

PURPOSE

Pursuant to the Revised Charter of Honolulu (“RCH”) Section 6-107(h), the City & County of Honolulu Climate Change Commission (“Commission”) is charged with gathering the latest science and information on climate change impacts to Hawai‘i. It provides advice and recommendations to the mayor, City Council, and executive departments as they look to draft policy and engage in planning for future climate scenarios as well as reduce Honolulu’s contribution to global greenhouse gas emissions.

The purpose of this document is to better understand the intersection between climate change and tourism - where tourism activities both contribute to global greenhouse gas (GHG) emissions and can be impacted by the effects of climate change. To the extent possible, this document provides indicators (i.e. data and data compilation) that can be used and tracked to better understand the intersectionality of climate change and tourism on O‘ahu.

RECOMMENDATIONS

The Commission has conducted research on . The Commission finds the following:

I. INTRODUCTION

Tourism is Hawai‘i’s largest industry, comprising about a quarter of Hawai‘i’s economy (Bond-Smith and Fuleky, 2022). Tourism arrivals statewide hit a record high of 10.4 million in 2019, prior to the COVID-10 pandemic, and recovered to 9.2 million in 2022 (UHERO, 2023). In 2019, visitors spent \$19.8 billion (\$2022) and, in 2022, \$19.3 billion (\$2022) (UHERO, 2023). Over half of visitors are destined for O‘ahu (53 and 58% for 2019 and 2022, respectively), though with a smaller proportion of statewide spending (46 and 44% for 2019 and 2022, respectively). Though tourism is Hawai‘i’s largest industry and thus a substantial contributor to Hawai‘i’s economy and tax base, it has not been an engine of economic growth for quite some time. Per capita visitor expenditures have been in a declining trend since 1992 (Bond Smith and Fuleky, 2022). That tourism today has more environmental impacts through increasing visitor arrivals but with relatively fewer economic gains, perhaps helps to explain growing discontent by residents of the tourism industry and resident demand for more tourism management (HTA, 2023). The COVID-19 pandemic, with visitor arrivals dropping by 98% in the second quarter of 2020 (UHERO, 2023), was also a window into the role that tourism plays in Hawai‘i - both economically and environmentally. This document identifies ways in which visitors and the tourism industry intersect with climate change - both its causes and its consequences - as well as identifies sources of data and models to further build understanding as well as track relationships between tourism and climate change over time.

The Commission has identified a number of ways that climate change intersects with the tourism sector. They are:

- Visitor and tourism industry contributions to global GHG emissions.
- Visitor and tourism industry consumption of natural resources that are also affected by climate change; specifically, water.

- Visitor impacts to environmental/ecological degradation, such as the overuse of trail systems, that might also be affected by climate change.
- Visitor impacts to local food systems, that might also be affected by climate change; however, there is limited research about local food systems and climate change.
- Impacts of acute disaster events on visitors and the tourism industry, including response needs.

II. VISITORS AND CLIMATE CHANGE IN HAWAII'

Visitors and GHGs

In 2019 Hawai'i contributed 22.01 million metric tonnes of carbon dioxide equivalent (MMTCO_{2e}, based on global warming potential) into the global atmosphere (DOH, 2023).¹ This is an increase from 21.92 MMTCO_{2e} in 2018. The highest estimated annual GHG emissions for Hawai'i is for 2007, which was 27.04 MMTCO_{2e}. Energy, Industrial Processes and Product Use, Agriculture, Forestry and other Land Use, are the major categories of measured GHG emissions within the State's GHG inventory, which follows national and international inventory and reporting standards (See IPCC, 2019). The Energy sector is by far the largest contributor to Hawai'i's GHG emissions, comprising 88% of sources in 2019 (DOH, 2023). Energy sector emissions include stationary combustion (primarily electricity generation), transportation (ground, marine and domestic aviation), oil and natural gas systems, waste incineration and a small portion of non-energy uses. International aviation is also measured within the State's GHG inventory, though not reported in the total accounting per best practices within inventory accounting methods (DOH, 2023).

O'ahu is the state's largest county based on population and therefore also has the largest measured annual GHG emissions. O'ahu contributed 14.45 MMTCO_{2e} to the global atmosphere in 2019, which is 66% of the state's total GHG sources. 13.62 MMTCO_{2e} were from the Energy sector, 94% of O'ahu's total GHG emissions.

Coffman et al. (2022) accounts for visitor contributions to Hawai'i's GHG emissions, both upstream and downstream sources (this can also be thought of as direct and indirect GHG emissions). The study uses the State GHG inventory for 2016 as well as the State's Input-Output Table (DBEDT, 2016) within a general equilibrium model (i.e. with price effects) to estimate visitor contributions to a policy scenario of a state-level carbon tax. This analysis measures all contributions of visitor demand in Hawai'i, including direct demand of GHG-intensive sectors through activities like driving a rental car to indirect demand through activities like electricity within hotel accommodations. The study finds that visitors would pay between 27-36% of total carbon tax revenues between the years 2025 and 2045 (increasing over time). This finding means that visitors contribute the same proportional amount in GHG emissions within the Hawai'i economy. Because the simulated tax rate is assumed to go into effect in 2025, and visitors are found within Fuleky, Zhou and Bonham (2014) to have inelastic demand for a Hawai'i vacation, the proportion of visitor contributions to GHG emissions would be smaller in 2020, but only slightly. Approximately a quarter of GHG emissions can be attributed to the visitor industry statewide.

A limitation of this analysis, however, is that as a tax scenario it accounts only for GHG emissions that are fueled within the borders and jurisdiction of the state. Outside of the scope, therefore, are domestic aviation flights originating elsewhere and flying to Hawai'i, military activities, and international aviation and marine fuels (in both directions). It is inventory accounting practices to attribute only the originating leg of the trip to the location, so as to not double count GHGs between localities. Should a more holistic "GHG footprint" analysis be desired, rather than an inventory, visitor demand of domestic aviation can simply be multiplied by two. International visitors, including those

¹ If sinks are considered, this drops to 19.42 MMTCO_{2e} (DOH, 2023).

on international cruise liners, would consume additional transportation fuels. International bunker fuels are reported within the State's GHG inventory (DOH, 2023). Because visitors do not consume military services while on a vacation, this is moot.

To get a more comprehensive picture of the visitor contribution and "GHG footprint" from the aviation industry, the Commission provides the following calculations. Within the State's 2019 GHG inventory, a total of 4.95 MMTCO₂e are attributed to domestic aviation and 1.64 to international bunker fuels (the vast majority of which will be aviation, and for this illustration, assumed to be in its entirety). Adding these together and multiplying by two, to account for the roundtrip, results in 13.18 MMTCO₂e. As a next step, a factor of 0.84 is applied, to account for the ratio of passengers to cargo (see Technical Appendix CAP, 2022). Next, a factor of 0.86 is applied, to account for the pre-pandemic ratio of visitors to residents (see Technical Appendix CAP, 2022). With this, there is a total of 9.52 MMTCO₂e attributed to the visitor travel footprint in the year 2019. Aviation has additional short-lived climate forcers, for example from NO_x contributions. There are still few definitive studies in this area and therefore *low confidence* within IPCC estimates of additional forcing from processes like contrails (IPCC, 2021). The IPCC AR6 states that: "Overall, cirrus and contrail cirrus warming, as well as NO_x-induced ozone increase, induce strong but short-lived warming contributions ... (medium confidence) ... while CO₂ both gives a warming effect in the near term and dominates the long-term warming impact (high confidence) (6.6.2.3 Transportation).

Visitors and Water

Climate change is impacting the availability of water across the state through declines in supply and increases in demands. Historic rainfall data shows that average annual precipitation has declined over the last century. While there is no consensus about expected future rainfall patterns, as different projection methods have led to different outcomes, the decline over the last century has already diminished the supply of water (Climate Change Brief, 2023). In addition to less supply, greater demands on water due to climate change will also impact its availability in the future. Climate change has caused prolonged and more intense droughts across the islands (Climate Change Brief, 2023). Droughts require more reliance on groundwater as the source for water consumption, while also limiting the ability for aquifers to recharge. In turn, this limits the ability to draw on groundwater sources in the future. Climate change has also caused more days of extreme heat (Climate Change Brief, 2023), which can create a greater water stress. With both the likelihood of less water availability and increasing demands for water caused by climate change, the tourism industry is likely to be impacted as a significant consumer of water.

The entire state consumed 275,500 million gallons of freshwater in a year period from 2018 to 2019, where O'ahu consumed a total of 47,500 million gallons of water (17%) (Hawai'i Data Book Table 5.25). The Hawai'i Data Book (Table 5.28) reports that 6 of the top 10 consumers of water on O'ahu in 2017 were golf courses, which provides an activity consumed by both residents and visitors. Isolating the consumption of water by visitors is a difficult research task that, unlike GHGs, has not been recently done. Similar to GHGs, an accepted method for unpacking resident and visitor consumption of water (direct and indirect) could be based on the State's Input-Output data and a complementary general equilibrium model. Input-Output data (also called I-O table) show the flow of sector demand through an economy, including intermediate industries and final consumers. A previous analysis was published by the Department of Business, Economic Development and Tourism in 2006, using the 1997 Input-Output data (DBEDT, 2006). This study found that a \$1 million (\$1997) increase in visitor spending related to a 1.12 million gallon increase in demand for non-agricultural water.

Both residents' and visitors' expenditures are given in Hawai'i's 2017 I-O table. We provide an illustration of how visitor water consumption can be characterized with available data for O'ahu and the state. Using the 2017 State I-O tables, visitors are, as a first pass, estimated to have consumed 19% of the total value of water consumed in the state during 2017. This is largely due to the high use of utilities by the accommodation industry (\$48.7 million, 9.8% of total utility demand) and the high demand visitors have for accommodation (62% of total demand for the industry) while visiting. Visitors make up the highest portion of spending on accommodation in the City and County of Honolulu relative to the demand for the industry, then Hawai'i County, Kaua'i County, and Maui County respectively. Only the demand for utilities on O'ahu is greater than 10% (about 13%). The rest of each counties' demand for utilities through accommodation is less than 6%. These estimates do not, however, constitute a precise measure and should be further evaluated because the I-O table lumps the value of water utilities with gas and sewer utilities. At the county level, utilities can also include electricity. This estimate assumes that they are in equal shares - and a more precise estimate would decompose the value of individual utilities. In addition, a modeling approach (like computable general equilibrium) could tease out further indirect water demand, e.g. water demand by residents that exists due the resident income generated by visitor spending. In general, the I-O table shows that visitors have a high demand for industries such as accommodation, eating and drinking, and retail. Some of the visitors' most demanded industries also have significant utility use (accommodation), which includes water utilities. Therefore, visitor demand for water can be estimated by assessing the visitor demand for industries with utility use.

In sum, visitors and the visitor industry creates additional demand for freshwater, both from direct consumption but also in indirect activities. The visitor industry also creates additional demand because it, in part, supports the size of the resident population; for example, through supporting visitor-industry jobs. The magnitude of visitor demand for freshwater is substantial and thus should be considered in broader water management strategies in the face of climate change.

Visitors and Environment/Ecology

Many tourists come to Hawai'i to experience the natural environment. Like many residents, visitors enjoy the beaches, swim in the ocean, and hike up mountains. Due to the diversity of activities, comprehensively measuring the impact that visitors have to the natural environment is a monumental task; however, some research exists as it relates to degradation of beach, nearshore ecological systems, and hiking trails.

Beachgoers often contribute to the degradation of beach dunes due to the high volume of foot traffic (Eversole, 2009). However, attributing impacts to visitors separate from residents is often a difficult task. Similarly, trail erosion has also been studied as an impact of overuse. According to DLNR, trail erosion is a problem on O'ahu but, similar to beach erosion, it is currently difficult to separate the impacts of visitors from the impacts of residents. There is a proposal for the Hawai'i Tourism Authority to study which trails visitors frequent based on cell phone data, which would help assign environmental impacts to visitors or residents (Yerton, 2019).

The degradation of coral reefs in Hawai'i is also a potential impact as a result of tourism, though available studies do not necessarily tease out tourists and residents in their assessment of impacts of visitors to a coral reef system. Lin et al. (2023) shows the relationship between beachgoers and coral - where live corals attract more visitors to the reef (both residents and tourists) but also more visitors relate to lowering coral cover. Essentially, the abundance of coral attracts visitors but this also makes the reef more susceptible to degradation. Rodgers et al. (2023) quantified the

impact of visitors to the reef (residents and tourists) to Hanauma Bay as “one reef disturbance for every two individuals,” which can begin to isolate the impact from visitors to Hawai‘i compared to the impact from residents. Lin et al. (2023) measured the impacts on corals, which include trampling and polluting of corals, through high resolution imagery. Measuring the impact visitors have on coral reefs is important because warming oceans due to climate change are already affecting the viability of coral (Climate Change Brief, 2023).

While the degradation of dunes, hiking trails, and coral reefs are stand alone problems, they also interact with climate change. The potential impacts visitors have on these systems may also be exacerbated by the impacts of climate change. For example, beach dunes provide a natural barrier to high wave flooding. Whereas healthy beach dunes help to mitigate erosion and provide a natural barrier to high wave flooding, an eroded beach dune could on the other hand exacerbate coastal erosion and subsequent impacts from sea level rise. Similarly, the erosion of hiking trails may be exacerbated by intense precipitation events and cause flash flooding as well as landslide events. Lastly, coral reefs are already being stressed through coral bleaching and ocean acidification. Otherwise stressed corals are less likely to survive the impacts of climate change (Climate Change Brief, 2023).

Add more on ecosystem services

Visitors and Food Systems

In 2018, Hawai‘i farmers produced 105 million pounds of food locally according to the Aloha+ Challenge dashboard. Food production (in pounds) has been trending downward since the 1980s, and there are statewide goals to increase (double) local food production (to double it, by 2030, according to the Aloha+ Challenge). Another goal of the State’s 2050 Sustainability Plan is to increase the statewide consumption of locally grown foods by 20-30%. Though it is difficult to track what portion of locally grown foods go to the visitor industry versus residents, again the State’s I-O table provides some insights.

The State’s I-O tables indicate that less than 1% of residents expenditures and visitor expenditures are spent directly on crop production in Hawai‘i. Demand for locally grown crops by both visitors and residents is mostly indirect as most of the outputs from crop production (73%) go into food processing. A majority of outputs from food processing (67%) are demanded by the eating and drinking industry which is highly demanded by both visitors (29%) and residents (42%). Visitors can affect the outcome of 2050 Sustainability goals by choosing to consume locally grown or raised foods either through direct purchase or through their choice of restaurants. Typically, locally grown foods are more expensive than imported foods, which can make it difficult for the average consumer (resident and visitor) to purchase the locally produced food item. However, a recent study found that visitors are more willing to pay higher prices for food if it is locally grown or raised (Linnes, 2022). This indicates that visitors may play an important, though indirect, role in supporting local food systems by creating demand for locally grown food.

Climate change may have an impact on Hawai‘i’s food systems by affecting crop production. First, changing weather patterns and rising sea levels may affect the viability of certain crops growing in the islands. Already, farmers are experimenting with the salt tolerance of different kalo varieties. Furthermore, changing precipitation patterns can lead to less favorable growing environments for many crops (Climate Change Brief, 2023). Under the RCP 8.5 scenario, which is the most extreme climate change scenario, Hawai‘i could lose up to 35% of its current land viable for agriculture as determined by the area of land in agriculture production in pre-contact Hawai‘i (Kurashima, Fortini, &

Ticktin, 2019). Though not all of the currently viable land is in agricultural production, or even zoned for agriculture, this study indicates that climate change, especially changing rainfall patterns, will affect agricultural practices across the islands. Examples of climate change affecting crop production have already occurred in other places. For example, shifting temperatures in Florida have made its citrus industry more susceptible to citrus greening, a disease that is seriously harmful to citrus plants, because the climate is more and more suitable to the pest that causes the disease (Taylor et al., 2019). Climate change is likely to impact food production since there are many aspects of the food system that are climate dependent.

In addition to impacts to production, climate change can also impact the infrastructure of the food system. Hawai'i imports nearly 90% of its food (Loke & Leung, 2013), which highlights the importance of shipping and transportation infrastructure within the food system. Honolulu Harbor and the airport are two important entry points for food in the state, as well as all other import/export goods (including visitors), and they are both vulnerable to sea level rise impacts. Proactive planning to ensure the future viability of critical infrastructure is therefore of utmost importance.

Visitors and Emergency Services

Emergency services related and unrelated to climate change are required by visitors and residents alike; services include police, fire, rescue and health. Climate related emergency services include, for example, search and rescue in the event of flash flooding or hurricanes, and health services for impacts related to extreme heat. Both visitors and residents require emergency services but there may need to be special considerations for visitors, especially when facing a climate related disaster.

Many visitors that come to O'ahu stay in Waikīkī, which is exposed to several climate hazards that make it a vulnerable location. As a coastal area, Waikīkī is vulnerable to hurricanes, tsunamis, storm surge flooding, and flooding associated with sea level rise. As a result of its exposure to acute hazards, emergency evacuation is a vital component of disaster response in services in Waikīkī. For some hazards like tsunamis and flooding, which will likely occur more frequently and intensely as a result of climate change, vertical evacuation is an acceptable option. Though many buildings in Waikīkī are tall enough to evacuate vertically, there is still a large population that needs to evacuate the area (horizontal evacuation). According to scenario modeling for tsunami evacuations in Waikīkī, Kim (2022) found that increasing the network capacity for evacuees and increasing the available evacuation times are two important factors for reducing fatalities associated with tsunamis. Improving these factors would also help reduce the burden on emergency services during a disaster event as it would maximize safety.

Hurricanes present different challenges for emergency services. Hurricanes are expected to increase in frequency and potentially intensity as a result of climate change (Marra & Kruk, 2017; Murakami et al., 2013). Instead of evacuating the hazard area, hurricane response is typically to shelter in place. However, there are challenges to sheltering in place across the O'ahu due to the aged infrastructure. Sheltering in place is only ever advisable if the house you are sheltering in is built to withstand hurricane force winds (on O'ahu, this practice was only required for residences built after 1995). This leaves a lot of residents vulnerable to hurricanes, as well as visitors. According to the State's "Hurricane Evacuation Shelter Planning and Operations Guidelines" many of the larger hotels will have shelter-in-place plans in the event of an emergency. However, visitors staying in smaller to medium sized hotels or in older vacation rentals, will need to find an emergency shelter. This will likely place a greater burden on emergency

services since visitors are less likely than residents to be able to stay with another resident or friends, thus requiring the need for an emergency shelter.

Emergency shelters present another set of challenges for emergency services. First, most of the emergency shelters are not built to withstand winds greater than a tropical storm. Therefore, these shelters will likely not be highly effective in the face of a hurricane stronger than a tropical storm (HI-EMA, 2017). Additionally, it is assumed that many people that choose to shelter in emergency shelters will not have the necessary supplies to wait out the storm (HI-EMA, 2017). This is especially true for visitors as they are much less likely to have stockpiled food supplies in preparation for a hurricane. In 2018, a “rain bomb” in Hanalei, Hawai‘i dumped about 50 inches of rain in a 24 hour period and caused severe flooding. Of the people that chose to shelter at the emergency shelter, most were tourists. Due to a lack of supply preparation for a disaster event and the inaccessibility of the shelter from the flooding, they temporarily ran out of food and water (Torrential Rains Leave Dozens Stranded in Hawaii Shelter, 2018). This example illustrates the potential increased burden on emergency services from tourism.

Long term disaster recovery may be impacted by climate change since Hawai‘i’s main points of entry (the port of Honolulu and the airport) are exposed to climate hazards. For example, if the port or airport are substantially damaged, it will be much more difficult to import disaster relief and emergency service workers or to evacuate visitors or residents (HI-EMA, 2021). In addition to entry points, impacts to critical infrastructure will affect the ability to quickly and effectively recover. In the worst case flood scenario from hurricane storm surge and tsunami that accounts for sea level rise, 69% of arterial roads will be flooded, as well as 44% of highways, 38% of freeways, and 40% of local streets (Kim, 2014). The impacts to transportation infrastructure will make evacuation and recovery difficult in the event of a disaster, for residents and visitors alike.

In sum, climate change is expected to increase the frequency and impacts of acute hazards. Visitors may create a greater burden on emergency services in hazard response because of their lack of resources on the island. For example, visitors may be less likely to have access to a vehicle and require support for evacuation, as well as seek emergency shelter. Specific plans for visitor-oriented disaster planning, such as is done for Waikīkī, may become increasingly relevant.

Add hotel industry perspective on how climate change is impacting their viability to stay/invest in Hawai‘i

- also hotels with their capacity to respond/adapt to climate change
- look at case studies of limiting tourism
- are certain parts of the tourism industry not as viable

Recommendations

- tracking impacts
- tracking tourism industry’s engagement/partnership with mitigation/adaptation
- 1-2 recs per section

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