

# **‘The impact of climate change on Bonaire: an analysis of different scenarios and their impact on a Dutch Caribbean municipality’**



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**Reading guide by Greenpeace Netherlands**

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**GREENPEACE**

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Cover image: The slave huts are very small structures on Bonaire where enslaved people slept while working in the salt pans. This is important cultural heritage that is very vulnerable to climate change.

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# BONAIRE



**The Institute for Environmental Studies (IVM), an interdisciplinary research institute of the Vrije Universiteit (VU) Amsterdam, was commissioned by Greenpeace Netherlands to research the consequences of climate change on the special Dutch municipality of Bonaire. Under the leadership of Prof. Dr. Pieter van Beukering, various scenarios were mapped out and the potential impact was examined on, amongst other aspects, the economy, health, infrastructure and cultural heritage of Bonaire. All the results of the research are to be found in six sub-reports and a synthesis report, which can be found here: [greenpeace.nl/bonaire-onderzoek](https://greenpeace.nl/bonaire-onderzoek).**

**In this reading guide you will find a short account of the most important results from the research reports and the conclusions that Greenpeace Netherlands has drawn from these results. Greenpeace Netherlands is responsible for this guide and has compiled it with care.**

# AN UNJUST KNOWLEDGE GAP: CLIMATE CHANGE IN BONAIRE



**Bonaire, a special municipality of the Netherlands since 2010, is a low-lying island. There are, therefore, great concerns that parts of the island will be flooded in the future due to rising sea levels. Additionally, climate change - if we don't take action - will also lead to the extinction of the coral reefs, which act as a breakwater. They protect the island and its inhabitants from flooding. Furthermore, climate research for all the Caribbean islands shows that temperatures could rise significantly.**

Anyone who is looking into climate scenarios for Bonaire must conclude that very little research has been done. While the European Netherlands is known for its struggle against the water, the Dutch government seems to have completely sidelined not only Bonaire, but also Saba and St. Eustatius in this context. Even though these islands are part of the Netherlands hardly any research is done by the government into possible scenarios for the Dutch Caribbean and also what can be done to protect these inhabitants of the Netherlands against the consequences of climate change.

Greenpeace Netherlands decided to do what the Dutch government is failing to do and commissioned the Vrije Universiteit Amsterdam (VU) to conduct research on the impact of climate change on Bonaire. This study is the first ever comprehensive and interdisciplinary analysis of the impact of the climate crisis on the island.

In this reading guide, we summarize the most important and striking results. Furthermore, it can be concluded that if global emissions continue to increase and, as a result, climate change becomes an increasingly threatening problem, the concerns for Bonaire's future will be great.

In brief:

- Large parts of the island are at risk of being permanently inundated.
- Much of the coral reef and popular dive sites around Bonaire could disappear in the coming decades;
- Due to extreme weather and heatwaves, residents of Bonaire will have to deal with increasing numbers of illnesses and deaths;
- All of this will have a major impact on the lives of people in Bonaire, the economy and cultural heritage.



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In the research by the VU several different scenarios have been used. These, so-called, shared socioeconomic pathway scenarios (SSP) originate from reports by the IPCC and are used internationally in climate studies. They describe global warming resulting from specific climate policies. They range from opting for sustainable and equitable development to ‘doing nothing’ and continuing the uninterrupted burning of fossil fuels.

The four scenarios in the study were chosen because they provide a good picture of what Bonaire may face in the future. An explanation of the scenarios is in **Table 1**.

Under the most optimistic scenario, SSP1-1.9, global warming is limited to 1.4°C. This scenario is the best approximation of what the effects will be if we adhere globally to the agreements in the Paris Climate Accord. For Bonaire and countless other islands, within the Caribbean and beyond, a maximum of 1.5°C warming offers the greatest chance of a safe future. According to the other three scenarios the warming increases far beyond 1.5°C and the consequences are often much greater. Sticking to a maximum of 1.5°C warming is therefore essential for many islands.

Shared Socioeconomic Pathway (SSP) scenarios	Global average warming of the earth relative to the pre-industrial era
SSP1-1.9	1,4°C
SSP2-4.5	2,7°C
SSP5-8.5	4,5°C
SSP5-8.5 Low Confidence (LC)	This scenario uses the same climate scenario as SSP5-8.5, but it also takes into account unpredictable factors, such as the melting of the ice sheets in Greenland and Antarctica. The latter could have a major impact on sea levels.

**Table 1:** Overview of the scenarios used in the study

# FLOODING DUE TO SEA LEVEL RISE AND STORMS



**The researchers conclude that climate change is causing sea levels to rise, increasing the risk of flooding and drastically changing the coastline of Bonaire. To map this, the VU used two methods. The first charts the expected flooding from sea level rise under the four different SSP scenarios. If these floods occur they will be irreversible. They will therefore determine the future coastline of Bonaire, if no adaptation measures are taken. The second method takes into account not only sea level rise but also the increasing probability of flooding from storms.**

## **Bonaire's future coastline due to sea level rise**

As early as 2050, sea level rise will cause permanent flooding on Bonaire, including at Lac Cai, Klein Bonaire and the salinas, the island's salt ponds. The function and character of these parts of the island will then change irrevocably. This will occur even according to the most optimistic scenario of 1.4°C (SSP1-1.9).

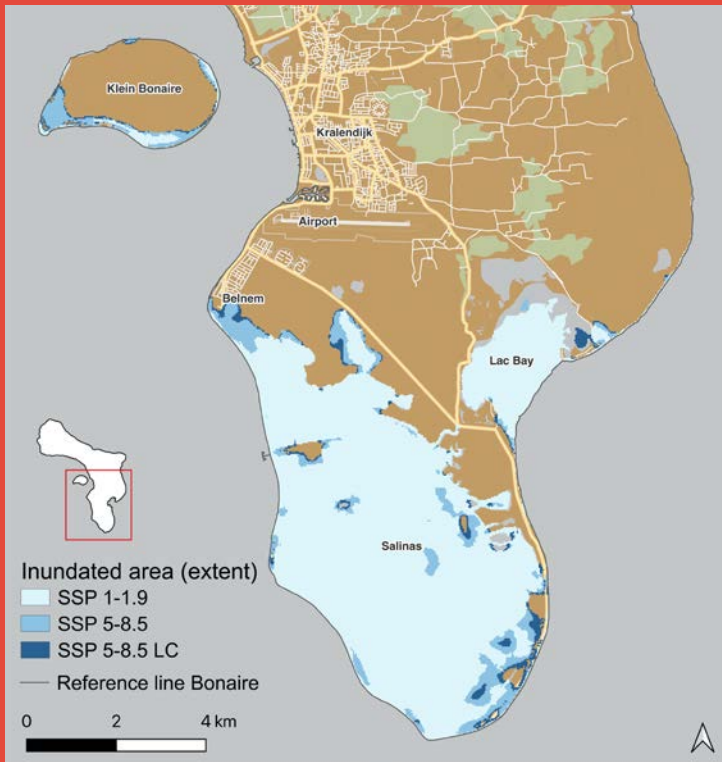
If we don't take action, the coastline will change significantly. Bonaire will then become a much smaller island. By the end of this century, as much as one-fifth of the island may have disappeared underwater, as shown in **Figure 1**. A lot of flooding will take place on the southern tip of the island because there the island is at its lowest. There will also be flooding around Lac Cai, the old fishing village. Plus in the models for 2150 and 2300, in the more extreme scenarios, flooding also takes place in and around the capital Kralendijk. **Figure 2** shows the flood areas for the different scenarios for 2150.

## **Flooding due to sea level rise and a severe storm**

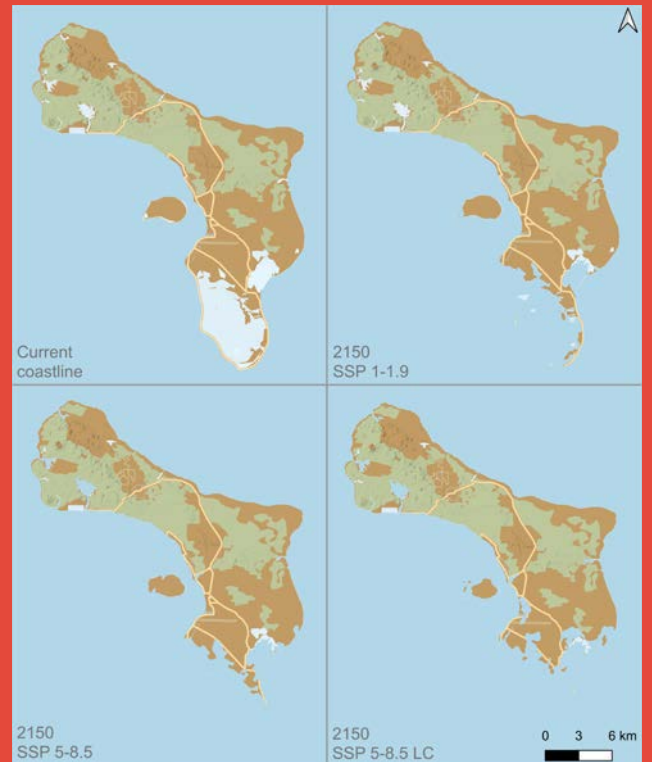
The situation is even more dire in the scenarios that take into account sea level rise plus a severe storm. A severe storm may temporarily raise the sea level even further. **Figure 3** shows the expected flooding for the year 2150 for the different scenarios. The storm used in this model occurs on average once every 100 years. This may seem a rare event, but in the European part of the Netherlands much stricter flood protection standards are applied. These often take into account storms that only occur once every 1000 or 3000 years.

It is important to note that for all these models, the elevation map used, or digital elevation model (DEM), are of great importance. After all, the higher Bonaire is, the less likely it is to flood. However, Bonaire's elevation maps are not that accurate. Therefore, a comparison was made with other elevation maps, but also with measurements made by the researchers themselves. Compared to their own measurements, the elevation map used seems to estimate the altitude of Bonaire to be on average 1.2 meters higher than it is. **Figure 4** gives an indication of what difference an elevation of 1.2 meters can make to potential flooding of the island.

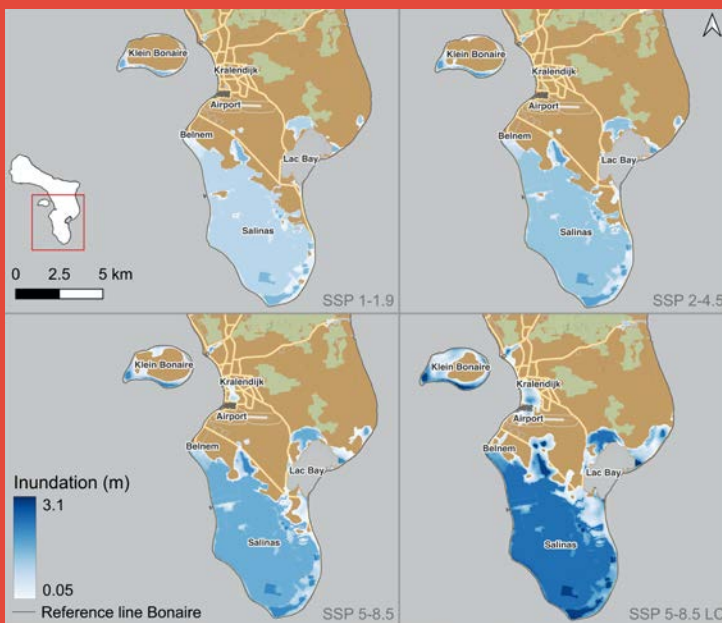




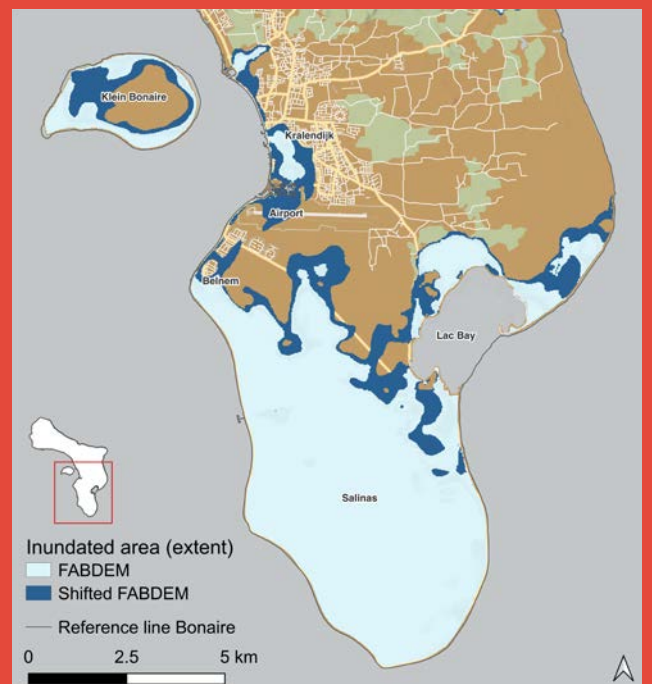
**Figure 1:** Flooding of Bonaire due to sea level rise in 2100. Three different scenarios: 1.4°C, 4.4°C and Low Confidence



**Figure 2:** The coastline of Bonaire in 2150 under three different climate scenarios. Clockwise, from top to bottom: current situation, 1.4°C, 4.4°C and Low Confidence



**Figure 3:** The coastline of Bonaire in 2150 as a result of sea level rise and a heavy storm. Four different climate scenarios. Clockwise from top to bottom: 1.4°C, 2.7°C, 4.4°C and Low Confidence.



**Figure 4:** Comparison of the elevation map used with measurements made by the VU researchers themselves, for flooding in the scenario of 4.4°C in 2150. In dark blue it shows how much of Bonaire will be flooded if we assume that the island is on average 1.2 meters lower than it is in the elevation map that was used.

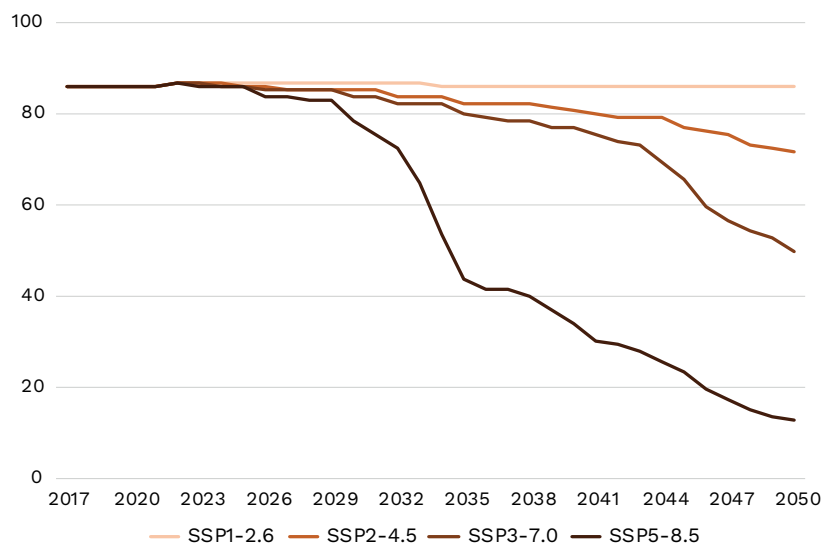
# CORAL DIE-OFF



**The coral reefs are of great importance to Bonaire for many reasons. They act as a breakwater, without healthy coral, the chance of flooding only increases. In addition, the coral is linked to the Bonairean identity. It is for good reason that the capital is called Kralendijk, or “Coral Dike”. Coral is also very important to the economy, because of the large amount of diving tourism on Bonaire.**

Bonaire currently has 86 official dive spots. Only in the most favorable climate scenario, in which we manage to keep warming below 1.4°C, will all those dive sites still exist in 2050. In the worst case scenario, the number of dive sites will decrease from 86 to 13 over the next 30 years, as shown in Graph 1. The reason for this is that the quality of the coral will be so poor that diving in many of the sites is not expected to continue.

As the number of dive sites declines, tourism declines sharply. Consequently, the researchers predict an economic contraction from 16.3 to 25.4% by 2050, according to the 4.4°C scenario (SSP5-8.5). Under the 1.4°C scenario (SSP1-1.9), there is no decline in the diving sector before 2050.



**Graph 1:** Number of dive sites in 2050 under 4 different scenarios. Plotted from top to bottom: 1.4°C, 2.7°C, 3.6°C and 4.4°C

It is important to emphasize that coral die-off will continue beyond 2050 if we do not intervene. If global warming increases further than 1.5°C, the consequences for coral will be disastrous (IPCC 2019). In that case, the number of dive sites on Bonaire will continue to decline after 2050, with all the negative consequences that this has for the economy.



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# DAMAGE TO INFRASTRUCTURE AND BUILDINGS



**The more extreme the climate crisis, the more damage Bonaire can expect to buildings and essential infrastructure. The VU study shows that if no measures are taken there could already be millions of dollars worth of damage in 2050, caused by flooding due to sea level rise and a heavy storm. If we look at 2150, the damage to buildings according to the most extreme scenario is 16 times greater than in the 1.4°C scenario. The amounts then run into the hundreds of millions of dollars.**

During floods, roads can usually still be used as long as the water is less than 40 centimeters high, they become impassable if the level is higher than that. Without adaptation measures, by 2050 all roads in the south of Bonaire will be unusable. Also the

road to BOPEC, the current oil storage facility in the north of the island, will be inaccessible. In the more extreme scenarios in 2150, in which Kralendijk floods, the airport and fire station would also be inaccessible. Floods can also damage the police station and medical aid stations.

The above scenario is based on flood damage caused by a combination of sea level rise and a severe storm. The assumption is that damage to infrastructure and buildings is still repairable, as the flooding will partially recede once the storm has subsided. The damage caused by permanent flooding has not yet been considered, this damage will be far more extensive.



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**Climate change can damage or even destroy important cultural heritage. Protection of cultural heritage is a human right and important for cultural identity, social cohesion and historical awareness. Consequently, research was conducted, again based on various scenarios and dates, into the impact that the climate crisis will have on the cultural heritage of Bonaire. A distinction was made between tangible cultural heritage (such as buildings) and intangible cultural heritage (such as customs or traditions).**

The majority of Bonaire's tangible cultural heritage is located on the coast and is therefore vulnerable to flooding from sea level rise and/or storms. In all climate scenarios, if we do not intervene, all cultural heritage in the south of Bonaire will disappear under water. The faster the planet is warming, the more heritage is threatened on the

rest of the island, including the capital. **Table 2** provides an overview of this.

Intangible cultural heritage is also under threat, partly due to extreme weather and increasing heat. These are the things that give the residents of Bonaire a sense of identity and continuity. An example being fishing, which is an iconic and important part of the culture. The circle on the Bonaire flag represents a compass, a reference to Bonaire's many fishermen and sailors. Healthy coral is essential for fishing, as it is an important shelter and breeding ground for most fish. As described above, the coral around Bonaire is in danger of dying off en masse. Another example is agriculture, and the so-called kunukus; a piece of land with a simple dwelling on it, often passed down from generation to generation and used for agriculture and recreation. Drought and storms can make agriculture on Bonaire very difficult, while food production on the island is already very limited. The lion's share of the food needed on the island already has to be imported.

Year	2050	2150	2150	2300	2300
Scenario	All scenarios	1,4, 2,7 en 4,4°C (SSP1-1.9, SSP2-4.5, SSP5-8.5)	Low Confidence (SSP5-8.5LC)	1,4°C (SSP1-2.6LC)	Low Confidence (SSP5-8.5LC)
Southern part of Bonaire	All cultural heritage at risk	Permanent flooding of all cultural heritage, except the red obelisk, unless there is a severe storm	Permanent flooding of all cultural heritage	Permanent flooding of all cultural heritage	Permanent flooding of all cultural heritage
Northern part of Bonaire	No risk	Permanente overstrooming van Boka Slagbaai en Playa Frans	Permanent flooding of Boka Slagbaai, Playa Frans, Gotomeer and small parts of Washington Slagbaai	Permanent flooding of Boka Slagbaai, Playa Frans, Gotomeer and small parts of Washington Slagbaai	Permanent flooding of all cultural heritage, except in the northwest
Kralendijk and immediate area	No risk	No risk	In the event of a severe storm, there is flooding of Fort Oranje, Playa and parts of the Kunuku area	No risk	Permanent flooding of all cultural heritage

**Table 2:** Impact of flooding due to climate change on material cultural heritage.



# PUBLIC HEALTH

**Climate change has a major impact on the health of people worldwide. The researchers conclude that it is highly likely that climate change will cause more illnesses and deaths on Bonaire. Some important examples:**

- The number of heatwaves on Bonaire is increasing due to climate change. During these heat waves more people become ill and the number of deaths increase. Bonaire has a relatively high number of obese people and the number of elderly people is steadily increasing. These groups are extra vulnerable to extreme heat.
- Climate change is expected to have a direct impact on respiratory, kidney and cardiovascular diseases. Increasing heat will worsen symptoms.
- Diseases caused by parasites, bacteria, and viruses will become more common due to climate change. These vector-borne diseases, including chikungunya, dengue and zika, are spread by, amongst other things, mosquitoes. The increase in extreme weather and flooding creates a more favorable climate for mosquitoes and so they will spread these types of diseases more often and more rapidly.
- There is also the risk of mental illness. Floods and storms can cause severe psychological trauma, which individuals and families can suffer from for years. People with mental health problems often have difficulty adjusting to extreme heat, so heatwaves can lead to more hospitalizations.

# ADAPTATION MEASURES



**In order to protect Bonaire we must not only focus on reducing global emissions, as agreed in the Paris Climate Agreement, but also on adaptation. Adaptation measures are all measures that are taken to absorb the impact of climate change. In the case of Bonaire, this mainly involves reducing the risks of flooding, heat and coral degradation.**

The researchers conducted interviews with experts and stakeholders. There is a great deal of support on Bonaire for the far-reaching restoration of the mangrove forests and the coral reef. There is also support for limiting or even preventing new construction along the coast. There is less support for building a dike. These results clearly show that adaptation measures, which are often very drastic in nature, cannot be imposed from above. A careful approach will be needed.

The study did not assess what measures are actually needed, to keep Bonaire as safe and inhabitable as possible in the future. There is a good chance that measures that are popular, such as restoring coral and mangrove forests, are not sufficient to protect Bonaire's residents. It may well be that other and additional measures are also needed, which have less support at this time. It is essential that the Dutch government, in cooperation and agreement with the inhabitants of Bonaire, works on a complete package of adaptation measures. Exactly as this has been done in the European Netherlands for decades.

# CONCLUSIONS GREENPEACE NETHERLANDS



**If the VU's research reinforces anything, it's that we need to do everything we can to minimize climate change by bringing greenhouse gas emissions rapidly to zero.**

The more the earth heats up, the more profound and irreversible the consequences will be for Bonaire. It is highly likely that the same will be true for all six Caribbean islands in the Dutch Kingdom. If we do not act, all residents of these islands will face flooding and increasing heat. Initial observations suggest that climate change may also cause more tropical storms to occur in the Caribbean; more research is needed on this. If the risk of tropical storms does indeed increase, St. Maarten, Saba and St. Eustatius will be very vulnerable to them, given their location in the hurricane belt. Bonaire has the healthiest coral

reef of the six islands, thanks to the high-level conservation efforts that have been taking place on the island for decades. It is likely that on the other five islands the coral will deteriorate even faster.

The Dutch government is responsible for the three special municipalities, but at the moment the government does not apply the same standard to all of us. In Bonaire, for example, many people find it difficult or impossible to make ends meet from their jobs, partly because the government does not provide an adequate minimum wage. The climate crisis threatens to exacerbate this existing poverty. Rising sea levels, extreme heat and dying coral are causing people to lose their jobs, land and important cultural heritage and are increasing the pressures on their health. In Bonaire, as much as one-fifth of the island is at risk of being swallowed by the sea by the end of the century.



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Also in terms of climate policy, the Dutch government has so far hardly any plans to protect the island. And yet the government must ensure that everyone is protected against the life-threatening dangers of climate change, whether you live in Terschelling, Bonaire or in Valkenburg. It stands in stark contrast to the extensive and research-based coastal protection in the European part of the Netherlands. While Bonaire has historically contributed little to the climate crisis and has

few resources to protect itself, the Dutch special municipality is nevertheless at great risk. The Dutch government must take the lead: because of the high CO<sub>2</sub> emissions produced by the European Netherlands, but also because the people of Bonaire are Dutch citizens. We have the means and the knowledge to protect all of us. Therefore, the government must also act to protect the people living on Bonaire.



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