters.com

Article history: Received 13 June 2017; Accepted 6 September 2017

CASE STUDY

Climate change and migration in the rural sector of northern Mexico (Zacatecas and San Luis Potosí)

Ana María Aragonés Castañer [±]
Uberto Salgado Nieto [¥]

Abstract

In this paper we study the effects of climate change on rural populations and the circumstances under which some of them are forced to abandon their communities becoming part of international migratory flows. In our study we claim that climate change is a new factor that leads the population to abandon their regions in order to overcome their vulnerability. In our opinion the lack of measures implemented by the State has serious consequences provoking an enormous vulnerability forcing the populations to emigrate. We study two locations in Mexico, San Luis Potosi and Zacatecas, analyzing the peasants' situation working under temporary agricultural production. Using a complementary log-log estimator we found that the migration is the result of adverse economic-climatic conditions, because the poorest populations, which usually depend directly on natural resources, are the most vulnerable to climate shocks and the only way to overcome their vulnerability, has been international migration.

Keywords: climate change; environmentally induced migration; forced migration; droughts; international migration.

Introduction

The causes for the migration of labor from underdeveloped to developed countries have much to do with the economic difficulties experienced by the former in absorbing their population. These conditions represent what are called push factors, in essence, creating a forced migration in which workers have no other option but to move to destinations that can productively incorporate them under better conditions for survival.

But developed countries also have a pressing need for such workers, with a wide range of qualifications, because of the structural problem of their societies — demographic and educational shortfalls among them. We cannot ignore the fact that migrant workers are highly functional for receiving economies, because of the differences in unit labor costs (lower for immigrants than native workers), which

± Ana María Aragonés Castañer, Institute of Economic Research, Universidad Nacional Autónoma de México, México. E-mail: amaragones@gmail.com.
¥ Uberto Salgado Nieto, Institute of Economic Research, Universidad Nacional Autónoma de México, México. E-mail: ubesk8@gmail.com.

mean higher profits and more competitive products for the companies that employ them.

There is another phenomenon that has shown itself to be highly important and which also affects migration: climate change. The relationship has only begun being explored recently, and proposals vary. There are authors who do not believe climate change can be blamed for migration, and others who believe it has a unique responsibility for that phenomenon. The reality, as established by Frank Laczko (2010) is complicated, because it requires determining the role of climate change in the economic, political and social factors that encourage migration.

Current awareness of the phenomenon and our conviction that climate change exists leads us to delve further into this issue, particularly when many authors are finding that environmental migrants come primarily from rural zones of the least developed countries (Ionesco, 2017). Based on this assertion, we are prompted to ask: why, if climate change affects all countries equally, are rural zones harder hit? In seeking answers to these questions, we have formulated the following hypothesis: climate change is very real, but there are ways to mitigate it, and the ideal agent to do so is the State. Accordingly, the absence of government measures to address this phenomenon exacerbates the vulnerability of people from underdeveloped countries, and therefore migration. While some migrants travel within their own countries and others move beyond their borders to escape the effects of climate change, the reality is that the migratory phenomenon is confirmed[1].

Environmental migrants are referred to in several ways: "environmental refuges," "eco-migrants," and others. We find the definition developed by the International Organization for Migrations to be the most useful: "Environmental migrants are persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" [IOM, 2011:33]. The purpose of this definition, according to Frank Lazko [2010:2] is "to try to accompany population movements or displacement, whether temporary or permanent, internal or across borders, regardless of whether they are voluntary or forced, or the result of a sudden or gradual change in the environment."

Methodological considerations

It is widely recognized that poor countries suffer more from the risks and vulnerabilities relating to climate change. The Economic Commission for Latin

[1] Although at present there are observable movements from north to north, south to south, and north to south, the most prominent migratory flows are those that go from underdeveloped to developed countries. According to statistics from the United Nations, there are close to 232 million international migrants in the world today, 31% of which live in Europe, 23% in North America and 30% in Asia. [UN 2013].

America and the Caribbean (ECLAC) has found that an area's vulnerability to climate change relates to the extent that it is affected by the manmade or natural phenomenon considered a threat, and this in turn depends on the region's capacity to deal with it. Vulnerability, then, is understood as "the inability of a system to adapt to that climate change, and this has to do with its ecological fragility, which is related to the fragility of elements like infrastructure, housing, productive activities, degree of organization, warning systems, political-institutional development and others, all of which leads the population to suffer human and material losses, and the magnitude of those human and material losses are related to the degree of vulnerability" [Gomez, 2001].

A joint study by ECLAC and the Inter-American Development Bank (IDB) found that 95% of deaths from natural disasters in 1998 occurred in developing countries, and certain natural phenomena have had a devastating effect on standards of living and possibilities for development. In contrast, the consequences of these same climate changes on developed countries' populations have been marginal [ECLAC-IDB, 2000]. On this basis, ECLAC links the climate change situation to the vulnerability of underdeveloped countries. In other words, the poverty that exists throughout most of the underdeveloped world prevents access to basic services and to pre- and post-disaster protection, and the omissions of the State appear to be key in understanding a situation of vulnerability. As this organization points out, one of the main causes of the marked vulnerability to natural phenomena is precisely the inefficiency of public policy and the weakness of the democratic system.

Climate change has wrought havoc in the planet's most vulnerable regions, and its effects have intensified in recent decades, because the average temperature of the earth has increased by three-quarters of a degree Celsius over the past century. In the past 25 years, however, the pace of global warming has accelerated more than 0.18ºC per decade [Deheza and Mora, 2013]. Mexico is as much a victim as a cause of this climate change: it accounts for 1.5% of total greenhouse gas emissions and is among the 15 countries that burn the most fossil fuel in the world, but at the same time, it is highly vulnerable to the effects of climate change. The northern regions of the country are plagued by drought, the southeast by flooding, both coasts by extreme meteorological phenomena, and the entire country by social and economic structural weakness, the continuation of which can only heighten the latent inequalities that afflict broad segments of the Mexican population. [Moreno and Urbina, 2008].

A study by University Autonomous of Mexico (UNAM, by its Spanish acronym) calculates that the average temperature in Mexico will rise by 4°C by the end of this century, and most of the warming will take place in northern and northwestern Mexico. It also calculates that rainfall will diminish by as much as 11% in the same period, while natural hazards will worsen during extreme weather events, like those resulting from the Southern Oscillation, or El Niño, which alters rainfall

patterns and causes severe droughts, reservoir shortages and a scarcity of seasonal crops [Deheza and Mora, 2013].

Environmental processes called "gradual events"

This concept encompasses drought, desertification, and water shortage, and results in food insecurity produce by the gradual depletion of sustenance and lack of sustainability —all of which would fuel migratory movements linked, precisely, to climate change.

On this subject, Juan Manuel Torres Rojo, director of Mexico's National Forestry Commission (CONAFOR, by its Spanish acronym) says that around 400,000 Mexicans emigrate from the country every year due to desertification and the unproductivity of farmlands, which cause malnutrition, unemployment and misery. According to this same official, today six out of every 10 hectares of farmland suffer from some degree of degradation, ranging from light to extreme. He says that the country is dealing with the consequences of desertification, because drought and water shortages have reached troubling proportions due to the overexploitation of aquifers [Enciso, 2010].

Although in recent years Mexico has created the National System to Combat Desertification and Degradation of Natural Resources (SINADES, by its Spanish acronym), and prepared a National Forestry and Soil Inventory that should provide a dynamic view of changes in soil use, degradation and deforestation in order to continue recovery programs, the reality is that these programs have not had any positive effect. Based on information from the Ministry of Agriculture, Livestock, Rural Development, Fishing and Food (SAGARPA, by its Spanish acronym), Mexico has 24 million hectares of cultivatable land, approximately 8 million of which must be irrigated. In the spring-summer cycle, production is concentrated in 14 million hectares, while the autumn-winter cycle uses only 4 million irrigated hectares. Data supplied by the head of the Coalition of Popular and Peasant Organizations, (COPyC, by its Spanish acronym) are even more alarming, showing that at least 7 million hectares have been abandoned for lack of investment, while the rest are planted irregularly because of climatological risk, lack of credit, and other elements that prevent them from providing a substantive yield [Dávila, 2013].

SINADES is one of nine systems provided for in Article 22 of the Sustainable Development Act, intended to comply with the commitments Mexico took on when it joined the United Nations Convention to Combat Desertification (UNCCD). It has made little progress, however, and drought and desertification remain a pressing concern in Mexico.

The National Forestry Commission notes that 17 of the 22 largest Mexican cities in terms of population and economic activity are located in arid zones, and are home to an estimated 48 million people. This has very serious consequences, ranging from the reduction of food production, soil infertility and salinization, decreased natural land recovery capacity, increased flooding in low-lying portions of

watershed regions, and water shortage to the sedimentation of water bodies [CONAFOR, 2013]. In Mexico, a severe desertification belt has been formed that runs from Sonora to San Luis Potosí. This belt is continuous and extensive (it encompasses Chihuahua, Durango, Zacatecas, Coahuila and San Luis Potosí). Soil degradation within the belt is caused by over-farming and tree-cutting, which has contributed to soil erosion [Ibid.]. In fact, former SAGARPA Minister Alberto Cardenas said in 2006 that the desertification of Mexico was advancing more rapidly than official efforts to contain it [Restrepo, 2006].

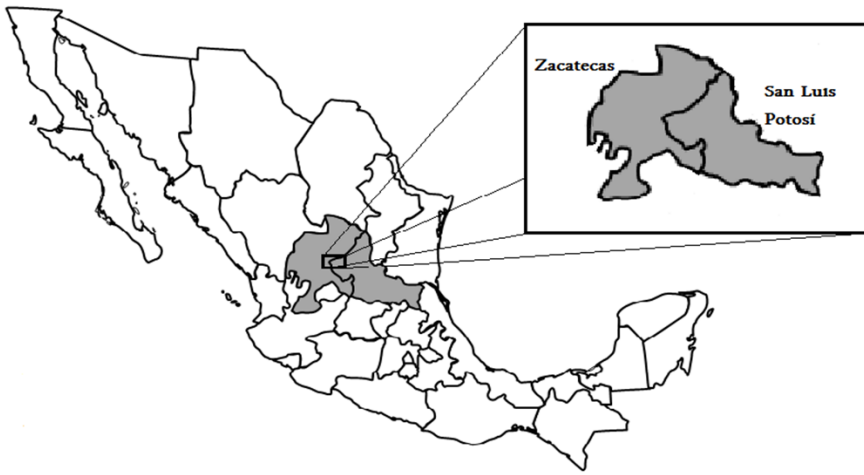
The Mexican government has created a set of accords relating to climate change, called the National Climate Change Strategy, with specific programs under the supervision of the Ministry of the Environment and Natural Resources (SEMARNAT, by its Spanish acronym). One of these was the 2012 national climate change strategy, which aims generally at reducing the effects of the agents that cause climate change, diminish vulnerability and even combat pests. It does not, however, specify the actions that must be taken to achieve these ends, and it leaves it up to the institutions to decide how they will take action. This is completely inefficient, because of the inherent difficulties in coordination to achieve the common goals of the program.

In the area of soil restoration and conservation, the federal government has the "Pro-Tree Program" and others that crop up temporarily depending on where in the six-year presidential administration the country is situated. What the data show is that the number of trees planted has grown significantly since 2001-2008, meaning reforestation is carried out by planting trees by hectare, but specific soil recovery and restoration activities have lessened, according to SAGARPA itself. This is a clear example of the tremendous inconsistencies these programs present.

Desertification is a threat to biological diversity. It can cause episodes of prolonged famine in already impoverished countries that cannot withstand a high level of agricultural losses. Poor people in rural zones that depend on land for survival frequently face the dilemma of emigrating or going hungry [FIDA, 2010]. Significantly, these displacements are linked largely to socio-economic conditions in a country, and Mexico itself faces wide social inequality gaps that result in poverty and extreme poverty —a phenomenon that has only worsened since it adopted the neoliberal model. Essentially, in addition to climatic events, there are sweeping socioeconomic changes that have had highly pernicious effects on the poorest communities, who have found their living conditions complicated and their capacity to adapt diminished [Ibid.], to such an extent that migration becomes their sole opportunity for survival.

To analyze the relationship between climate change and migration, we studied two states, San Luis Potosí and Zacatecas, taking the rural sector as our universe of study. The two states we studied are located at the northern region of Mexico (Map 1), and are considered the hardest hit by high levels of desertification, adverse economic conditions and high levels of emigration.

Map 1. Zacatecas and San Luis Potosí location



Source: analisisydecision.es

Climate change and migration in San Luis Potosí and Zacatecas

It is important to note, as background, that with the signing of the North American Free Trade Agreement, (NAFTA) Mexico began to cut back on farming subsidies, although the United States, which also signed the agreement, not only continued subsidies to US farmers but even increased them, according OECD data. This created a situation of unfair competition for Mexican agricultural products, and one of the most unfortunate results of this policy was the devastation of rural Mexico [Bartra and Otero, 2007]. Adding to this situation is the fact that in the areas we studied for this paper, climate changes intensified, exposing them more to drought and desertification and making migration a compelling option for survival. Small wonder, then, that the United Nations Development Program (UNDP) should state that for a great many people living in developing countries, climate change projections indicate that their means of sustenance will become less secure while vulnerability to hunger and poverty will grow.

The agricultural sector in Zacatecas and San Luis Potosí

To observe whether agricultural production declined, we obtained information on loss of crops nationwide from SAGARPA's Agrofood and Fishing Information Service (Table 1). This is measured as the difference between planted and harvested area, as an indicator of agricultural production. By this indicator, both Zacatecas and San Luis Potosí are heavily loss crops regions. This is important, because one of the effects of climate change is the loss of means of subsistence, and therefore an indicator that relates to the decision to migrate. Furthermore, vulnerability grows

to the extent that the harvest depends more on natural conditions, precisely the definition of dryland farming.

Table 1. Agricultural production

Form: Dryland **Loss of crops by state, 2000 and 2010.**				
Ranking	2000		2010	
	State	Loss of crops (ha.)	State	Loss of crops (ha.)
1	GUANAJUATO	374,559.78	ZACATECAS	233589.1
2	ZACATECAS	365,518.00	SAN LUIS POTOSI	173516.0
3	CHIHUAHUA	357,324.00	GUANAJUATO	162935.7
4	SAN LUIS POTOSÍ	257,013.00	VERACRUZ	81943.8
5	TAMAULIPAS	185,390.25	JALISCO	73728.6

Source: SAGARPA

Note that in 2011, 80% of Mexico's territory was affected by some type of drought, and 40% was affected by severe drought. The hardest hit states were Durango, Chihuahua, Coahuila, Nuevo León, Zacatecas, San Luis Potosí, Aguascalientes and Guanajuato [Deheza and Mora, 2013]. These impacts have direct repercussions on agricultural production.

According to the 2007 agricultural census taken by the National Statistics and Geography Institute (INEGI, by its Spanish acronym) Zacatecas is known for its cultivation of carrots, beans, onions, and garlic; San Luis Potosí is primarily a producer of oranges, sugarcane, green chilies, tomatoes, oats and beans. Zacatecas has 1,737,560.66 hectares of agricultural land, 11.46% of which are irrigated and 88.5% are used for dryland farming. Meanwhile, San Luis Potosí has a total agricultural area of 1,039,811.71 hectares, 10% of which are for irrigation farming and 90% are dryland farms. It is reasonable to assert that there are a substantial number of people involved in farming who are highly vulnerable to the effects of climate change; if rainfall patterns are altered, dry seasons will be longer, and this will directly affect agricultural production that depends on natural conditions. This situation suggests that dryland farm areas are the most vulnerable to climate phenomena.

Because the risk posed by climate change comes from a combination of threats or dangers relating to the weather (heavy rains or drought) with vulnerability (socio-economic aspects, soil depletion, improper water management), any change in the climate can have a greater impact on the population of one particular region or social group. An analysis of vulnerability in turn takes into account the inter-relationship between geographic features and population conditions (levels of income, demographic factors, etc.). Nevertheless, a country's vulnerability is not determined exclusively by its geographic position and changes in its climate, but also in the lack of efficient public policies for improving living conditions for the populace [Moreno and Urbina, 2008].

Labor conditions and migration in Zacatecas and San Luis Potosí

An element that can help us to understand the level of socioeconomic vulnerability of residents of these two states is the labor market, because the ability to generate enough decently-paid jobs is a mechanism for combating poverty and achieving higher levels of development [Camacho, 2013]. In this matter, rural Mexico was devastated by the results of NAFTA, keeping the USA high subsidies. This meant that small and mid-sized Mexican farmers were severely affected by the inability to compete with dumping-level prices on agricultural products imported from the US.

A study by SAGARPA [2006], which analyzed rural income trends in Mexico, found that in the central-western region, which includes the states of San Luis Potosí and Zacatecas, labor compensation declined from 90% of rural household income in 1994 to only 70% in 2004; meanwhile, wage remittances from abroad rose from 3.7% to 10.6% of total rural household income in the same period.

The number of inhabitants over 5 years of age in rural areas of San Luis Potosí with some type of access to public health services declined by 7.7% between 2000 and 2005, from 145,854 to 134,495; meanwhile, in Zacatecas, the number of inhabitants over 5 years of age with some type of access to public health services declined by 25% between 2000 and 2005, from 95,568 to 70,955, according to official data reported by INEGI. These indicators show that the state's labor market is depressed both by low wage compensation and by the reduction of employment-related benefits.

Reviewing conditions in the rural labor market is highly important for analyzing poverty. Baqueiro and Klein [2012] point out that the factors that contribute to poverty in rural areas have to do with the precariousness and informality of the labor market, taking into account elements like wage sufficiency, social protection, unionization and ways in which employees are hired.

The deteriorating economic conditions and the impact of climatic variability on dryland farming; creates pressures over the incomes, employment and the food access of the most vulnerable families, and as a result, there are an increase in the propensity to emigrate [ECLAC, 2002]; according to data from the National Population Council (CONAPO) (see table 2), in the ranking for this index, San Luis Potosí went from 9th to 6th place in 2010, while Zacatecas continued to show the highest migratory intensity index.

This data suggests that migration in Zacatecas and San Luis Potosí can be attributed both to socio-demographic and climatic conditions. Such complex associations, however, cannot be drawn so simply, so we decided to conduct an econometric exercise to test whether there is some degree of association between the variables.

Table 2. Migratory Intensity Indexes by state in Mexico 2000, 2010

Ranking	State	2000		State	2010	
		Index	Degree		Index	Degree
1	Zacatecas	2.5835	Very high	Zacatecas	4.4216	Very high
2	Michoacán	2.0595	Very high	Guanajuato	3.8909	Very high
3	Guanajuato	1.3657	Very high	Michoacán	3.8684	Very high
4	Nayarit	1.2704	Very high	Nayarit	3.37	Very high
5	Durango	1.09	Very high	Hidalgo	2.8187	High
6	Aguascalientes	1.0388	High	San Luis Potosí	2.6638	High
7	Jalisco	0.8878	High	Guerrero	2.5841	High
8	Colima	0.8026	High	Durango	2.5395	High
9	San Luis Potosí	0.6734	High	Aguascalientes	2.4911	High
10	Morelos	0.5192	High	Oaxaca	2.4544	High

Source: CONAPO

Empirical evidence regarding migration and climate change in San Luis Potosí and Zacatecas.

Most research on the topic has revealed that the decision to migrate has multiple causes, and isolating the effects of climate change on this decision from economic, social or political elements is highly complicated. It is possible, however, to establish the direction and magnitude of each variable that plays into the migration decision using an econometric model. In this work, therefore, we assume that migration is the result of individual decisions in response to socioeconomic as well as climatic realities. To test whether this association is present in Zacatecas and San Luis Potosí, we have developed a complementary log-log model[2] that enables us to identify key variables and their capacity to influence the decision to migrate.

Using as a basis the work of Deheza and Mora [2013]; Hunter, Murray and Riosmena [2013]; based on the models proposed for these papers, we propose the following specification of our econometric model:

$$\Pr(\text{Migrate}=1)=F(\beta_0 + \beta_1\text{sex} + \beta_2\text{Age} + \beta_3\text{elec} + \beta_4\text{wage2} + \beta_5\text{damage} + \beta_6\text{temp} + \beta_7\text{precip})$$

Where $F(z)=1 - exp\{-\exp(z)\}$

The econometric model explains whether the probability of immigrating to another country is determined by socioeconomic variables, like personal characteristics (β_1 and β_2, data obtained from the 2010 Population and Housing Census). Since we are interested is determining the push effect of socioeconomic and climate factors, we took into account only emigrants over 15 years of age that emigrated from rural zones in both states. We added variables relating to the measurement of

[2] This is a binary choice model, and we believe this technique is most appropriate for modeling the relationship we are exploring because its conditional distribution function is not symmetrical around zero value, so the use of this model is recommended when the dependent variable (in this case, the decision to migrate) is biased so that there is a high proportion of zeros (non-migration) or ones (migration) in the data base [Cameron and Trivedi, 2005].

multifactorial poverty in the regions studied, such as if the person lives in a home without electrical energy (β_3) and the proportion of house members that earns less than two times the minimum wage (β_4), which is considered as a proxy variable for the deterioration of the labor market; both these indicators were obtained from CONEVAL.

We incorporated a variable to serve as a proxy for the agricultural yields of those regions, which is the damaged area (β_5) in order to relate agricultural yields with decision to migrate. This indicator is measured in hectares and was obtained from SAGARPA's Agrofood and Fishing Information System (SIAP).

We complemented these variables with atmospheric data at the municipal level, which approximate environmental impact: temperature (measured in degrees centigrade) (β_6) and average precipitation (β_7) (measured in milliliters). These data come from UNAM's Atmospheric and Environmental Sciences Information Unit, through the Digital Climatologic Atlas of Mexico. By using these variables, we attempt to capture socioeconomic conditions and climatic impacts that influence an individual's decision to migrate.

Empirical evidence on international migration and climate change

Table 3 presents the main results of our estimates on the decision to migrate of the entire set of variables used in the estimation. We were left only with the variables that reported a statistically significant coefficient in order to preserve the model's parsimony; these coefficients show that in all cases, both sets of variables — economic and climatic— play an important role in the decision to migrate.

The results show that men are more likely to emigrate to another country than women, given the positive sign in the gender variable; the likelihood of emigrating declines as age advances, meaning young people are more likely to emigrate; the likelihood of emigrating increases for an individual that belongs to a municipality with a high proportion of homes without access to electrical energy, in other words, with less access to utilities, which is an indicator of socioeconomic vulnerability. The same is true for individuals in municipalities where there is a high proportion of inhabitants earning less than two times the minimum wage, which is a clear sign that the deterioration of the labor market influences the decision to emigrate. These results stress socio-demographic and economic characteristics.

The results regarding climate variables and their impact show that the higher the amount of damaged area in a municipality of origin, the higher the propensity of its inhabitants to emigrate, because damaged area has significant weight in agriculture production, and the lower the agricultural yield the greater the need to emigrate. As to temperature, the results show that an individual will tend to emigrate if the municipality in which he or she lives presents high temperatures. The negative sign for the rainfall coefficient indicates that the less rainfall a municipality has, the greater the propensity of its inhabitants to emigrate. This

variable tracks the weight of droughts in this semi-arid region, whose impact is felt in agricultural production.

Table 3. Estimation of complementary log-log model for the dependent variable of emigration in the states of Zacatecas and San Luis Potosí.

Variable	**Coefficient**	**Z-Statistic**
$\beta_1$sex (Dummy, 1=male)	1.750961	(98.30)***
β_2Age	-0.0307302	(-102.66)***
$\beta_3$elec	0.0411162	(18.90)***
$\beta_4$wage2	0.0040044	(5.83)***
$\beta_5$damage	0.00000682	(4.83)***
$\beta_6$temp	0.0236729	(5.53)***
$\beta_7$precip	-0.0023889	(-14.52)***
β_0	-3.992515	(-56.86)***
Complementary statistics	**Values**	
Number of observations	749606	
Zero values	725567	
Non-zero values	24039	
Waldchi-square statistic (7)	16025.69	
Prob>Chi-square	0.00	

Source: Own preparation.
Note: Indicates statistically significant at *** 1%, ** 5%; * 10%.

Conclusions

It is indispensable to strengthen capacities for adaptation to changing climate conditions, and thus urgent for the Mexican State to take the lead in promoting this type of measures, above all to take on the task of attaining higher levels of development. Over the past 30 years, the neoliberal model has proven that it works only as an obstacle to development, because it has concentrated wealth in few hands, increasing poverty and irrationally stripping the country of its natural resources.

The econometric results should be considered a first approach to the potential effects that climate and socioeconomic variables may have on migration. They suggest that the poorest populations are those that depend most on natural resources, and thus are more vulnerable to climate risks. We were able to prove that given these socioeconomic and climatic conditions, the adaptation strategy was emigration.

For these reasons, the State has a responsibility not only to combat poverty but to take into account the effects of climate change. One of these alternatives may be stimulating the creation of “green jobs,” for improving adaptation levels in the poorest regions of the country, while at the same time serving as a way to confront the loss of jobs and poverty. With this it could help guarantee community adaptation, as a human right, without the need to emigrate.

Acknowledgement

The authors acknowledges the support given by Project DGAPA PAPIIT IN300716 and the collaboration of Luis Fernando González Martínez, Dorian Ivvon Martínez de Lara, Ulises Sánchez Guerrero y Olivia Salas Sauceda for they valuable support in the search and systematization of the information in the article.

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