



*Research article*

## **Public perception of climate change in a period of economic crisis in Puerto Rico**

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**Abstract:** In this study, an analysis is performed to measure Puerto Rican citizens' perceptions of environmental issues and global climate change (GCC). Puerto Rico (PR) is presently facing an economic crisis that began in 2010. In addition, the island has faced many extreme weather events that have greatly impacted the economy, including a dry period that lasted from the beginning of 2014 until the end of 2015 [1]. By replicating a study done in Greece (GR), [2] found that the citizens of PR are more informed about GCC (43%) than Greeks (34%). However, only 29% of Puerto Ricans said they knew about the effects of greenhouse gases, as compared to 44% of Greeks. The citizens of PR (67%) and GR (91%) claim they do not have confidence that their respective governments and agencies will be able to face GCC. In both cases, they have a higher confidence level in environmental organizations than in the scientific community. In PR, 89% of the citizens are concerned about the degradation of natural resources. At 64%, this concern is also significant in the case of GR, although the figure has decreased from previous years. Both countries place more responsibility in the hands of those in government and industry to take action on GCC. That being said, the people of GR have made it known they are willing to perform individual actions as well.

**Keywords:** climate change; perception; Puerto Rico; climate and economic crisis

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## 1. Introduction

Global climate change (GCC) is affecting countries and regions in very different ways. While in some countries (e.g., Iceland) it is predicted that there could be a benefit from the warming trend, such as more options for land use [3,4], other countries, such as the Caribbean nations, are more likely to incur serious risks to their economies, physical boundaries, and ways of life. For this reason, researchers warn that as the average temperature of the land increases and sea levels rise, these regions will suffer significant negative impacts that affect quality of life, causing an increase in disease incidence due to infectious vectors, such as mosquitos, and precipitating a number of extreme weather events, such as droughts, floods, and forest fires [5].

Puerto Rico (PR) is located in the center of the Caribbean (between latitudes 180°31' and 170°55'N and longitudes 65°37' and 67°17'N and between the Atlantic Ocean and the Caribbean Sea). Including five smaller islands nearby, PR measures 180 km long and 65 km wide and has an area of 11,700 km<sup>2</sup>. For several decades, the country has been the scene of environmental and social struggles, especially with regards the protection of forests and coastlines [6]. For this reason, some researchers, such as [7], say the conflict between socio-environmental movements, environmental colonialism, and the criminalization of socio-environmental protest surged in PR from 1960 to 2012.

PR has experienced a decade of negative economic growth. Indeed, there is a consensus that the island's economy has collapsed. For nearly four centuries, PR was a possession of Spain, but in 1898 it became a commonwealth of the United States. Therefore, the economic and environmental policies have been shaped by both countries [8]. According to 2010 census data (CENSUS PR) [9], the population of PR is 3,725,787 citizens. Due to the economic crisis, it was projected by the Census that the population will decrease to 3,474,182 people, which represents a loss of 6.75%, or approximately 251,000 citizens. The surveyed region is the most densely populated region with 1.7 million, a number that represents approximately 50% of the island's population.

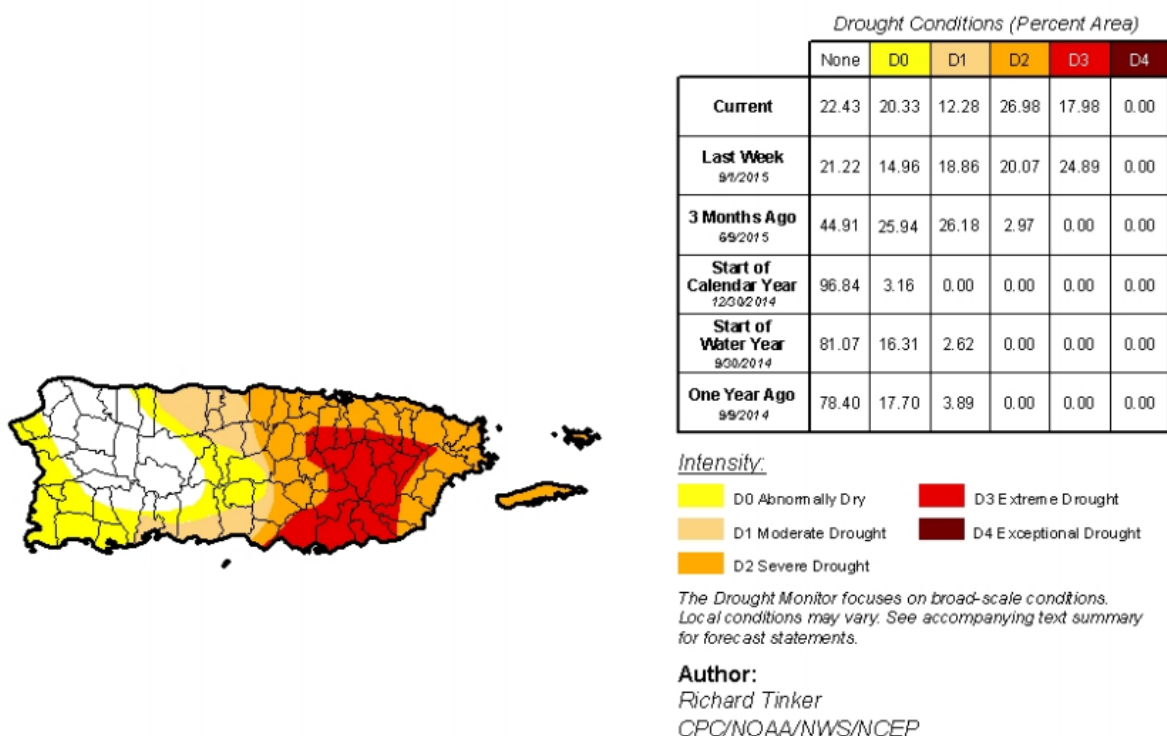
Since the early 1990s, the island of PR has faced diverse climatic phenomena, including two extended periods of drought, the first of which began in February 1994 and lasted until September 1996. This drought affected the whole island [10,11]. The second drought began in mid-2013 and lasted until November 2015. Regions impacted included the metropolitan areas (San Juan, Bayamon, Guaynabo, and Carolina) and the eastern central region (Caguas, Gurabo, San Lorenzo Juncos, Canóvanas, Loiza, Rio Grande Luquillo, and Humacao) of the island. Reservoirs that supplied water to these regions were severely affected by the drought (Figure 1).

In the last four years, PR has been hit by heat episodes, which has led to an increase in visits to health centers [12]. With to regards to the warming trend and its correlation with [13-15] and more recently the Zika virus [16], the results show an increasing trend of cases of citizens infected with both viruses. According to this analysis, dry days decreased in the San Juan metropolitan area between 1955 and 2009 and were more common in the winter months. Heavy rains were more common in summer and fall, in accordance with the hurricane season, whereas the most intense rainfall episodes tended to occur in spring [15].

The results provided by researchers such as [17-20] indicate an increase in mortality and whitening corals. There was also a reported increase in the number of forest fires [21] and a rise in sea level due to cyclonic systems and cold fronts that resulted in a large amount of coastal erosion [22,23].

## U.S. Drought Monitor Puerto Rico

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**Figure 1. The region of Puerto Rico affected by drought during 2014–2015. D2 corresponds to cities with severe drought and D3 to cities with extreme drought. Source. Source: United States Drought Monitor.**

An examination of the magnitude of the trend revealed that in the driest months, precipitation linearly increased as elevation increased; the evidence for the linearly increasing trend with elevation was much stronger in the driest months compared to the rest of the year. As the mean yearly amount of precipitation was greater at higher elevations, this means the wetter higher elevations got wetter from 2001 to 2013 and the drier, lower elevations got slightly wetter. When the increase was calculated as a percent, the result at the average elevation of 500 m was  $+3\% \text{ yr}^{-1}$  for all months and  $+4.5\%$  for the driest months, with a smaller percentage increase at the higher elevations and a larger percentage increase at the lower elevations. Although the wetter months of the rainfall seasons did not show any trend, there was a trend of a shrinking difference between the drier months and the wetter months, and more so at higher elevations [24].

There have been more drastic impacts from heavy rainfall since 1995 [25-27,12] and an increase in the intensity of hurricanes in the Atlantic [28-35]. Among the cyclonic systems that have had a greater impact on the island are the following:

In September 1989, Hurricane Hugo, with winds of 140 mph (making Hugo a Category 4 hurricane), hit PR's eastern half, along with the islands of Vieques and Culebra. On September 16 1995, Hurricane Marilyn impacted PR. 1995 was a very active year in terms of hurricanes. The Virgin

Islands, near the town of Culebra, also felt the effects of Marilyn. Its torrential rains caused widespread flooding and significant agricultural losses [36].

A year later, in September 1996, Hurricane Hortense hit the south of PR, from Guayanilla to Mayaguez. This hurricane reached Category 1, and the rainfall caused widespread flooding. Southern cities suffered the greatest impact. Hurricane Georges was the most expensive hurricane in the history of PR. It crossed the island from east to west, affecting the entire country. Hurricane Georges lasted from 21 September to 22 September 1998. With winds of 115 mph (making Georges a Category 3 hurricane), the damage amounted to USD 6 billion [37]. Heavy rains caused the overflowing of rivers, large cyclonic storm surges, and extensive damage in various sectors, including agriculture and tourism [36].

The main objective of this article is to analyze the possible effect of living in a country with economic crises on the perceptions of citizens regarding climate change and environmental issues. Taking as a starting point the study of [2]. In addition, we will look at citizens' assessments of their own general knowledge about climate change.

The Intergovernmental Panel of Climate Change (IPCC) has associated the increased frequency and intensity of cyclonic systems with climate change in the case of PR since the 1990s. The impacts of these phenomena have been substantial, as in the case of Hurricane Georges (1998), which according to *National Oceanic and Atmospheric Administration* (NOAA) resulted in losses of USD 1.75 billion. Other phenomena such as Jeanne (2004), Irene (2011) also gave rise to substantial economic losses. The frequent occurrence of drought increased the incidence of diseases (dengue, Zika, chikungunya, etc.) associated with changes in precipitation and GCC [11,38]. Coastal erosion has begun to threaten tourism and therefore the island economy. This has led researchers to show more interest in all things related to CCG [39].

## 2. Materials and Methods

This study was conducted in the metropolitan and eastern areas of Puerto Rico between August 2015 and September 2015. The selected zone is the one with the most economic development. Approximately a half of the population live in this zone, and this is where climate change has had the most impact.

Data used in this study were collected when the drought of 2014–2015 was the most severe. The data were collected in the towns of Carolina, Caguas, Gurabo, Canóvanas, Luquillo, Las Piedras, Juncos, Humacao, Trujillo Alto, Ceiba, and Fajardo. These towns were chosen as a representative random sample for this study.

With the idea of preserving that the sample was random, we used the map (Figure 1) where an imaginary line was drawn from North to South, beginning in the towns marked as severe drought (D2), towards the East of the island. The sample list was obtained from a drought map (see map). The sample consisted of people over 21 who live in the specific randomly selected area. The respondents comprised 211 females (57%) and 163 males (41%). To analyze the content, format, and clarity of the instrument, the questionnaire was pre-tested using a sample of 30 participants with characteristics similar to those of the people in the sample. Next, the primary data were collected via a structured face-to-face questionnaire. The interviewer conducted a drop off survey and waited while the person completed the survey. Four hundred and fifty questionnaires were obtained, although the final sample comprised 374 completed questionnaires.

### 3. Questionnaire

The questionnaire consists of eight parts, plus a demographic part (see Table 1). A five-point Likert scale was used, where 1 = completely disagree and 5 = completely agree. The data analysis employed descriptive statistics and SPSS. Means, standard deviations, and percentages were used in analyzing the perception of climate change. In addition, a Cronbach's alpha was used to assess the internal consistency of the constructs in the questionnaire (Table 1).

**Table 1. Questionnaire construct.**

Construct	Items	Alpha
Assessment of major environment issues	7	.736
Severity of impacts	5	.780
Confidence	4	.827
Responsibility	3	.852
Actions taken by the state	10	.872
Individual actions	10	.686
General assessment	3	.650

Most respondents replied that the degradation of water resources is a major problem in PR and said they agreed (90%, with a mean of 4.63). The destruction of ecosystems is seen as a major problem by 85% of the respondents (with a mean value of 4.53), and solid waste and air pollution are seen as major problems by 83.3% and 81%, respectively.

We also found that 65% of respondents (with a mean of 3.89) believe GCC is one of the main environmental problems in PR. This perception increased in the case of extreme weather events to 67% (Q 1.4) (with a mean of 3.96). Finally, 62% of the participants perceive the environmental problem of noise pollution as slightly less important (with a mean of 3.99). Looking at the data of Greek researchers in relation to noise pollution, 46% of people in GR see this issue as a major problem (with a mean of 3.4); therefore, Greeks give more importance to noise pollution than do Puerto Ricans.

A possible explanation for drought being high on the list of concerns of Puerto Ricans is the fact that at the time of data collection, PR was experiencing a drought that lasted from the end of August 2014 to November 2015 [1]. This increased the population's sensitivity to the problems created by a lack of water.

#### 3.1. Severity of the impacts

In assessing the severity of the impacts on the environment as they correspond to increased temperatures (Q 2.1), it was discovered that 87% (with a mean of 4.47) of citizens believe PR would be affected by an increase in the average temperature of the planet. This result is higher than the 58% (3.66 mean) of Greeks who answered this question in the affirmative. Regarding the impact of extreme weather phenomena (Q 2.2), 85% of citizens (with a mean of 4.44) perceive this as a major problem.

When looking at land use, 82% of respondents believe that PR is and will continue to be affected by the impacts of activities such as deforestation (Q 2.4). When we analyze the impacts on ecosystems (Q 2.5), 85% (with a mean of 4.53) of citizens agree or strongly agree that ecosystems will be greatly affected.

About 77% believe PR will be greatly affected by the rising sea level. This is significant considering the proportion of the population that earns its livelihood in industries such as tourism and fishing.

### *3.2. Confidence in the agencies responsible for evaluating these aspects*

When analyzing the level of citizens' confidence, we must consider that the governmental system of PR is structured as a federal (USA) system and a local system (PR). The evaluation was conducted using a Likert scale based on the premise of strongly agree or strongly disagree. The level of distrust in the federal system (Q 3.1) was found to be 54% (with a mean of 2.51), while the level of distrust in the local government was 67% (with a mean of 2.15). The Greek level of distrust in the national government was 91% (equivalent to the federal government in PR), while for local authorities (municipalities) it was 83%. As the level of distrust of the Greeks in their authorities is superior to PR level of distrust towards their authorities.

The study reveals that PR's confidence in its citizens to combat GCC is 46% for environmental organizations, followed closely by the scientific community at 43%. These data are very similar to the data for GR. In PR, there is a confidence rate of 40% for environmental organizations and 30% for the scientific community.

### *3.3. Level of responsibility*

The survey reveals that the highest level of responsibility for addressing GCC is awarded to the citizens (82%, with a mean of 4.39). The second highest level is awarded to companies (78%, with a mean of 4.27). The states are assigned the lowest level of responsibility (71%, with a mean of 4.05). It is important to note that the majority answered 5 or completely agree, and for the three tested areas, population, business, and government, the figures were 66%, 55%, and 62%, respectively. The results allow us to conclude that citizens understand that the greatest responsibility for confronting GCC lies with themselves. In the case of GR, more responsibility is placed on the government (at 84%) than on citizens (at 74%). In both cases, the answers given by the people in GR had higher scores than those given by citizens in PR. Very little responsibility was placed on companies.

### *3.4. Government actions*

In PR, 86% of the population believes (Q 5.5) that the state should take further action in terms of renewable energy (with a mean of 4.44). However, 83% of the population believes that the government should give priority to educating the public about the impacts of change climate. In addition, according to the survey state action must be directed to the protection of drinking water resources and reforestation (82% and 82%, respectively).

In relation to the integrated management of solid waste (Q 5.6), 79% of respondents understand that it is a major environmental problem and believe that the government should take action. Conservation of energy is another priority for the population, with 78% regarding it as a major problem. Finally, these three aspects are considered to be of great importance: fines for environmental violators, the creation of greenbelts, and stricter environmental legislation (69%, 68%, and 61%, respectively).

### *3.5. Individual actions*

The biggest concerns of Puerto Rican society are the protection of water resources (93%) (Q 6.2), followed by recycling (92%) (Q 6.1), and the conservation of natural resources (90%). Other important aspects are energy savings and reducing car usage by promoting alternative means of transportation, such as cycling and public transport.

### 3.6. *Participation in action*

Of those surveyed, 82% (Q 6.7) stated their willingness to participate in actions to address climate change; however, only 58% currently participate in individual actions to address this issue. In addition, 49% of respondents agree that there should be incentives to participate in individual action. This is in contrast to GR, where only 5% agree with this premise (Q 6.9). The respondents who believe that individual actions will not be effective if the main culprits (Q 6.8) do not participate actively is 75%; 78% of PR citizens are concerned about the impacts of GCC, and only 16% believe there is no reason to worry.

### 3.7. *Self assessment*

In assessing the quality of the environment in PR (Q 7.1), 37% of respondents understand that the quality is poor or very poor. During self-assessment, however, 32% rated their environmental knowledge (Q 7.2) as poor or very poor. As for climate change, 44% (Q 7.3) claimed to have a good understanding of the subject.

## 4. **Discussion**

In various economic studies, PR has been compared to Greece (GR) due to their similarities in terms of the economic crisis they have experienced. For this reason, some researchers [40,41] have called PR “the Greece of the Caribbean”. To establish a comparative basis between PR and GR, we note that the gross domestic product (GDP) of GR for 2013 was USD 21,842.7 million, while for PR it was USD 28,681.7 million. The GDP in GR decreased by an estimated 0.997% in 2014; in the case of PR, there was no official data [42].

### 4.1. *Level of confidence and responsibility*

As mentioned, distrust is high in both GR and PR. The Greeks distrust national authorities more than their local authorities, whereas Puerto Ricans distrust local governments more than the federal government. The levels of distrust in the scientific and environmental communities were similar among the citizens of both countries. It is important to note that the majority response in terms of responsibility is 5 or completely agree for the three areas assessed, government, citizens, and companies; the figures are 71%, 82%, and 78%, respectively (Q4.1–4.3). The people of GR consider the government to be the party most responsible for addressing the issue of GCC (84%), followed by the citizens (74%). In both cases, the public response was higher than in PR.

### 4.2. *Institutional and individual actions*

The actions taken by the state are important citizen concerns, as observed in questions Q5.1-5.10, where the answers from those interviewed that agreed with the statements varied between 61% and 88%, this reveals the public concern for the government’s actions.

When compared to the results in PR, the results in GR show citizens who agreed with the creation of green belts and the conservation of potable water at 91% and 89% respectively, this indicates an important difference in the environmental problems of the two countries, as the results in PR for these parameters only reached 67% and 72% respectively.

The fact that 82% (Q6.7) of respondents expressed an interest in participating in activities to combat climate change and only 51% currently participate in these activities is in harmony with the notion that government and environmental organizations should be more active in developing educational campaigns. In PR, 49% of the population says they would have to be compensated to participate in environmental protection activities, whereas 5% of the citizens of GR are willing to do so without compensation.

## 5. Conclusions

It should be emphasized that most of the Puerto Rican population is greatly concerned about the impacts of climate change, and only 16% (Q6.10) express a lack of concern.

Upon evaluation, the survey responses appear to be inconsistent. How can one be knowledgeable about GCC but at the same time have poor knowledge of the quality of the environment and greenhouse gases?

Further examination reveals that a number of citizens admitted to feeling insufficiently equipped in terms of knowledge to evaluate the questions. For example, the quality of the environment 45%, greenhouse gases 37%, and GCC 35.9%, respectively, made in the premise poor or very poor. Therefore, we can conclude that there is no reported impact of climate change on citizen knowledge.

The fact that 82% (Q6.7) expressed interest in participating in activities to combat climate change but only 51% actively participate currently is in harmony with the notion that government and environmental organizations should be more active in developing and promoting educational campaigns. It is very important to note that 49% of the population in PR says they would require compensation for participating in environmental protection activities, while only 5% of the inhabitants of GR would require compensation. This makes it clear that environmental efforts in PR should focus on promoting GCC awareness and developing educational campaigns on the topic. Another consideration is the issue of government distrust. The population in PR relies more on federal authority than Greeks rely on their national authorities. Both PR and GR show great confidence in the abilities of environmental organizations and the scientific community to handle matters relating to the GCC.

Water conservation is a topical issue in PR due to the recent drought. Additionally, solid waste represents an enormous environmental problem for PR, as 85% of the landfills have been closed by the Environmental Protection Agency (EPA) [43].

In response to question Q7.3, 44% of Puerto Ricans and 34% of Greeks stated they are knowledgeable about GCC, whereas 43% of Puerto Ricans stated they do not have enough knowledge.

After decades of discussing the phenomenon of GCC, in PR opinions about the impacts of GCC have not been formed, even though we are already feeling its effects. This is why individual actions to combat this phenomenon are not significant. It is imperative to conduct intensive educational campaigns so that people understand the extent of these impacts on the economy of the island.

Finally, we recommend that similar studies on the regions of PR that have not yet been affected by drought be conducted and that the results be compared. In addition, this study should be replicated in a Caribbean country that has no economic crisis.

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## Conflict of interests

The authors declare there is no conflict of interest.

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