



## Potential Climate Change Impacts to American Samoa

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Prepared by the Governor's Coral Reef Advisory Group

The average temperature of the earth's surface has risen by 0.6 degrees Celsius since the late 1800s, and it is expected to increase by another 1.4 to 5.8 degrees Celsius by the year 2100. A primary reason for this increasingly evident temperature rise is the rapid industrialization that has taken place over the past century and a half.

The burning of ever-greater quantities of oil, gasoline, and coal, the cutting of forests, and the practice of certain farming methods all serve to increase the amount of green house gases in the atmosphere. These greenhouse gases, especially carbon dioxide, methane and nitrous oxide, keep some of the sun's warmth from reflecting back into space. In naturally occurring quantities, these gases serve to keep the world from becoming cold and inhospitable. At the artificially high levels found in the atmosphere today, however, they could stimulate a rapid and profound change in average temperatures, and initiate a progression of impacts that pose significant threats to small islands in particular.

The United Nations Framework Convention on Climate Change (UNFCCC), which entered into force on March 21, 1994, set an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. Ratified by the United States in 1996, the stated objective of the UNFCCC is:

*the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.*

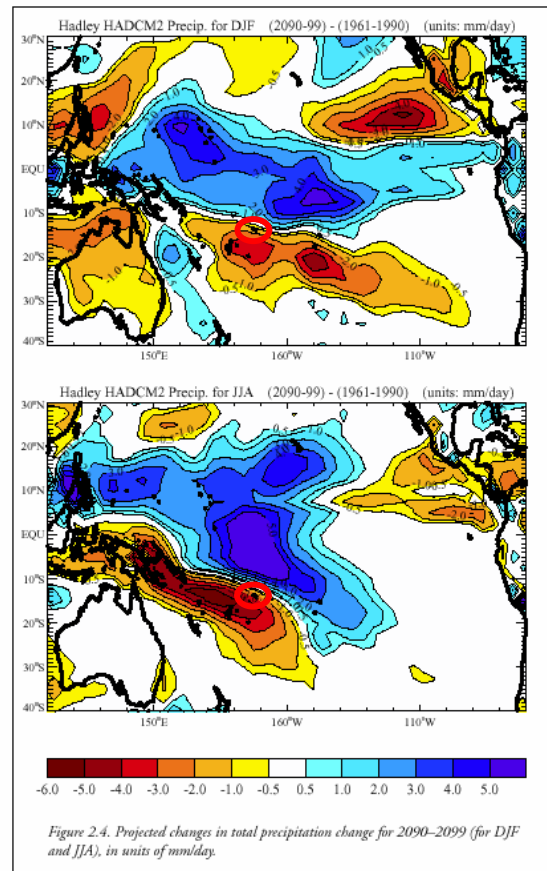
Now, ten years after United States' ratification of the treaty, we are experiencing ever-increasing impacts of climate change and greenhouse gas emissions worldwide. "It is now evident that even if actions could be taken immediately to dramatically curtail the global emissions of greenhouse gases, the inertia of the Earth's climate system is such that 0.5°C (0.9°F) or more of additional warming would still occur (Luers et al 2006. Preparing for the Impacts of Climate Change in California: Opportunities and Constraints for Adaptation. p4)". Efforts to reduce greenhouse gas emissions must be redoubled in order to stand any chance of mitigating climate change. But in addition to increasing our mitigation efforts, we must also adapt in advance of the predicted impacts of climate change. Both mitigation and adaptation are equally critical to the territory's resilience to climate change.

This paper examines the potential impacts of climate change to American Samoa's people, economy, culture and natural environment. With a clear understanding of the challenges, experts in all sectors of American Samoan life can initiate the discussion of opportunities. This paper will provide several recommendations for mitigation and adaptation policy, and should serve as a starting point for further consideration of local action to increase territorial resilience to climate change.

## Possible Environmental Changes

The environmental changes that may be experienced by American Samoa as a result of climate change vary across a range of certainty levels. Some changes, such as increasing average surface water temperatures and sea level rise, are already being observed in the Pacific Islands. The available analysis regarding other changes, such as alterations in precipitation patterns, however, show the importance of accurate models and adaptability at the local and regional level. As the figures to the left indicate, American Samoa is right on the boarder between two very different futures.

Projected changes in total rainfall for the years 2090-2099 indicate that the territory, circled in red, may experience a decrease in precipitation in both the winter and summer months. While these models may project drought conditions over the long run, American Samoa is right on the boundary between regions expected to receive less rainfall and those expected to receive significantly more rainfall. These analyses highlight the importance of both increased investment in research and the necessity to increase social, economic and environmental resilience to a broad range of potential impacts.



Projected changes in total precipitation for 2090-2099 (for DJF and JJA) in units of mm/day. Source: East West Center

## American Samoa's Vulnerability to Climate Change

There are a number of factors that increase American Samoa's vulnerability to climate change relative to the mainland United States. Some of the territory's unique features that compound the effects of climate change include:

- American Samoa is already susceptible to natural hazards such as tropical cyclones, storm surges, droughts, and tsunamis. It is predicted that climate change will result in greater frequency and intensity of such extreme events.
- American Samoa has a limited physical size, which reduces adaptation options, and forces a greater portion of the population to live and work in the highly effected coastal lands.
- Our relative isolation, both in terms of high transport costs and distance to major markets, increases the territory's vulnerability to external shocks of any kind.
- The limited natural resources and past over-exploitation has rendered American Samoa's natural systems heavily stressed and degraded, even before the full impacts of climate change have been realized. These stressed systems will be less resilient to the predicted changes to the environment.

- The limited range of terrestrial habitat types eliminates the option of migration for heat sensitive species, particularly plants.
- Fresh water resources, the factor expected to limit the territory's population carrying capacity, may be further reduced by salt-water intrusion as a result of sea level rise.
- American Samoa's dependence on imports leaves the territory highly sensitivity to external market shocks. Reduced availability of traditional subsistence products due to shifting ecosystems and reduced productivity will increase the territory's dependence on imports.
- High population density and rapid population growth force people onto increasingly marginal lands – people are moving closer to the coast and onto steeper slopes as more suitable land becomes harder to find. Populations in these marginal lands are more vulnerable to the impacts of climate change and these populations put added pressure on already stressed natural and social systems.
- Intra- and inter- island migration may result in rapid changes in social structure. Strong social structures contribute to a community's ability to adapt and respond to extreme events such as cyclones or droughts.
- Limited funds and human resource skills restrict American Samoa's capacity to adapt to the impacts of climate change.

### **A Closer Look: Sea level rise in Nu'uuli**

For the Pacific, perhaps the most significant negative effect higher global temperatures is the rise in sea levels resulting from the thermal expansion (warming causes seawater to expand) of the oceans and melting of ice-caps. It is projected that sea levels will rise by as much as 5 mm per year over the next 100 years as a result of global warming.

Utilizing the coarse data currently available to the territory, the American Samoa Coastal Zone Management division developed projection of the areas of Tutuila that may be impacted by a meter rise in sea level. Across the island critical sections of primary roads as well as private and public structures may be affected. The village of Nu'uuli and the airport, in particular, are expected to be heavily impacted. As shown by the figure to the left, large portions of the airport runway and most of Coconut Point may become inundated by seawater.

Sea level rise, combined with erosion of the coast and reef, could seriously disrupt transportation to and around the islands, and reduce public access to critical services such as the hospital. Adapting the rising seas will require significant funds to relocate or retrofit the potentially affected roads, runways and buildings. In order to efficiently allocate funds to adaptation of the most critically threatened structures, better data, in the form of LIDAR images, is needed.

Airport and Coconut Point Overview



## Potential Impacts to American Samoa

The following table summarizes the potential environmental and socio-economic impacts facing the territory.

Sector	Environmental Impacts	Socio-economic Impacts
Culture	<ul style="list-style-type: none"> <li>• Rising temperatures to result in changes in fish production</li> <li>• Loss of mangroves, which serve as breeding grounds for some fish and other aquaculture</li> <li>• Sea level rise</li> <li>• Increased rate of coastal erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Decreased/altered availability of traditional natural resources for cultural events and practices</li> <li>• Increased dispersal of Samoan population as a result of relocations to avoid the economic and physical impacts of climate change (climate change refugees)</li> </ul>
Settlements and the built environment	<ul style="list-style-type: none"> <li>• Extreme heat days</li> <li>• Increased probability of flooding</li> <li>• Increased severity of tropical cyclones</li> <li>• Vector born diseases</li> <li>• Damage to gardens and playing fields</li> <li>• Sea level rise</li> <li>• Increased rate of coastal erosion</li> <li>• Retarded coral reef growth and increased reef erosion resulting from the acidification of the ocean</li> </ul>	<ul style="list-style-type: none"> <li>• Rising insurance costs</li> <li>• Potentially substantial reconstruction, reinforcing costs – including the potential that extreme weather events may become so severe that many buildings become no longer able to withstand peak impacts: need for new building codes to improve livability during extreme weather</li> <li>• Social and economic costs of relocation for environmental refugees</li> <li>• Increase in costs associated with flooding</li> <li>• Cyclones likely to destroy settlements</li> <li>• Rising land and water management costs, sewerage/sanitation costs</li> <li>• Changes to building regulations, impacts on property values</li> <li>• Need for a territorial program to increase water conservation</li> </ul>
Agriculture	<ul style="list-style-type: none"> <li>• Rising temperatures and changing rainfall patterns may result in changes in crop viability and production</li> <li>• Rising temperatures to result in increased pests</li> <li>• Rising sea levels could lead to loss of land for agriculture</li> </ul>	<ul style="list-style-type: none"> <li>• Declines in production</li> <li>• Increased costs of pest and insect control</li> </ul>
Energy supply and transmission	<ul style="list-style-type: none"> <li>• Rising temperatures to change consumer needs (higher demand for air-conditioning)</li> <li>• Extreme events expected to threaten infrastructure including more frequent and severe rainfall, high winds, storm surges, flooding</li> </ul>	<ul style="list-style-type: none"> <li>• Increasing demand for energy services in summer, particularly in summer</li> <li>• Increased investment in transmission</li> <li>• Potential damage to transmission lines</li> </ul>

Sector	Environmental Impacts	Socio-economic Impacts
Biodiversity	<ul style="list-style-type: none"> <li>• Rising temperatures and changing rainfall to result in coral bleaching, loss of some plant/animal species</li> <li>• Deteriorating water quality</li> <li>• Loss of native vegetation and rising salinity</li> <li>• Major changes in vegetation composition</li> <li>• Increased infestation of invasive species as systems become more stressed</li> <li>• Increased concentrations of CO2 in the oceans will reduce the rate of coral growth and promote coral erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Damage to natural heritage of American Samoa</li> <li>• Loss of biodiversity could represent loss of tourism industry potential</li> </ul>
Fisheries and forestry	<ul style="list-style-type: none"> <li>• Rising temperatures to result in changes in fish production</li> <li>• Loss of mangroves, which serve as breeding grounds for some fish and other aquaculture</li> <li>• Shifting ranges of certain fish species, with the possibility of key fisheries such as tuna moving outside the range of American Samoa's Exclusive Economic Zone</li> </ul>	<ul style="list-style-type: none"> <li>• Potential fish industry losses as species shift</li> <li>• Damage to natural heritage</li> </ul>
Water quality and quantity	<ul style="list-style-type: none"> <li>• Reduced rainfall run-off, damaging catchment areas and water quality</li> <li>• Changing rainfall patterns may result in falling groundwater tables</li> <li>• Increasing evaporation may lead to reduced water quantity for catchment-based communities</li> </ul>	<ul style="list-style-type: none"> <li>• Increasing pressure on water supply and quality</li> <li>• Rising water prices and potentially severe water restrictions</li> <li>• Increasing management requirements and declining income for distribution companies</li> </ul>

Sector	Environmental Impacts	Socio-economic Impacts
Major infrastructure	<ul style="list-style-type: none"> <li>• Extreme events expected to threaten infrastructure, including more frequent and severe rainfall, high winds, storm surges, flooding</li> <li>• Rising sea levels to encroach on sections of primary roads and the airport</li> <li>• Increased concentrations of CO<sub>2</sub> in the oceans will reduce the rate of coral growth and promote coral erosion</li> </ul>	<ul style="list-style-type: none"> <li>• Damage to roads, port installations, operations</li> <li>• Changes to building regulations</li> <li>• Rising insurance costs</li> <li>• Disruptions to or discontinuations of critical transport to, from and within the territory</li> <li>• Decreased access to services (health, banking, education, etc.)</li> <li>• Reduced natural protections against extreme weather events and coastal erosion</li> </ul>
Tourism	<ul style="list-style-type: none"> <li>• Rising temperature to result in more frequent coral bleaching events and the loss of some plant/animal species, habitats</li> <li>• Increasingly intense tropical cyclones, storms likely to result in direct losses to beaches and tourism sites</li> </ul>	<ul style="list-style-type: none"> <li>• Tourism industry contraction (and reduced potential for future tourism industry)</li> <li>• Increasing quarantine costs to screen for pests</li> <li>• Damage to natural heritage</li> </ul>
Human health	<ul style="list-style-type: none"> <li>• Rising temperatures giving rise to heat stress and increased disease-bearing insect populations</li> <li>• Rising sea levels may result in a loss of agricultural land and fresh water resources</li> <li>• Extreme weather events likely to threaten human populations</li> <li>• Decreased availability of locally produced sources of nutrition</li> <li>• Potential drought, saltwater intrusion and/or intense rains will increase the chance of contaminated drinking water</li> </ul>	<ul style="list-style-type: none"> <li>• Increased poverty, perhaps ability to afford quality water</li> <li>• Increasing deaths from disease, heat stress (causing heart attack, stroke), extreme weather events</li> <li>• Rising prevention and treatment costs</li> <li>• Increased reliance on imported sources of food will increase cost of meeting basic nutritional requirements</li> <li>• Increasing cost of potable water treatment and health care as more people get sick from poor water quality</li> <li>• Increased cost of effective emergency response as extreme weather events increase in frequency and intensity</li> </ul>

## **Mitigation**

Although American Samoa has contributed only minimally, relative to the rest of the world, to the current level of greenhouse gases in the atmosphere, the territory has the opportunity to contribute to the mitigation of future greenhouse gas emissions. By taking symbolic as well as meaningful action now to reduce the territory's emission of climate change inducing gases, American Samoa can be a leader in the effort and increase the urgency of action by the United States Government. The options for mitigating American Samoa's greenhouse gas emissions include:

### *Tax the import of low mileage vehicles into the territory:*

The imposition of a graduated fuel efficiency tax for imported vehicles could both provide incentives for reduced greenhouse gas emissions as well as generate revenue. The sliding scale for a fuel efficiency tax could be based upon the Environmental Protection Agency's (EPA) published mileage ratings for the make and model of vehicle imported, with no charge for the importation of highly fuel-efficient vehicles.

There are two options for creating a graduated fuel efficiency tax: by executive order of the Governor or through legislation. Executive order could be enacted quicker, however legislation would allow for earmarking of the revenue generated, targeting activities that increase the territory's adaptability and resilience to future climate change impacts. The possible effective uses of this revenue, several of which will be discussed below, include: subsidizing public transport (aiga busses), possibly through a waiver of the gasoline tax; promotion of biodiesel use; promotion of alternative energy such as solar power, hydropower and wind power; funding of critical infrastructure needs resulting from increased weather damage and rising sea levels.

### *Graduated annual registration fees based on fuel efficiency:*

Linking annual vehicle registration fees to fuel efficiency would provide a longer-term incentive for residents to purchase fuel-efficient vehicles and provide a more consistent flow of revenue than that generated by an import tax. These graduated fees should be phased in over time in order to minimize the penalties for past purchases of low-mileage vehicles and maximize the incentives for changing vehicle purchase decisions in the future.

### *Subsidize public transport:*

Increased availability and use of public transportation, particularly aiga busses, throughout the territory should result in a decrease in private vehicle use and greenhouse gas emissions. Although aiga busses are already heavily used and private vehicles frequently transport multiple individuals, there is an increasing number of single passenger vehicles on the road. Aiga busses could be subsidized through a waiver of the gasoline tax or allowing aiga owners to purchase gas from the government service station, at government rates.

### *Promote alternative sources of energy:*

Promoting the use of alternative sources of energy, such as solar power, hydropower and wind power will allow the territory to reduce emissions of greenhouse gases on several levels. By increasing the use of more efficient and less polluting technologies, the territory will reduce its local emissions of greenhouse gases. Additionally, the increased energy independence will reduce the amount of emissions released in transporting diesel to the island, as less diesel will be required.

*Promote biodiesel use:*

Biodiesel is a renewable fuel made from alcohol and vegetable or animal oils, fats, or greases. Biodiesel can be used in any diesel engine in pure form or blended with petroleum diesel at any level and will significantly reduce carcinogenic emissions and gases that may contribute to global warming. Hawaii based Pacific Biodiesel produces biodiesel from used restaurant fryer oil, an option that may work well in American Samoa as well.

Due of the extent of the government's vehicle, there is an excellent opportunity to promote the use of biodiesel though the conversion of several government vehicles. Although biodiesel can be created easily on a small scale, provision on a larger scale will require an industrial level operation.

*Ban open burning:*

Many people in American Samoa still use on-site disposal methods like backyard burning to dispose of their household wastes. Burning household waste in a burn barrel produces carbon dioxide (CO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>), both primary greenhouse gases. Household burn barrels, fire pits, wood stoves or similar homemade devices produce low-temperature fires. They receive very little oxygen and produce a lot of smoke. Under these conditions a variety of toxic substances is produced. Virtually all of the pollutants are released into the air, and close to ground level where they are easily inhaled.

In addition to greenhouse gases, smaller amounts of more poisonous chemicals are commonly detected in the smoke, including dioxin. Dioxin is a potent human carcinogen that is especially harmful for pregnant women, children, and the elderly. Dioxin is also an endocrine disrupter and can cause reproductive, developmental, and immunological problems in humans and animals.

**Adaptation**

Many of the impacts of climate change, such as sea level rise and temperature changes will be felt incrementally. Adaptation to these gradual impacts can be similarly incremental, but will require planning and some degree of flexibility. Some activities and systems have fewer opportunities to respond flexibly because they can change only slowly. The risks and consequences of future disruption of these activities and systems can be significant. Policy makers, to ensure that adequate incentives and actions are in place to deal with the risks, must first identify these at-risk activities and systems.

Not all climate change impacts are expected to be gradual, however. The predicted increase in frequency and intensity of tropical cyclones and storm surges will result in discreet events requiring adaptive action. Similarly, certain impacts may occur rapidly once a threshold has been exceeded. For instance, although sea level rise is expected to progress slowly, once the reefs protecting our shores sink to a substantial depth, shoreline protection will be eliminated. This lack of protection resulting from deepening reefs could result in extremely rapid shoreline erosion, compounding the effects of sea level rise.

Regardless of the timeframe of the impacts, implementing planned adaptation measures will help to raise the critical threshold of at-risk systems and reduce vulnerability to future climate events.