The Costs of the Vehicle Economy in Hawai‘i

Final Report

January 26, 2021

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Table of Contents

List of Tables

List of Figures

Acknowledgements

This report was prepared for Ulupono Initiative by ICF Incorporated, L.L.C. ICF is a global consulting services company that is internationally recognized for expertise and leadership in transportation assessment, benefit-cost analysis, greenhouse gas mitigation, and climate resilience planning.

This project was led by Kathleen Rooney and Micah Munekata of Ulupono Initiative with support from Adam Buote, Keith DeMello, and Greg Gaug.

This report was prepared by ICF, with project staff including Jeffery Ang-Olson, Susan Asam, Hana Colwell, Elizabeth Johnston, Jonathan Hecht, Kristina Heggedal, David Ryder, and Jeremy Stumpp.

The authors would like to thank the many experts consulted to review and critique this report. The following individuals volunteered their time and expertise in support of this assessment:

Kari Benes, *State of Hawaiʻi Department of Health*

Mark Garrity, *Urban Pacific Consulting*

Beth Giesting, *Hawaiʻi Budget & Policy Center*

Colin M. Hayashida, *State of Hawaiʻi Department of Commerce and Consumer Affairs, Insurance Division (Insurance Commissioner)*

Kendrick Leong, *Hawaiʻi Data Collaborative*

Brennon Morioka, *Dean, University of Hawaiʻi-Mānoa, School of Engineering*

Stevie Olson, *New Mexico Legislative Finance Authority*

Jill Tokuda, former Hawaiʻi state senator

Justin Tyndall, *University of Hawaiʻi Economic Research Organization*

1. Executive Summary

Roadways are a heavily subsidized part of the state economy. The vehicle transportation system is supported by a combination of federal, state, local, and private expenditures. The inclusion of both direct public and private investments, as well as the difficulty associated with assessing and quantifying indirect costs, makes it difficult to determine the true full cost of the vehicle economy. While public costs, such as roadway construction and maintenance, may be readily identified in annual budget documents, other costs, such as emergency services related to crashes and injuries and the cost of parking, are not always considered. Private individuals who track their budgets may identify car and insurance payments, but rarely consider operating and maintenance costs because the majority of roads and parking areas are either free or heavily discounted for users.

This report presents a summary of the public and private costs in Hawaiʻi of the vehicle economy, which includes all roadways, vehicles, and transportation infrastructure costs (e.g., bridges, on-off ramps, signs, speedbumps, parking) as well as associated costs such as pollution and congestion that result from the use of the ground transportation system.

This report concludes that the annual cost of the vehicle economy in Hawaiʻi is approximately $21.8 billion (see Table 1). More than half, or $11.2 billion of the total, is borne by the public in the form of state and county budget costs, social and economic costs (such as road-related injuries and fatalities, congestion, and pollution costs), and the real estate value of land set aside for roadways and parking spaces. The remaining $10.6 billion is borne by consumers in the form of the cost of vehicle ownership (including maintenance and operation costs).

KEY FINDINGS

Costs of the vehicle economy are extensive:

Annual costs of $21.8 billion ($11.2 billion public and $10.6 billion private).

Public costs amount to roughly $15,000 per taxpayer ($24,400 per household), annually, regardless of vehicle ownership.

Personal vehicles cost an additional $8,100 per vehicle per year ($16,200 per household).

Significant revenue gaps exist:

User fees amount to approximately $378.0 million, annually, covering only 49 percent of the public roadway expenditures from the state and counties.

The *revenue gap* is expanding with 10-15 percent of the state's highway system set to be directly impacted by sea level rise.

Maintenance backlog is large:

The *maintenance backlog* is equal to annual expenditures ($560.2 million) and unlikely to be resolved soon.

Table 1. Annual Cost of the Vehicle Economy in Hawaiʻi

Category	Cost (Billions of $)	Percent
Public Costs	$11.2	51.2%
Consumer Costs	$10.6	48.8%
Total Costs	**$21.8**	**100.0%**

2. Introduction

There are approximately 9,800 miles of public roadways [U.S. Department of Transportation (USDOT), 2018], and more than 1.27 million registered vehicles [State of Hawaiʻi Department of Business Economic Development, and Tourism (DBEDT), 2020a] that comprise the state's ground transportation system, which is inextricably linked to the state's economy, environmental footprint, and quality of life. Transportation policy and planning is the primary opportunity to shape the transportation system so that it supports state and local goals. In the past, decisions regarding where and how to invest in the transportation system may have been made without full recognition of their impacts on broader community goals. Consequently, those decisions sometimes focused narrowly on objectives like traffic speed and vehicle throughput or cost of per-mile roadway maintenance. Today, there is a growing recognition among public agencies that transportation plans and projects can be critical to advance important community goals around greenhouse gas (GHG) mitigation, expansion of multimodal choices, social equity, and improving the health and safety for all system users and modes.

In addition to roadways and vehicles, the vehicle economy includes the transportation infrastructure (e.g., bridges, on-off ramps, signs, speedbumps, parking) as well as associated costs such as pollution and congestion that result from the use of the ground transportation system. Funding the road system is a default policy decision that is rarely considered or scrutinized. This system is financed by a combination of federal, state, local, and private funding sources, which are becoming increasingly strained due to increasing budget demands and shortfalls. Some of these budget demands are imminent (e.g., funding needed for COVID-19 relief and recovery), while others are longer-term (e.g., retrofitting deteriorating roadway systems that are at high risk of damage from climate change impacts).

There are a few characteristics of the vehicle economy that make it particularly difficult to assess. For example, the vehicle economy includes both public systems (e.g., roads) as well as private, consumer-borne components (e.g., vehicles). This split makes a true accounting of the costs of the system inherently difficult. Some costs (e.g., roadway maintenance) are denoted on publicly available budget documents, while private vehicle-related expenditures are not captured in the aggregate and must be estimated. The costs associated with the vehicle economy are further complicated by components that are not directly budget-related nor have a direct monetary component. Examples of such indirect costs include those from pollution or congestion.

This inequality of the costs of the vehicle economy is an additional concern, since the negative impacts of pollution and congestion tend to be borne disproportionately by the most vulnerable in the community. These communities tend to be near sections of the transportation system that suffer from high air pollution, high congestion, and noise pollution and that these transportation-related costs are borne by individuals regardless of vehicle ownership.

A goal of this report is to provide comprehensive local data to Hawaiʻi leaders as they weigh expenditures and investments to best address community needs and facilitate post-pandemic recovery efforts. On Dec. 21, 2020, Gov. David Ige submitted his Fiscal Biennium Budget 2021-23 to the Hawaiʻi State Legislature, requesting $15.4 billion for the operating budget in fiscal year (FY) 2022, along with another $1.2 billion for the Capital Improvements Program budget. In the wake of COVID-19, budget strain is a prominent issue. The governor anticipates a $1.4 billion shortfall each year of this two-year budget period (Hawaii.gov, 2021), necessitating reductions in both the operating and capital improvements program budgets as the state's tourism industry declines and as unemployment spikes to one of the highest rates in the nation (NPR, 2020). This funding contraction will be felt across all agencies including transportation.

Although the counties currently appear to have more balanced budgets, it remains to be seen whether the structural issues in funding and system maintenance will be resolved, particularly as the impacts of the pandemic continue. For example, Honolulu's fiscal year 2022 proposed budget was balanced only after nearly all city agencies were required to slash their current year's expenses by 10 percent (Pang, 2020).

This analysis develops a conservative estimate of the costs associated with the vehicle economy using a combination of publicly available budget information, state and federal analysis guidance, academic research, and financial modeling. The analysis contained in this report adapts a methodology used by the Harvard Kennedy School on the vehicle economy in Massachusetts (Olson et al., 2019), which has been adjusted to reflect Hawaiʻi's unique context. The Massachusetts analysis presents a framework that can be used to assess the costs of the vehicle economy as well as several useful data sources for the Hawaiʻi project. For this analysis, we first identified which metrics, methods, and data sources would be applicable to Hawaiʻi. We adjusted the methods used to fit Hawaiʻi, substituting in Hawaiʻi-specific data sources and assumptions to fit the unique characteristics and geography of the state. In cases where Hawaiʻi-specific information was not available, we relied on national averages. While the Massachusetts study solely estimated impacts at the state level, this report estimates county-level impacts along with statewide costs. Because Hawaiʻi's county boundaries are aligned with islands, they have distinct and unique geographic boundaries.[1] Results for this analysis are presented for the City and County of Honolulu and Counties of Hawaiʻi, Maui, and Kauaʻi. [Results are not presented for Kalawao County because its population is very small (less than 100), and it functions as a judicial district of Maui County.]

As discussed, vehicle economy costs are broken into two distinct types: publicly borne costs and consumer costs. The publicly borne costs represent the investments made by the local and state governments (along with federal dollars) to construct and maintain roadways and the resource trade-offs incurred by the public, either directly or indirectly, regardless of vehicle ownership. The consumer costs represent those costs incurred by individuals who own and operate vehicles. Following suit, this report is divided into two primary chapters focusing on the publicly borne costs and consumer-borne costs.

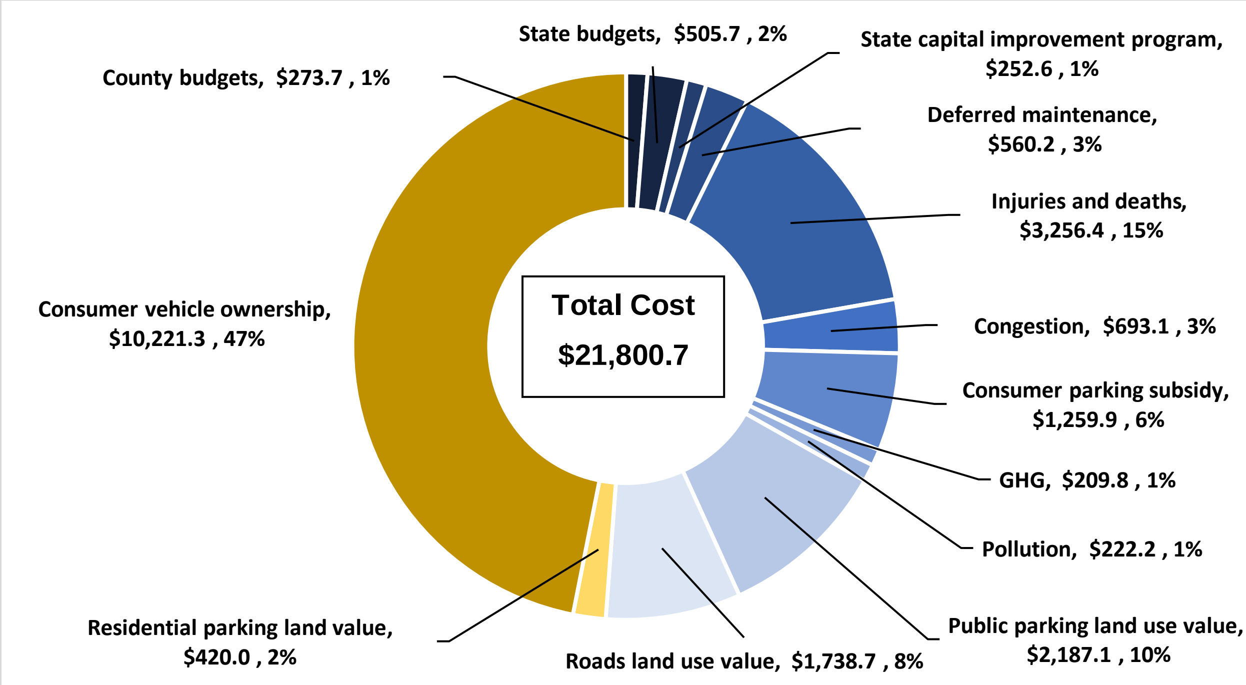
It is important to clarify that this analysis is not a cost-benefit analysis as it does not account for benefits of the various transportation investments or vehicle ownership, which may be numerous. Instead, this analysis is focused on estimating the true costs of the vehicle economy in Hawaiʻi as a first step in understanding the depth of our transportation system investment. Our analysis takes a conservative approach, estimating the value of the costs of the vehicle economy while taking care not to use inflated assumptions. As such, the costs presented in this report can be viewed as a floor, or a lower bound, of the true costs of the vehicle economy. All dollar figures in this report are expressed in 2019 dollars.

3. Costs of the Vehicle Economy in Hawaiʻi

Based on this analysis, the annual cost of the vehicle economy in Hawaiʻi is approximately $21.8 billion (summarized in Figure 1). Of this total, $11.2 billion are publicly borne costs, including public budgetary costs, indirect social and economic costs, and annualized land usage costs. Costs to consumers, including parking and vehicle ownership costs, account for the remaining $10.6 billion.

[1] The islands that make up each county are as follows: The City and County of Honolulu contains the island of Oʻahu; Hawaiʻi County contains the island of Hawaiʻi; Kauaʻi County contains the islands of Kauaʻi and Niʻihau; and Maui County contains the islands of Maui, Kahoʻolawe, Lānaʻi, and most of Molokaʻi. Kalawao County encompasses the Kalaupapa or Makanalua Peninsula, on the north coast of Molokaʻi.

Figure 1. Annual Costs of the Vehicle Economy in Hawaiʻi (Millions of $)



At a county level, Honolulu has the highest vehicle economy cost at $14.3 billion (66 percent), followed by Hawaiʻi County at $3.1 billion (14 percent), Maui County at $3.0 billion (14 percent), and Kauaʻi County at $1.4 billion (6 percent).[2] As state costs were assigned to counties by resident vehicle registrations, these costs are generally proportionate to county populations.

Table 2. Annual Cost of the Vehicle Economy in Hawaiʻi by County

County	Cost (Millions of $)	Percent
Honolulu	$14,340.8	66%
Hawaiʻi	$3,118.9	14%
Maui	$2,957.7	14%
Kauaʻi	$1,383.3	6%
Total	**$21,800.7**	**100%**

[2] The county-level costs represent the aggregation of all the cost components presented in the analysis. Some cost categories are naturally disaggregated into counties, such as for the county-specific vehicle-related budgets. Other cost categories are not naturally disaggregated, such as state-level expenditures and capital outlay. Where cost components were not disaggregated, we used the county-level vehicle registration proportions: Honolulu 63 percent, Hawaiʻi 16 percent, Maui 14 percent, and Kauaʻi 7 percent. We recognize that this cost disaggregation is not perfect, but it provides some insight into the county dynamics of the Hawaiʻi vehicle economy.

3.1 Publicly Borne Costs

Public-borne costs amount to $11.2 billion, annually:
- Roughly $15,000 per taxpayer
- Roughly $24,400 per household
Regardless of vehicle ownership

Publicly borne costs are costs incurred by the public either directly or indirectly, regardless of vehicle ownership. Direct public costs include costs from local, county, state, and federal governments to build, repair, and maintain public roads. Indirect public costs include the costs of vehicle-related injuries and fatalities, congestion, GHG emissions, and pollution. Many of these non-monetary costs represent negative externalities associated with vehicle travel.[3] The last component of public costs is the land value of public roads and parking spaces because they represent the full opportunity cost of subsidizing vehicle travel.

The calculations of public costs rely on publicly available data from county and state-level budget documents. Publicly available information was supplemented through discussions with local and state officials, where necessary. Table 3 contains data for each category of publicly borne cost, which total $11.2 billion. Direct budgetary costs from county governments, state governments, and outlays from the federal government total nearly $1.6 billion, or roughly 14 percent of all public costs. More than half ($5.6 billion, or 51 percent of publicly borne costs) are indirect social and economic costs. The most expensive indirect costs are those associated with injury and fatalities, followed closely by subsidies for consumer parking. The final roughly 35 percent of publicly borne costs are the opportunity costs of using land for parking ($2.2 billion) and roads ($1.7 billion). Each cost line item is explained in further detail in the subsequent sections.

[3] A negative externality is a cost that is suffered by a third party as a consequence of an economic transaction. Air pollution is considered a classic example of a negative externality because there are negative health impacts on people who did not cause the initial pollution.

Table 3. Annual Public Costs of the Vehicle Economy in Hawaiʻi

Category	Sub-Category	Cost (Millions of $)	Percent
Direct Budgetary Costs	County Budgets	$273.7	
	State Budgets	$505.7	
	State Capital Improvement Program (CIP)*	$252.6	
	Deferred Maintenance	$560.2	
	Total	**$1,592.2**	**14%**
Indirect Social & Economic Costs	Injuries and Fatalities	$3,256.4	
	Congestion	$693.1	
	Consumer Parking Subsidy	$1,259.9	
	Greenhouse Gas Emissions	$209.8	
	Pollution	$222.2	
	Total	**$5,641.4**	**51%**
Land Value Costs	Parking	$2,187.1	
	Roads	$1,738.7	
	Total	**$3,925.8**	**35%**
Grand Total		**$11,159.4**	**100%**

* State capital improvement program includes federal funding.

There are several reasons why the magnitudes of these costs are important to consider. The current estimated public costs of the vehicle economy ($11.2 billion) amount to roughly $15,000 per taxpayer, or about $24,400 per household, annually, regardless of whether or not they own a vehicle.[4] In addition, many of these costs are indirect – so they are not directly attributed to the original roadway investment decision nor usually reflective of user's willingness to pay. For a state whose household median income is roughly $80,000 per year, these costs amount about 30 percent of household pre-tax income.[5]

One of the problems with these costs is that they are not internalized within household budgets, but rather paid through taxes, separated from the impacts of these costs. Indirect costs, such as GHG emissions and air pollution, impose real costs on communities in the form of poor air quality and respiratory illness, which can lead to lost work productivity, higher lifetime costs of medical care, and lower enjoyment of recreational activities. These costs are not likely to be distributed evenly either. Those who live in urban areas, near tourist locations, or along major highways are more likely to be impacted by pollution and congestion impacts. Multiple studies have shown links between low socioeconomic status and pollution, such as particulate pollution, often relating to bias in housing market dynamics and land costs (American Lung Association, n.d.). Studies have also linked socioeconomic status to road safety, where neighborhoods with lower socioeconomic status have higher incidences of crashes and road injuries (Morency et al, 2012; Harper et al, 2015; Pirdavani et al, 2017).

[4] This calculation assumes a taxpayer base of 739,352 (State of Hawaiʻi Department of Taxation, 2020) and a household-level of 456,782 (U.S. Census, 2019). Note that the household values can sometimes be misleading because Hawaiʻi has household size larger than the national average with significant range depending on household ethnicity.

[5] Based on median household income from Data USA (2018). We understand that households are not directly paying these costs but put into context of household income these costs are considerable. This estimate helps highlight just how much the vehicle economy is subsidized by the private sector.

3.1.1 Direct Public Budgetary Cost

Summary

Direct public budgetary costs are expenditures from the various levels of government dedicated to vehicle infrastructure and associated deferred maintenance. This is inclusive of county budgets, state budgets, state capital improvement program, and deferred maintenance costs. These costs relate to new road capacity, road paving, signal repairs, signage replacement, and other road maintenance expenditures. Together these public budgetary costs amount to $1.6 billion, annually (Table 4). About one-third of these costs come from state expenditures ($505.7 million) and another third from deferred maintenance ($560.2 million).

Direct public budgetary costs amount to $1.6 billion, annually

Collected revenues only amount to 49% of county and state level expenditures

Annual costs are set to increase as much of the Hawaiʻi road infrastructure at risk of sea level rise and climate change

Table 4. Direct Budgetary Costs (Millions of $)

Category	Sub-Category	Cost
Direct Budgetary Costs	County Budgets	$273.7
	State Budgets	$505.7
	State CIP	$252.6
	Deferred Maintenance	$560.2
	Total	**$1,592.2**

To put some of these costs in context, the maintenance backlog ($560.2 million) is roughly equal to the sum of the annual county investments ($273.7 million) plus annual state capital outlay ($252.6 million), implying that the backlog is not likely to diminish in the near future. If anything, this backlog is likely to increase as unexpected hazards disrupt activities and expenditures and maintenance costs increase as roads deteriorate. Costs that are unexpected, unbudgeted, or significantly higher than anticipated tend to push back or defer other projects (often resulting in additional higher costs or continued negative effects of their own).

Two reasons for deferred maintenance are competing budget needs and a budget gap between necessary roadway expenditures and collected revenues. Hawaiʻi is one of a handful of states that do not have toll roads, and so user fees are based on vehicle fees, various car rental and tour vehicle surcharges, and fuel taxes. Hawaiʻi collects roughly $169.4 million in fuel tax revenue, an additional $72.5 million in rental vehicle surcharges, and another $136.1 million in vehicle registration fees.[6] These revenues amount to approximately $378.0 million, annually, or roughly 49 percent of the county and state budget expenditures for the road system (about $779.4 million, annually). This shortfall results in a large funding gap between user revenues and public budgetary expenditures, which must be made up from other sources of revenue. This shortfall implies that roadway users' current fees ultimately do not pay for the system they use, and that the transportation economy is subsidized from other funding sources. With these continued funding shortfalls, deferred maintenance is only set to continue to increase, further exacerbating the problem.

[6] Fuel and rental vehicles taxes are from the State of Hawaiʻi Department of Taxation (2020). Vehicle registration fees are from the State of Hawaiʻi Comprehensive Annual Financial Report (Department of Accounting and General Services, 2019).

Additionally, the geography of Hawaiʻi places many of its roadways along the coastline, where roads are at risk of erosion and sea level rise. For example, HDOT estimates that, under the predicted 3.2 feet sea level rise by 2100, 10-15 percent of the state's highway system will be directly impacted (HDOT, 2019). These impacts will require continual and increasing investments which are not accounted for within the current annual budgets, or else suffer the consequences of continued erosion, submersion, and salinization. While this analysis is a static look at the costs of the vehicle economy in Hawaiʻi, these costs could be an underestimation given the expected impacts of sea level rise and climate change on the transportation system.

County and State Budgets

Honolulu, Hawaiʻi, Kauaʻi, and Maui counties, along with the State of Hawaiʻi and the U.S. DOT, all contribute to direct public budgetary costs. Since only a fraction of county-level budgets go towards building and maintaining the vehicle infrastructure and responding to vehicle activity, we only included vehicle-related costs from the county budgets in our analysis. These costs include:

Annually, Hawaiʻi state and county government budgets include $779.4 million of vehicle-related costs with $273.7 million from the county level, and $505.7 million from the state level.

- Road maintenance expenditures
- Vehicle registration, related fees, and licensing
- Capital spending for road-related projects and other infrastructure
- Road and highway beautification
- Emergency medical services (EMS), fire department, and police department traffic-related costs[7]
- Costs to repair traffic signals
- Costs of replacing signage
- Lease payments (such as for DOT office space)

Public budgets tend to fluctuate yearly, and we averaged budget costs from the last five years to account for these differences.[8] Table 5 presents the average annual budget (related to the vehicle economy) in millions of dollars for each county in Hawaiʻi, up to a total of over $273.7 million, annually.

[7] Only a fraction of the emergency service calls are vehicle-related. To estimate the percentage, we used data from the State of Hawaiʻi Department of Health (DOH) (DOH, 2020) for 2017-2019. We calculated the percentage of motor vehicle responses (about 4 percent) for each county based on the number of vehicle-related crashes and total responses. We then applied these proportions to the publicly available budgets.

[8] We average the vehicle related budget costs from 2014-2018 for Honolulu, Hawaiʻi, and Maui Counties, and budget costs from 2015-2019 for Kauaʻi.

Table 5. County-Level Vehicle Economy Budgets[9]

County	Averaged Annual Budget (Millions of $)
Hawaiʻi	$54.3
Honolulu	$161.6
Kauaʻi	$27.0
Maui	$30.8
Total	**$273.7**

The primary transportation costs in the state budget documents include operating expenses and capital investment on Oʻahu, Hawaiʻi, Maui, and Kauaʻi highways. Also included in the statewide budget are costs for building, repaving, marking, and repairing roads, parking, signs, and more (B&F, 2019a). Data for state public budgetary costs was sourced from publicly available information from the HDOT's Highways Division budget published online. Based on these budget documents, the state government in Hawaiʻi spends $505.7 million on roads, annually. In total, an estimated $779.4 million of government spending is spent on roads each year.

State Capital Improvement Program

The state capital improvement program includes transportation investments and costs identified by HDOT. States use these expenditures on new capital assets or improvements to capital assets meant to ensure that the road infrastructure is maintained and remains in operation. In the case of transportation, the capital improvement program includes the disbursements from the federal government with a match from the state. The matching funds provided by the state are captured in the budgets above. FHWA disbursements are directly attributed to the fuel tax amount collected in Hawaiʻi through the federal fuel taxes. Since fuel taxes fluctuate by year, we take an average of these outlays for the 5 most recent years available.[10] Our estimate for total annual state capital improvement program costs is $252.6 million.

Deferred Maintenance

Deferred maintenance costs, which often occur in order to meet budget funding levels or to realign available budget funds, are an additional public budgetary cost (although not an immediate cash outlay). Deferred maintenance costs represent maintenance activities, such as repairs to pavement and sign postings, that are delayed in order to save costs, or meet budget funding levels. Deferred maintenance costs in this analysis are inclusive of the annual State of Hawaiʻi budget (B&F, 2019b), specifically costs attributed to the HDOT Highways Division. These costs include pavement and pavement marking for roads, spall and deck repair,

[9] Budget information varied by county. We gathered data from county department budget documents. For Hawaiʻi County we consulted transportation related funding from the automotive, engineering, and traffic division, as well as funding for roadside beautification, vehicle disposal, and highway maintenance. For Honolulu, we included highway funds from the Department of Design & Construction, Facility Maintenance, Planning and Permitting, Police, Parks and Recreation, Transportation, Customer Services, Public Works, and Planning and Permitting. For Kauaʻi County we sourced vehicle-related funding from the highways and streets, and transportation funds. Finally, for Maui we sourced budget information from the Emergency Management Budget, Fire and Public Safety Budget, Planning Budget, Police Budget, Public Works Budget, and Transportation Budget.

[10] We estimated the Federal Highway Administration capital outlays using the average 2014-18 from Table SF-4 in the Federal Highway Administration Highway Statistics reports (FHWA, 2015; FHWA, 2017; FHWA, 2018b; FHWA, 2019; FHWA, 2020).

repainting, expansion joint and bearing pad for bridges, tile work, fan repair, spall repair for tunnels, and signs. We calculate that these costs total $560.2 million in Hawaiʻi, annually.[11]

3.1.2 Indirect Social and Economic Costs

Indirect social and economic costs of vehicle activity, while not monetary costs, still create economic costs borne by the public. Indirect costs valued in this analysis include injuries and fatalities, consumer parking subsidy, GHG emissions, air pollution, and lost productivity/reduced quality of life due to vehicle congestion. We estimate these costs to be $5.6 billion (Table 6), annually, with the majority of these costs coming from the value of injuries and fatalities ($3.3 billion).

Table 6. Indirect Social and Economic Costs

Category	Sub-Category	Cost (Millions of $)
Indirect Social & Economic Costs	Injuries and Fatalities	$3,256.4
	Congestion	$693.1
	Consumer Parking Subsidy	$1,259.9
	Greenhouse Gas Emissions	$209.8
	Pollution	$222.2
	Total	**$5,641.4**

Injuries and Fatalities

Injuries and fatalities from vehicle-related crashes constitute the largest source of indirect social and economic costs. On average, there are 6,237 injuries and 106 fatalities from vehicle crashes in Hawaiʻi (DBEDT, 2020b).[12] Once quantified and monetized, vehicle-related fatalities and injuries result in an estimated annual $3.3 billion in costs.[13]

To arrive at this estimate, we valued the costs of fatalities and injuries separately. We monetized the economic impacts of vehicle-related fatalities using the USDOT's Value of Statistical Life (VSL). Formally, the VSL is the total benefit of preventing fatalities regardless of age, race, gender, or other subcategories. In total, annual vehicle-related fatalities resulted in a total cost of $1.1 billion.[14]

We quantified the cost of vehicle-related injuries using the Federal Highway Administration's Comprehensive Crash Unit Costs for injuries (FHWA, 2018a). The Comprehensive Crash Unit Costs are most appropriate for quantifying the cost of injuries since they include the economic costs of crashes such as lost wages and pain and suffering. We used a value of $347,648 per

[11] The values for deferred maintenance are cost estimates. As roadways continue to deteriorate as a result of lack of maintenance, total costs for repairs may increase. We recognize that this cost is not going to be resolved within a single year, as there are currently no budget plans to address this cost. Rather, deferred maintenance costs will be spent down across several years.

[12] Based on averaged data from 2014-18

[13] We recognize that the costs of vehicle-related fatalities and injuries may be partially offset by consumer borne insurance costs. Vehicular insurance is required in Hawaiʻi, and a portion of this insurance is related to personal-injury protection which covers medical expenses of crashes. The costs, however, are borne as two separate components, one as a public loss in terms of loss of life, lost wages, or pain and suffering. Insurance costs are borne by individuals through their insurance payments. A subsequent review of insurance premiums suggests that any double counting of insurance and the value of injuries and fatalities is minimal (only about $90 million).

[14] To quantify the economic impact of vehicle-related fatalities we multiplied the VSL ($10.2 million) by the annual number of vehicle-related fatalities (USDOT, 2016).

injury to monetize the injuries.[15] Vehicle-related injuries are responsible for a total annual indirect cost of $2.2 billion annually in Hawaiʻi.[16]

Consumer Parking Subsidy

Parking space costs are borne by businesses and passed on to consumers as they are bundled into the price of rents, products, and services. To monetize this indirect cost, it is necessary to know the total number of parking spaces in the state. To determine the number of parking spaces, we multiplied the number of registered vehicles (DBEDTa, 2020) by three using the benchmark measure from Shoup (2005) and Gellerman and Ben-Joseph (2012).[17]

Table 7 presents the estimated number of parking spaces by county in Hawaiʻi. The total estimated number of parking spaces in the State of Hawaiʻi is 3,766,276. Honolulu has the most parking (2,375,651), followed by Hawaiʻi (599,425), Maui (539,586), and Kauaʻi (251,614).

Table 7. Total Number of Parking Spaces

County	Number of Parking Spaces
Hawaiʻi	599,425
Honolulu	2,375,651
Kauaʻi	251,614
Maui	539,586
Total	**3,766,276**

To monetize parking spaces, we used county-specific values for the cost of construction garage and asphalt based on Ulupono Initiative's 2020 report on "The Costs of Parking in Hawaiʻi" (Ulupono Initiative, PBR Hawaii, and Rider Levett Bucknall, 2020). These costs reflect the county-specific materials and labor costs associated with construction of both asphalt and garage spaces in Hawaiʻi. The cost of these parking spaces is not borne all at once, however, and we annualized the total construction value. To annualize the value of parking spaces, we assumed that the life of a parking space—both asphalt and garage—is 40 years and that the value is financed through a 2.5 percent interest rate loan (Olson et al., 2019).[18]

We estimated that annualized cost of building parking comes to $1.7 billion. This total cost reflects both public and private parking costs. However, the consumer parking subsidy is assumed to be three-quarters of this because there are an estimated three public parking spaces for each one residential parking space (Gruen, 1973).[19] The remaining quarter of these

[15] The severity of injuries is not provided by the State of Hawaiʻi Data Book. We averaged the comprehensive crash unit costs for the three possible types of injuries—suspected serious injuries (A), suspected minor injuries (B), or possible injuries (C) to arrive at the injury cost value of $347,648. These economic costs include costs for emergency and medical service, lost wages, legal, and vehicle damages. While Hawaiʻi-specific injury data were not available, we assessed national crash data and determined that the weighted-average of cost implications of injuries were similar to the value used in our analysis.

[16] To quantify the economic impact of vehicle-related injuries we multiplied the average injury cost ($347,648) by the annual number of vehicle related injuries (6,237).

[17] This calculation reflects a change from Olson et al. (2019). The Harvard Kennedy School report used a multiplier of 4, but based on a review of the Shoup (2005), Gellerman and Ben-Joseph (2012), and the characteristics of Hawaiʻi, this analysis used a multiplier of 3. This calculation uses the average number of parking spaces between 2014 and 2018.

[18] We used 40 years as the life of an asphalt parking lot to remain conservative since they can last 20-30 years and 20-30 years more with proper maintenance/reconstruction. We also used 40 years as the life of a garage structure since the IRS claims that the cost of structures are recovered in 39 years.

[19] We assume that public parking represents parking garages and unassigned (first-come-first-serve) on-street parking. Residential parking represents off-street parking or on-street parking that is designated to residents.

parking construction costs is relegated to the private consumer cost section. Based on these calculations we estimate the total consumer parking subsidy in Hawaiʻi to be $1.3 billion.

Greenhouse Gas Emissions

Another indirect cost of vehicle usage is GHG emissions. These GHG emission costs represent the environmental and economic damages that CO_2 and other emissions cause through environmental degradation, loss of human health, and damages from sea level rise, etc. In Hawaiʻi, vehicle users drive an average of 11.3 billion miles, annually.[20] Each year in Hawaiʻi, ground transportation leads to 4.05 million metric tons of CO_2 emissions, based on the 2016 Hawaiʻi GHG Inventory (DOH, 2019).[21]

To monetize the economic and social cost of GHG emissions, we use the global mean value ($51.80) of the social cost of carbon emissions per metric ton (Interagency Working Group, 2017).[22]

Table 8 shows the costs of GHG emissions for each county in Hawaiʻi. The annual cost of GHG emissions is $209.8 million statewide. A majority of GHG emissions from vehicles across the islands comes from Honolulu (approximately $132.1 million each year), with Hawaiʻi County ($33.7 million), Maui County ($30.0 million), and Kauaʻi County ($14.0 million) producing the rest.

Table 8. Cost of GHG Emissions

County	Cost of GHG Emissions (Millions of $)
Hawaiʻi	$33.7
Honolulu	$132.1
Kauaʻi	$14.0
Maui	$30.0
Total	**$209.8**

Air Pollution

Along with GHG emissions, air pollution is an additional environmental cost that vehicle use imposes on society. Unlike GHG emissions, which trap heat in the atmosphere and lead to higher temperatures, air pollution's impact is more localized. Vehicle-related air pollution increases mortality and morbidity from respiratory and heart diseases, as well as impaired pulmonary function. Air pollution can also reduce crop yields.

There is harm to the population regardless of vehicle ownership or use.

Air pollution tends to impact more lower-income demographics because they are located along major roadways and in urban areas.

Table 9 shows the total cost of air pollution damages from vehicle travel in Hawaiʻi by county. We calculated these costs by multiplying the average vehicle miles traveled (DBEDT, 2020c) by the $0.015 per mile air pollution damage

[20] Based on average vehicle miles for 2015-2019 from the Hawaiʻi Data Book (DBEDT, 2020c).

[21] When discussing the cost of GHG emissions, emissions are generally converted to CO_2 equivalent to present a single emissions estimate.

[22] This cost of carbon accounts for impacts on the entire planet and has been scaled from 2007$ ($42.1) to 2019$. We recognize that not all costs of GHG emissions will be borne locally; however, no method exists to adequately capture only the local GHG impacts. Even discounting the social cost of carbon by 10 percent only results in a $21 million difference in the total results.

cost (Parry et al., 2005).[23] The annual statewide cost of air pollution in Hawaiʻi is **$**222.2 million. The majority of this cost is from Honolulu ($134.8 million), because Honolulu has the highest VMT (an average of 6.86 billion miles, annually). The counties of Hawaiʻi, Maui, and Kauaʻi comprise the rest of the costs, with $38.5 million, $31.5 million, and $17.4 million, respectively.

Table 9. Cost of Air Pollution

County	Cost of Air Pollution (Millions of $)
Hawaiʻi	$38.5
Honolulu	$134.8
Kauaʻi	$17.4
Maui	$31.5
Total	**$222.2**

Congestion

The final component of the indirect social and economic costs of the vehicle economy is lost productivity due to vehicle congestion on roads and highways. These costs are essential to include because congestion leads to other uncaptured indirect costs such as increased travel time, other non-emissions environmental damage, vehicle operating costs, and other circumstances that increase the costs of using automobiles. To estimate the costs of congestion, we followed a methodology developed by the Texas Transportation Institute (TTI, 2019). This method involves multiplying the median hourly wage for private sector workers in Hawaiʻi (Bureau of Labor Statistics, 2019) and the median hourly wage for commercial workers (from TTI) by the aggregate number of hours each group spends in traffic delays, annually. TTI provides data on the number of commuters and annual hours of delay for urban areas (with an average annual delay per commuter of 64 hours for heavily travelled urban areas like Honolulu).[24] TTI does not make a distinction between regular commute time, and congestion commute time, so the congestion time reflects the value of travel time. Based on these calculations, we estimate that Hawaiʻi realizes an estimated $693.1 million each year in lost productivity from time commuting.

3.1.3 Land Value Costs

The final category of publicly borne costs is the value of land used for roads and parking. The figures in this section represent the opportunity costs associated with dedicating land to roads and parking. The value of the land that is currently used for the vehicle economy can be understood as a tradeoff since the land could be used for other uses.[25] These costs capture the potential value that could be generated (based on comparable land sales) if the land were otherwise used for commercial or residential uses. There are two parts to these costs: the value of land dedicated to parking and the value of land dedicated to roads. At a high level, we

[23] This value is an average since passenger vehicles vary widely in gas mileage and other factors that determine air pollution footprint. We recognize Hawaiʻi's geography results in the dispersion of some of the pollution over the ocean. Particulate matter, one of the more costly pollutants, is more stagnant and resistant to dispersion. Additionally, there are other pollutants that are not easily monetized. For these reasons, we believe the standard pollution cost-per-mile estimate is appropriate.

[24] TTI provides data on the number of commuters and annual hours of delay for urban areas, but only publishes data for the urban centers of Honolulu and Kailua-Kāne-ʻohe (Honolulu County), and Kahului (Maui County). To scale available data to the missing counties, we assumed that those counties would have 25 percent of the congestion costs.

[25] Note that this analysis does excludes the potential increase in tax revenues that could occur from this land being converted into other uses.

estimate land value costs by estimating the area of parking spaces and roads, and then monetizing using county-specific land costs.

Parking Spaces

To identify the land value of parking spaces in the State of Hawaiʻi, we utilized the number of parking spaces (identified earlier in Table 7), the surface area of a parking space, and real estate land values. The land area for parking was determined by multiplying the number of parking spaces by the area of an average parking space (330 square feet) (Ulupono Initiative, PBR Hawaii, and Rider Levett Bucknall, 2020). In total, we estimate approximately 27,462 acres in Hawaiʻi are dedicated to parking (roughly 14 percent of the urban land designation).[26] To monetize this land area, we consulted an experimental dataset published by the Federal Housing Finance Agency (Larson et al., 2020).[27] Land value costs vary considerably between rural and urban areas within the state. To account for this disparity, we use values from the Federal Housing Finance Agency that have been standardized to account for land price disparities and have excluded properties to avoid potential bias.

As part of the monetization process, we recognized that garage parking saves on land use by stacking parking spaces. To account for this land use savings, we assess a 25 percent discount on commercial parking land area according to a prior study on the costs of the parking in Hawaiʻi (Ulupono Initiative, PBR Hawaii, and Rider Levett Bucknall, 2020) to account for some of this stacking.

The land value of parking spaces is similar to the construction cost of parking spaces, in that costs are not borne all at once. We annualized the opportunity cost of dedicating land to parking spaces by applying a 2.5 percent interest rate and dividing by the 40-year expected life of a parking space (Texas Department of Transportation, 2015; Green, n.d.).[28]

Using this approach, we estimate that the annual cost of committing land to parking is $2.2 billion including financing costs. Most of this total—approximately $1.8 billion—comes from Honolulu, which has the most vehicles and parking of any county in Hawaiʻi as well as the most expensive land in the state. Maui County accounts for the second-highest annual opportunity cost of parking land value, with nearly $229.9 million, followed by Kauaʻi County at $100.9 million and Hawaiʻi County at $86.4 million. Table 10 shows the surface area and annual land value of parking across the state by county.

Table 10. Parking Area Costs in Hawaiʻi

County	Surface Area (Acres)	Annual Land Value (Millions of $)
Hawaiʻi	2,477	$86.4
Honolulu	9,817	$1,769.9
Kauaʻi	1,040	$100.9
Maui	2,230	$229.9
Total	**15,564**	**$2,187.1**

[26] The 27,462 acres are made up of 17,322 acres in Honolulu, 4,370 acres in Hawaiʻi County, 3,934 acres in Maui, and 1,834 acres in Kauaʻi. These parking acreages make up about 14 percent of the urban designated land based on data from State of Hawaiʻi Department of Planning (n.d.).

[27] The Federal Housing Finance Agency dataset contains standardized county-level estimates for the land value per ¼ acre. The standardized ¼ acre estimates account for the "plattage effect," the tendency for the price of land per acre to fall as acreage increases. We multiply these numbers by 4 to arrive at a full acre estimate.

[28] We use a 2.5 percent interest rate as a conservative estimate. This interest rate is in line with recent county and state debt issuances, although is less than the 5 percent interest rate used in the Massachusetts study (Olson, 2019).

Roads

The methodology used to calculate the road land value in Hawai‘i is similar to the process used to calculate the parking land value. We first identified the area covered by roads by identifying lane miles within each county and converted to surface area using a standard road width for Hawai‘i (HDOT, 2013). We then multiplied the area covered by roads in each county by the value of land in each county from a dataset from Federal Housing Finance Agency (Larson et al, 2020) (the same dataset used to monetize land value costs for parking spaces) and summed to reach a statewide estimate. We annualized the opportunity cost of dedicating land to roads applying a 2.5 percent interest rate and dividing by the 40-year expected life of a parking space (Texas Department of Transportation, 2015; Li and Madanu, 2009).

Across the state, roads take up 22,513 acres of land. By multiplying the area of land taken up by roads in each county by the value of land in each county, we found that, in total, roads in the State of Hawai‘i are valued at $1.7 billion (Table 11).

Table 11. Roads and Highways in Hawai‘i

County	Surface Area (Acres)	Land Value (Millions of $)
Hawai‘i	5,055	$100.0
Honolulu	14,222	$1,453.1
Kaua‘i	1,031	$56.7
Maui	2,205	$128.9
Total	**22,513**	**$1,738.7**

Together the value of the roads, highways, and parking comes to nearly $3.9 billion, with roughly 56 percent ($2.2 billion) derived from parking costs and 44 percent ($1.7 billion) from roadway costs.

3.2 Consumer-Borne Costs

In addition to the public costs that vehicles impose, there are substantial costs to consumers who own vehicles. Because vehicle owners cannot use their vehicles without paying these costs, they are necessary to include in any comprehensive analysis of the vehicle economy. Consumer costs include the cost of owning and operating a vehicle and the costs of building residential parking areas. We estimate that consumers pay $10.6 billion annually on vehicles and vehicle-related costs. Most of these costs ($10.2 billion) are associated with vehicle ownership while the remaining amount are costs from private parking ($420.0 million).

3.2.1 Cost of Owning a Motor Vehicle

Owners of motor vehicles face several costs to operate their vehicles, namely their vehicle’s Manufacturer Suggested Retail Price and financing costs, repairs and maintenance, depreciation, insurance, and fuel. Vehicle users must pay these costs to operate vehicles and use the infrastructure developed using direct public costs. In Hawai‘i, many households feel the need for a vehicle for work, leading to the majority of households (91 percent) owning a vehicle (ALICE, 2017). The cost of owning a motor vehicle is a significant drag on household income, as discussed below.

To calculate the consumer cost of owning a motor vehicle, we developed a financial model to calculate the costs of owning a car from the five most popular car makers in Hawai‘i: Toyota, Honda, Nissan, Ford, and Chevrolet (DBEDT, 2020a). More specifically, the model considers the average cost of owning the three most popular vehicles for each manufacturer to calculate the cost of owing the typical—or “average”— car from each maker.[29] Although the five most popular makes comprise only 64 percent of the total market share for vehicles in Hawai‘i, we assumed they are a representative sample of the rest of the vehicle market and the associated costs.

Vehicle purchase prices were based on the Kelley Blue Book’s Fair Purchase Price for the base model of each car analyzed.[30] We factored in depreciation assumptions based on the guidelines outlined by CARFAX.[31] Vehicle purchase costs, however, are rarely immediate, and to annualize the annual cost of car payments, we assumed financing costs based on Kelley Blue Book.[32]

The full cost of owning a motor vehicle also includes the cost of full coverage insurance (about 8 percent of the total cost of ownership), and repairs and maintenance for each model car. For insurance costs, we consulted the report of the insurance commissioner from the State of Hawai‘i Department of Commerce & Consumer Affairs (DCCA), averaging the annual cost of private and commercial auto insurance over the last five years (DCCA, 2020).[33] The cost of vehicle repair and maintenance were calculated by dividing the 5-year costs for these expenses by 5 using the Edmund’s Cost to Own Calculator (Edmunds, 2019), which estimates the expected maintenance costs for each model of vehicle.

Table 12 shows the number of registered vehicles and the cost of vehicle ownership by county. Most of the $10.2 billion spent on vehicle ownership by Hawai‘i residents comes from Honolulu ($6.4 billion) where there are 791,884 registered vehicles. Hawai‘i and Maui Counties have the second- and third- most registered vehicles (199,808 and 179,862, respectively) and cost of vehicle ownership ($1.6 billion and $1.5 billion, respectively) in the state. Lastly, Kaua‘i has 83,871 registered vehicles, where vehicle owners spend roughly $682.9 million, annually.

Table 12. Vehicle Ownership in Hawai‘i

County	Registered Vehicles	Cost of Vehicle Ownership (Millions of $)
Hawai‘i	199,808	$1,626.8
Honolulu	791,884	$6,447.2
Kaua‘i	83,871	$682.9
Maui	179,862	$1,464.4
Total	**1,225,425**	**$10,221.3**

The costs of vehicle ownership are significant. On a per-vehicle basis, the costs of vehicle ownership sum to more than $8,100 per vehicle. With an average of two cars per household (Data USA, 2018), which mirrors the national average, these costs double to $16,200, represents about 20 percent of pre-tax median household income. With the aforementioned per-household public borne costs, this amounts to $31,200 or 39 percent of pre-tax household income.

[29] We use four models to calculate the annual cost of owning the typical Toyota—Tacoma, 4Runner, RAV4, and Corolla—since these vehicles are four of the five most popular in Hawai‘i (Edmunds, 2019).
[30] To reflect that the age of the average vehicle in Hawai‘i is 11.7 years old, we assess the average cost of owning each model for three different model years: 2020, 2012, and 2005 (AutoAlliance, 2018).
[31] A new car depreciates 20 percent in its first year of operation and 10 percent in each year thereafter. All used cars (model years 2012 and 2005) were assumed to depreciate 10 percent each year (Krome, 2018).
[32] We assumed each car was financed by a 5-year loan with a 3 percent interest rate and 20 percent down payment (Kelley Blue Book, 2019).
[33] To assess insurance costs we consulted the insurance commissioner report for 2019, 2016, and 2015 (DCCA, 2016; DCCA, 2017; DCCA, 2020).

3.2.2 Cost of Residential Parking

As discussed in a previous subsection, of the total parking costs in Hawaiʻi ($1.7 billion), three-quarters are assumed to be public costs because there are an estimated three public parking spaces for each one residential parking space (Gruen, 1973). The remaining quarter of these parking construction costs is relegated to the motor vehicle owners. Consumers also indirectly take on the costs of residential parking as minimum parking requirements lead to greater reliance on automobiles, which beget more stringent parking requirements and more expensive housing to comply with these regulations (Shoup, 2005). Based on the estimate that one quarter of parking is residential, we calculated that the annualized cost to consumers of building parking is $420.0 million.

4. Conclusion

This report concludes that the annual cost of the vehicle economy in Hawaiʻi is staggering, totaling approximately $21.8 billion, split between the public and consumers. Often in direct contrast to the scope and size, some of the largest-cost elements receive little scrutiny relative to projects with far smaller costs. More than half of the costs, $11.2 billion, are borne by the public in the form of state and county budget costs, social and economic costs (such as road-related injuries and fatalities, congestions, and pollution costs), and the real estate value of land set aside for roadways and parking spaces. The remaining $10.6 billion is a private cost, borne by consumers, in the form of the cost of vehicle ownership.

These costs are significant, and made more so by the fact that there is a sizeable gap between state and county vehicle-related revenues collected and the annual expenditures, meaning that the funding gap for the vehicle economy needs to be subsidized from other funding areas. Additionally, we find that the costs to the public are significant on a per-taxpayer and per-household level. When divided out amongst the population of Hawaiʻi, the public costs amount to roughly $24,400 per household, annually, regardless of vehicle ownership. Layering in that the cost of vehicle ownership is substantial, an additional $22,400 per household per year, and the costs of the vehicle economy are shown to be a sizeable portion of annual income. Moreover, these costs are not borne equally across the population. Those of lower socioeconomic status are more likely to experience the negative impacts of noise and air pollution. Additionally, research has shown that road safety is worse is areas of lower socioeconomic status, implying that these areas will see a higher share of the calculated injury and fatality indirect social and economic costs.

One of the main concerns with the size of the costs of the vehicle economy, is that costs are only slated to increase, as funding stays stagnant or decreases. In the wake of COVID-19, budget cuts are expected across many agencies which will only further exacerbate deferred maintenance. The threat of climate change also necessitates a look at how such expenditures and investments are being made, and how we could be better addressing or prioritizing these investments.

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Appendix

To ensure accuracy and consistency within this report and the accompanying model, this analysis was subject both internal and external review. Internally, ICF cost analysis and economic impact subject matter experts, with more than 40 years of combined experience, reviewed the economic assumptions and results of the analysis. Additionally, a senior transportation expert, with more than 20 years of experience, verified the transportation assumptions and results. The Ulupono Initiative project team further vetted all of the assumptions within the analysis. As mentioned in the acknowledgements section, various experts were consulted to review and critique this report, providing valuable feedback on the assumptions, data, content of the report.

More detailed information about the methods, data, and the analytical model can be made available upon request.

Table 13. Cost Component Methodology

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
Public Borne Costs			
Direct Public Budgetary Costs	• Road maintenance expenditures • Vehicle registration & licensing • Road & highway beautification • Federal Capital Improvement Program funding	• Average costs for each item from each county for the 5 most recent years available[36] • Average state budget costs for Hawai‘i, Honolulu, Kaua‘i, and Maui highways for the 5 most recent years available • Average annual capital improvement program disbursements from the FHWA for the 5 most recent years available[37]	**County-specific budget files:** • County of Hawai‘i, “Operating Budget FY 2019-2020,” 2019 • City and County of Honolulu, “The Executive Program and Budget Fiscal Year 2020: Volume 1—Operating Program & Budget”, 2019 • Kaua‘i County, “Annual Operating Budget Ordinance,” 2020 • Maui County, “FY 2020 Council Adopted Budget,” n.d. **State budget file:** • State of Hawai‘i Department of Budget and Finance, “Executive

[34] All dollar values are expressed in or converted from original sources to 2019$.
[35] The most recent documents are cited here. Previous years are necessary to calculate 5-year averages.
[36] This analysis uses “actual,” rather than “preliminary” values which are sometimes released up to two years later.
[37] Annual capital outlay disbursements are federal funds.

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
			Supplemental Budget, Fiscal Year 2019” **Federal funds:** • FHWA, 2020
	• Fire Department costs (EMS expenditures) • Police Department costs (EMS expenditures)	• Calculate the percentage of motor vehicle-related EMS responses using data State of Hawai‘i Department of Health • Multiply percentage of vehicle calls by police and fire department budgets for Kaua‘i and Maui Counties • Add “EMS-S&W”, “EMS-OCE”, and “EMS-Eqpt” line items for Hawai‘i County Fire Department • Multiply percentage of vehicle-related responses by entire fire department budget in Honolulu County • Take portion of Honolulu County Police Department budget funded through Highway Fund • Add “Dispatch S&W”, “Admin Serv S&W”, “Traf Svc S&W”, “HCPD Roadblock Program”, “Distracted Driving Project”, and “Speed Enforcement” line items for Hawai‘i County Police Department • Average the five most recent years to calculate the estimated annual cost for each county + entire state	**EMS data:** • State of Hawai‘i Department of Health, 2020 **County budget data:** • County of Hawai‘i, “Operating Budget FY 2019-2020,” 2019 • City and County of Honolulu, “The Executive Program and Budget Fiscal Year 2020: Volume 1—Operating Program & Budget”, 2019 • Kaua‘i County, “Annual Operating Budget Ordinance,” 2020 • Maui County, “FY 2020 Council Adopted Budget,” n.d.

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
	• Deferred maintenance costs	• Add all vehicle-related costs from the State of Hawai‘i Department of Transportation's deferred maintenance costs (paving & pavement marking, signs, repaving roads & parking lots, road & parking repairs, spall & deck repair)	• B&F, 2019
Indirect Social & Economic Costs	• Cost of vehicle injuries & fatalities	• Average the number of injuries and fatalities for the 5 most recent years available • Multiply the average number of fatalities by the VSL ($10.2 million) • Multiply the average number of injuries by the average cost of injuries at severity A, B, and C • Add the estimated annual costs for vehicle-related injuries and fatalities	**Vehicle crash data:** • DBEDT, 2020b **VSL:** • U.S. DOT, 2016 **Injury cost:** • FHWA, 2018a
	• Costs of Congestion	• Multiply the average annual hours of delay per commuter (by urban area) by the number of commuters • Multiply the total hours of delay by the cost of travel time • Scale Maui County metrics to Hawaii County and Kauai County (missing from TTI data) using a scalar of 25%	**Average hours of delay per commuter by urban area** • TTI, 2019 **Number of commuters** • TTI, 2019 **Cost of travel time (private)** • Bureau of Labor Statistics, 2019 **Cost of travel time (commercial)** • TTI, 2019
	• Consumer parking subsidy	• Average the number of registered vehicles for the 5 most recent years available • Multiply number of registered vehicles by 3 to calculate number of parking spaces	**Vehicle registration data:** • DBEDT, 2020a **Vehicle to parking space ratio:** • Shoup, 2005 **Parking space cost:**

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
		• Multiply number of parking spaces by 75% to calculate number of asphalt spaces; the remaining number are garage spaces • Multiply number of asphalt parking spaces by building cost (varies by county) • Multiply number of garage parking spaces by garage cost varies by county) • Add 2.5% in interest then divide by 40-year useful life to calculate annual cost • Multiply the total cost of parking by 75% (the other 25% are consumer costs)	• Ulupono Initiative, 2020 **Interest assumption:** • Conservative assumption based off of Olson et al (2019) and state interest rates **Parking space useful life:** • Olson et. al., 2019
	• Cost of pollution	• Average the number of VMT for the 5 most recent years available • Multiply the average number of VMT by $0.02 per mile	**Vehicle miles traveled:** • DBEDT, 2020c **Pollution cost per mile:** • Parry, 2005
	• Cost of GHG emissions	• Obtain CO_2e from the Energy Inventory for the State of Hawai‘i • Multiply CO_2e MMT by cost of carbon ($51.80)	**CO_2e emissions:** • DOH, 2019 **Social Cost of Carbon value:** • Interagency Working Group, 2020
Land Value Costs	• Parking land value per acre	• Multiply number of parking spaces by average size of parking space (330 sq ft) to calculate area of land for parking in each county • Divide area of land for parking by 4,840 to calculate area of parking in acres	**Parking space size and garage space savings** • Ulupono Initiative, PBR Hawaii, Rider Levett Bucknall, 2020 **Land prices:** • Larson et al, 2020

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
		• Split parking area into garage parking (15%) and asphalt parking (85%) • Multiply garage parking area by 75% to reflect that 25% of parking garages have a second story, and there are space savings. • Multiply standardized ¼ acre land value by 4 to calculate land value per acre • Multiply acres used for parking in each county by land value per acre to calculate land value of parking by county • Add 2.5% in interest then divide by 40 years to calculate annual building cost	**Interest assumption:** • Conservative assumption based off of Olson et. al. (2019) and state interest rates **Parking space useful life:** • Olson et. al., 2019
	• Road land value per acre	• Multiply lane miles for each county by 5,280 to calculate road length in feet • Multiply road length by average lane width (14 ft.) to calculate area of land used for roads in feet then divide by 43,560 to calculate road land in acres • Add 2.5% in interest rate then divide by 40 years to calculate annual building cost	**Lane miles:** • Hawai‘i Data Collaborative, 2020 (Lane miles in Hawai‘i, Kaua‘i, and Maui Counties; road acres in Honolulu County) **Lane width:** • HDOT, 2013 **Interest assumption:** • Ulupono Initiative **Parking space useful life:** • Olson et. al., 2019

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
Consumer Costs			
Cost of Vehicle Ownership	• Vehicle MSRP	• Find the 3 most popular models of the 5 most popular car makes in Hawaiʻi [38] • Calculate the market share for each car make in Hawaiʻi then normalize so that the 5 makes comprise 100% of market share • Multiply market-share by vehicle registrations to identify the number of vehicles of each make/model • For each make find the MSRP of a new car in the most recent model year plus used cars that are 7 and 15 years old • Add each of the above costs to calculate the annual cost of owning a car for each model then average the costs for each model year together • Average the cost for each car from each make to calculate the average annual cost of the "typical" make	**Make/Model data:** • Edmunds, 2019 **Vehicle registrations:** • DBEDT, 2020a **MSRP:** • Kelley Blue Book, 2019
	• Insurance	• Summary of Hawaiʻi insurance premiums for private and commercial auto personal injury protection, auto liability, and auto physical damage • Average the insurance premiums for the 5 most recent years available	• DCCA, 2016 • DCCA, 2017 • DCCA, 2020

[38] Use 4 for Toyota since 4 of the 5 most popular car models in Hawaiʻi are Toyota.

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
	• Maintenance & Repairs	• For each make and model year divide the 5-year costs of “maintenance and repair” by 5 to calculate annual costs	• Edmunds, 2019
	• Financing Costs	• Calculate annual financing costs using the MSRP for each model year. Assume a 20% down payment and a 3% loan with a 5-year term	• Olson et. al., 2019
	• Fuel Costs	• Calculate the average gas price in Hawaiʻi for the 5 most recent years available and the average vehicles traveled per vehicle by dividing the total VMT by the number of registered vehicles • Use the above figures in the tool at fueleconomy.gov to calculate the annual fuel cost for each model year	**Vehicle miles and registrations:** • DBEDT, 2020a • DBEDT, 2020c **Gas prices:** • U.S. Department of Energy, n.d.
	• Aggregate costs at county and state levels	• Multiply the average annual cost of the “typical” make by the standardized number of cars in each county (multiply the standardized % by the number of cars in each county)	• Calculation

Cost Component	Costs[34]	Quantification/Monetization Steps	Source[35]
Cost of Residential Parking	• Costs of Residential Parking	• Multiply the cost of parking from “Indirect Social & Economic Costs” by 25%	• Calculation