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A Scoping Study for Climate Action Planning in Kauai

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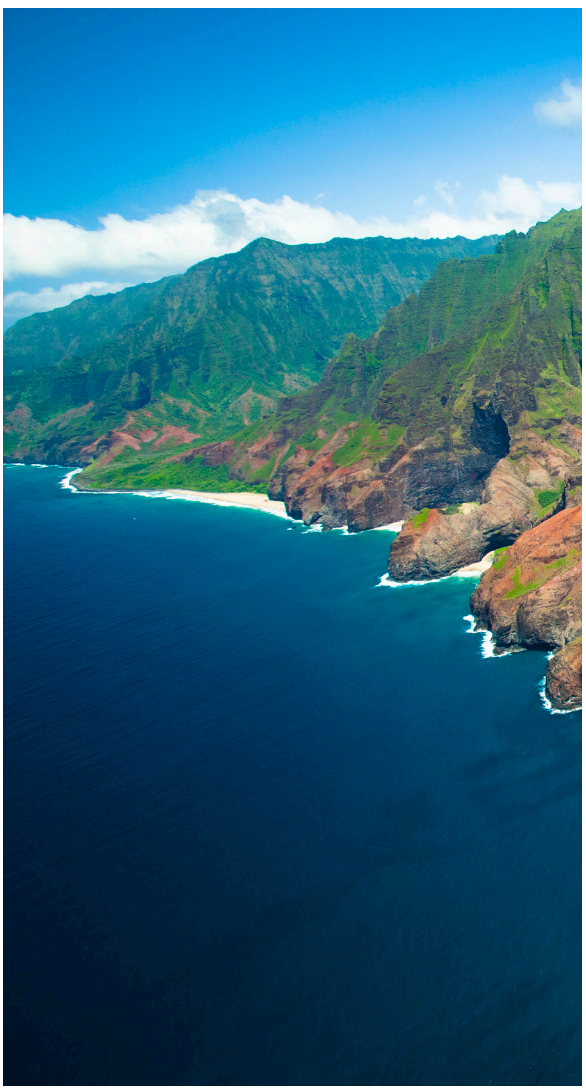

A Scoping Study for Climate Action Planning in Kauaʻi

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Executive Summary

This report documents best practices for county-level climate action plans (CAPs), with considerations for Kaua'i. A CAP is primarily a process by which a jurisdiction agrees upon greenhouse gas (GHG) reduction strategies and policies. This report is based on the gathering of studies and protocols addressing climate action planning and GHG mitigation best practices.

We find that while local CAPs vary widely, there are resources that identify best practices both for process and content. Regarding process, the establishment of a supervisory climate action team (CAT) stands out as important for successful CAP development. The CAT can facilitate effective data gathering and collaboration between a range of stakeholders and government agencies. Ensuring collaboration between stakeholders is not only critical to crafting the CAP itself, but also to ensuring there is buy-in for implementation.

To meaningfully establish GHG emissions reduction targets, a jurisdiction must first develop understanding of baseline emissions. The *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)* is a framework created specifically for local government GHG inventories, and provides detailed yet flexible guidelines for consistent data collection and determining the scope of the inventory. We recommend the County create a detailed GHG inventory including emissions from county operations as well as activities within the island, according to the BASIC framework of the GPC guidelines. This can later be expanded to include BASIC+ requirements, including transboundary air travel and indirect (scope 3) emissions.

The development of the CAP should also be informed by existing plans and policies relevant to GHG emissions as well as technical analysis regarding locale specific feasibility. Locally appropriate yet ambitious GHG reduction targets can then be established, where there is consistent evaluation of the efficacy of policy and progress toward reduction goals. Goals should be accompanied by clear policy or actions prescriptions, and should identify responsible agencies and funding opportunities.

This report documents current efforts in Kaua'i to reduce GHG emissions; for example, related to implementation of the state's 100% renewable portfolio standard for the power sector, implementation of Kaua'i's multi-modal transportation plan, and policies aimed at waste reduction. We review mitigation practices for three major sectors according to the GPC: stationary energy, transportation and land use, and waste.

I. Introduction

Human-induced climate change is both a global and local issue. Greenhouse gases (GHGs) are global pollutants, meaning that the location of emissions has no bearing on the outcome for a particular place. However, sources of GHG emissions and many of the laws and policies that govern their activities are local in scope (Association of American Geographers, 2003). This is particularly the case in the United States, where state and local governments have taken the lead on mitigating the effects of human-induced climate change (Kousky & Schneider, 2003). Without a strong set of national abatement policies, an increasing number of local leaders and government officials are developing climate action plans (CAPs). These plans tend to focus on GHG reduction strategies, though they can also catalyze adaptation efforts (Boswell, Greve, & Seale, 2012; Bulkeley, 2010). Implementation of a CAP has the potential to not only lower GHGs, but also to achieve co-benefits through improving public health and the local economy (Boswell et al., 2012). There are a plethora of examples of state and local CAPs, and a growing literature on the effectiveness of their outcomes. An important first step within the development of a CAP is to robustly estimate baseline emissions.

As of the latest estimate in 2007, Kauaʻi emits 1.1 MMTCO2eq annually (ICF, 2008). Kauaʻi emits 5% of the state's GHG emissions and the State total is 24.3 MMTCO2eq. In context, Hawaiʻi emits 0.4% of U.S. GHG emissions (US EPA, 2016). On a per capita basis, however, Kauaʻi's emissions are similar to the State and nation – and more than double that of the globe (World Bank, n.d.). Kauaʻi's 2007 per capita emissions were 17.5 MTCO2eq,[1] while the State average was 18.9 MTCO2eq, national average was 24.6 MTCO2eq, and global average was 7.5 MTCO2eq. This suggests that though Kauaʻi is a small fraction of the world's population, it could contribute in terms of GHG emissions reductions.

To develop a CAP for Kauaʻi requires updating its GHG inventory, and creating mitigation strategies that build upon current efforts and opportunities with consideration for Kauaʻi's unique geographic and economic attributes. This report documents best practices and considerations for county-level CAPs, including implementation of the *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories* (GPC). This report is organized as follows. Section II provides recommendations for developing a CAP for Kauaʻi based on best practices from the literature. Section III makes recommendations on GHG baseline measurement approaches and target setting, based on the GPC. Section IV describes possible actions that counties can take to reduce GHG emissions, based on the review of best practices. It also describes Kauaʻi's existing plans and policies that may result in GHG emissions reductions, and possible planning activities and policies to help achieve additional reductions. Section V provides conclusions and summary recommendations. It is outside the scope of this report to conduct primary financial or economic analyses – meaning that the feasibility or cost-effectiveness of specific actions for Kauaʻi are not assessed.

[1] Calculated based on the ICF (2008) estimate for Kauaʻi, excluding sinks, divided by Kauaʻi's 2007 population based on DBEDT's data book time series. State estimates are similarly calculated. National estimates are based on data from the EPA GHG inventory explorer. Global estimates are calculated using data from the World Bank Databank.

II. Developing a Framework for Climate Action

CAPs range in scope and content. They tend to emphasize GHG reduction strategies but can also include adaptation. More comprehensive CAPs also emphasize implementation. The process by which CAPs are created, their content, and level of guidance for implementation, impacts their effectiveness in achieving GHG reduction targets. The following section provides a selection of important procedural best practices for climate action planning.

An Integrated Approach to Climate Action Planning

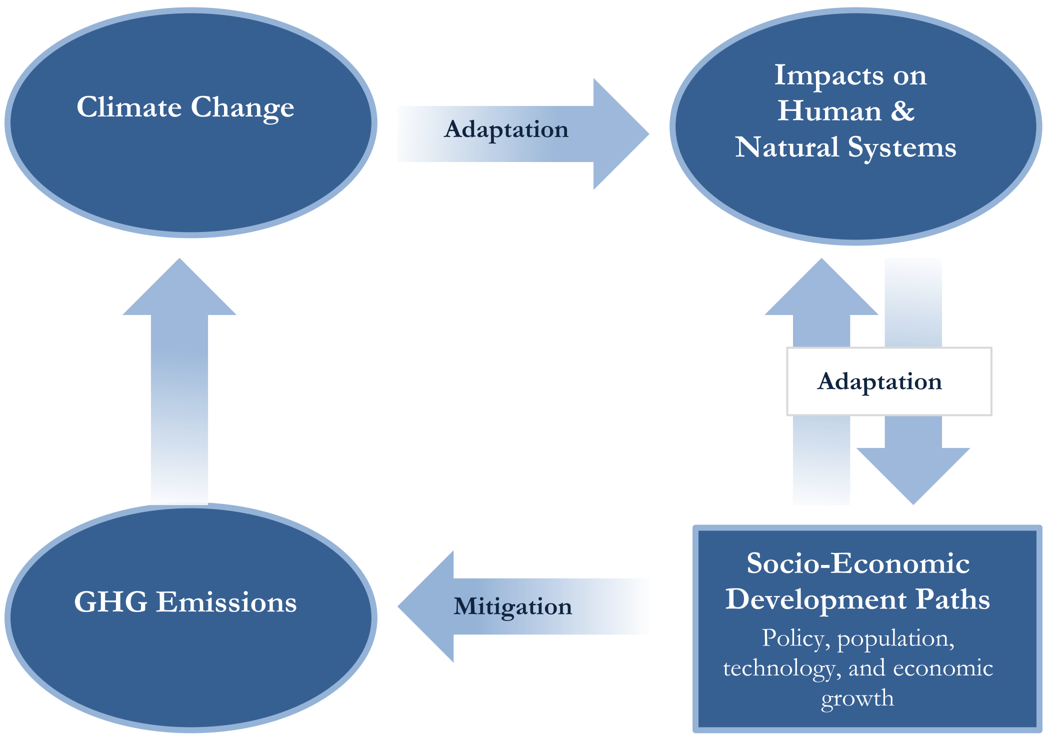
Strategies for achieving GHG reductions are also called "mitigation strategies" – implying the mitigation or lessening of the effects of climate change. Adaptation strategies focus on what people and communities can do to better live with the effects of climate change. These two sides to the coin of climate change issues are largely complementary and certainly intertwined, as the level of mitigation will determine the level of need for adaptation and the ability to adapt may also determine peoples' willingness to mitigate. There are, however, debates as to what should be the first or primary focus of climate action. Some argue that despite the inevitability of some impacts of climate change, mitigation should still be the primary climate change adaptation strategy (Howard & Monbiot, 2009).

Figure 1 depicts the Intergovernmental Panel on Climate Change (IPCC) perspective on the interrelationship between adaptation and mitigation, showing socio-economic development paths as the arena where potential policy overlaps between the two can be found (IPCC, 2001, p.3). Though mitigation and adaptation approaches often differ, co-strategies between mitigation and adaptation are prevalent in the energy sector, the agricultural and forestry sector, and in urban land use planning (Bernstein et al., 2008). Because the policy focus between mitigation and adaptation can be quite different, with the exception of several sectors and approaches in which overlaps can be found, CAPs often treat the two separately. However, a divided approach might lead to missed opportunities for leveraging complementarities or even adverse outcomes where mitigation and adaptation are not mutually supportive. Further, opportunities to take advantage of complimentary effects of climate change adaptation and mitigation might diminish over time mainly due to increasing limitations to adaptation (Bernstein et al., 2008).

An integrated approach to climate action planning is advantageous in three ways. First, assessing both adaptation and mitigation strategies simultaneously can help planners detect contradicting policies. This will help make sure mitigation strategies do not undermine adaptation strategies or vice versa. Second, an integrative approach can help identify any co-benefits (Davoudi, Crawford, & Mehmood, 2009). Lastly, treating the two as joint policy streams can be more resource effective.

To illustrate the benefits of integrated planning we can look to land use planning in urban areas. Mitigation strategies, such as compact development, can have adverse effects if implemented in increasingly vulnerable areas. For example, coastal developments, such as many towns within Kaua'i, are especially vulnerable to climate change due to pressures such as sea level rise and exacerbated coastal erosion (Zimmerman & Faris, 2011). Urban development is further characterized by an increase in impervious surfaces and loss of plant and forest cover due to land use conversion. Amongst other things, these factors have an exacerbating effect on flash flooding (Frazer, 2005), and contribute to the urban heat island (UHI) effect (Ivajnšič, Kaligarič, & Žiberna, 2014). These adverse effects can be reduced or ameliorated through complementary strategies such as green roofs, urban forests, and cool pavements, which also promote climate change mitigation by reducing the energy demand of cooling appliances (US EPA, 2010).

Figure 1



The above figure illustrates the interrelationship between climate change mitigation and adaptation with socio-economic development paths representing the arena where policy interactions between the two can occur. Adapted from IPCC 2001, p3.

An integrated approach to climate action planning requires effective collaboration between adaptation and mitigation experts and stakeholders. Such joint planning and implementation might be challenging; however, collaboration is an integral part of climate action planning whether an integrated approach is adopted. As a result, many local governments have established cross-sectorial teams with varying expertise and interests in climate action planning (Boswell et al., 2012).

Establishing a Climate Action Team to Facilitate Collaboration

Climate action planning requires extensive cross-sector cooperation and information sharing. Both the benefits and challenges of climate change mitigation and adaptation impact multiple sectors (Boswell et al., 2012). Further, local governments are part of a multi-level governance network. To be most effective, efforts should be vertically aligned with higher levels of state and national government. Moreover, local governments, community organizations, non-governmental organizations, and academic institutions often play an important role as horizontal partners in the CAP process (Boswell et al., 2012; UN HABITAT, 2015; Zeemering, 2012). Therefore, one of the first steps of climate action planning is often to establish a way for the creators of the CAP to communicate with important points of collaboration (Boswell et al., 2012).

One way to facilitate cross-sectorial cooperation and plan progression is to establish a climate action team (CAT). A CAT functions as a supportive middle link between plan creators and relevant departments and partners. The CAT can manage data rigorous processes, identify relevant partners, coordinate their cooperation, and ensure goal-oriented progression of the planning process. Teams should ideally be composed of well-assimilated representatives from each relevant department. Ideally the CAT members should be familiar with department procedures, have access to data, and have authority to implement actions established in the CAP (Boswell et al., 2012). If recruiting relevant actors from each department proves difficult or impractical, an option is a more central CAT that can perform consultations with each of the agencies (UN HABITAT, 2015). The former allows for greater cross-departmental learning and mutual understanding of climate action planning (Boswell et al., 2012).

Whether the CAT has a central structure or is made up of department representatives, the CAT should be able to map important partners and involve them in specific areas at particular times of plan creation and implementation. This is important to gathering necessary information, and establishing interest and commitment to formation and implementation of the CAP. Having a principal forum for collaboration and data gathering is also key to establishing clear strategies for implementation of mitigation policies, and forming measurable and accurate GHG reduction targets (Boswell et al., 2012).

Developing a Baseline, Establishing Targets and Clear Strategies

The foundation of CAPs is the GHG baseline inventory. An inventory is a record of GHG released to or absorbed from the atmosphere by an entity over a specific time period. The initial inventory forms the baseline for comparison of future emission quantities. A local government GHG inventory is usually done for government operations, community wide activities, or both (Fong et al., 2014; US EPA, 2016). Along with a GHG inventory, GHG reduction goals also function as a measuring stick of success for chosen mitigation policies. The progression towards goal attainment is dependent on GHG reduction targets that are tangible and agency specific (Wheeler, 2008). These targets should be articulated as anticipated GHG levels at a given time in the foreseeable future, as well as the corresponding actions needed to attain them. As such, having knowledge of the GHG reduction potential of particular policies are pertinent to the establishment of targets and action steps. Alongside shortage of funding and lack of political support, the absence of clear policy guidelines has been found to be a major obstacle to successful CAP implementation (Baker, Peterson, Brown, & McAlpine, 2012). Boswell et.al. (2012), recommend five components for each GHG reduction strategy to facilitate implementation:

1. Expected GHG reductions;
2. Identified sources of funding;

3. An estimate of when the policy implementation can be initiated, and the timeframe of implementation;
4. Assignment of implementation responsibility to a specific department; and
5. A tangible indicator that can be measured to evaluate success (Boswell et al., 2012).

Providing a clear and tangible strategy for implementation can aid cross-sector collaboration, enable commitment to plan implementation, and reduce uncertainties that often come with the novelty of implementing a CAP (Boswell et al., 2012). Such measures also set the stage for tracking progress towards goal achievement. Regular progress measures can be made public and accessible to increase transparency and interdisciplinary involvement.

Finding the Right Level of Ambition

A recurring tendency amongst existing local CAPs is the failure to set GHG emission targets that live up to scientific estimates of global and national reduction requirements. As most mitigation actions in CAPs are built upon GHG emission targets, an underestimation can lead to inadequate mitigation policies (Boswell, Greve, & Seale, 2010). Conservative GHG reduction targets might be a result of perceived political feasibility (Wheeler, 2008), perceived local capability (Bulkeley, 2010) or a tendency to focus on short-term actions with high political visibility (Baker et al., 2012). These lines of target setting are referred to as bottom-up approaches or forward planning, and have been criticized for failing to be sufficiently ambitious according to desirable atmospheric GHG levels (Wheeler, 2008), and for being more prone to negative externalities (Giddens, 2009).

A top-down approach is based on targets that are established by national governments, or by intergovernmental alliances based on current knowledge of climate change and equivalent GHG reduction requirements. Local climate action planners can then "work backwards" to establish local targets (Wheeler, 2008). However, because it is likely that local political or economic constraints will need to be taken into consideration, a combination of the two approaches has been suggested. With a combined approach, ambitious long term targets are set according to scientific estimates of global reduction needs, and tied to corresponding locally tailored short term targets and action steps (Damsø, Kjær, & Christensen, 2016; Wheeler, 2008).

Understanding Your Impacts

A major concern of national and sub-national climate change mitigation policies is "leakage" – the movement of GHG emission from places with more stringent emissions regulations to places with less stringent emission regulations. The literature on carbon leakage has mostly focused on higher-level jurisdictions, mainly international effects of national carbon policies (Bushnell & Mansur, 2011; Farber, 2013; Michalek & Schwarze, 2015). Nonetheless because leakage is likely to be larger between localities with closer ties (Caron, Rausch, & Winchester, 2015) there is reason to assume that leakage effects will almost certainly occur if carbon policies are implemented on a county level. Leakage effects are an important consideration as they reduce the net effectiveness of mitigation strategies (Caron et al., 2015; Michalek & Schwarze, 2015).

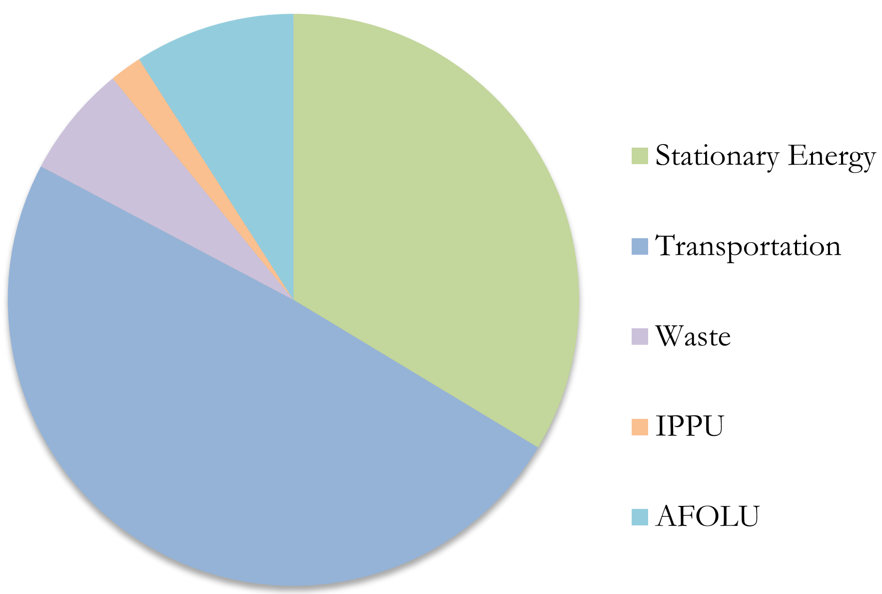
Policies aimed at reducing GHG emissions – especially efficiency measures – should also take into consideration the effects specific policies can have on consumer behavior. Efficiency measures can lead to an increase in demand due to the relatively lower cost of consumption, often referred to as the "rebound effect." For instance, policies targeted at increasing energy efficiency of buildings will lower the net cost of consumption, which might lead the consumer to increase electricity use.

Some have argued that leakage and rebound effects related to local climate action are a legitimate but overstated concern that should not get in the way of local climate action initiatives. In this view, losses are likely to be low compared to total GHG emissions reductions, thus net reductions will still be significant – though this is really an empirical question. Local initiatives can also be expected to have counteracting positive spillover effects as they can spur climate initiatives in other localities (Farber, 2013). As such, local governments should continue to spearhead climate action planning, but have knowledge of leakage and rebound effects as to inform GHG accounting and target setting, and in turn select policies that are most appropriate on a local level while considering impacts elsewhere.

III. Developing a GHG Inventory for Kauaʻi

The most recent statewide GHG inventory is from 2007, with Kauaʻi's emissions illustrated by *figure 2*. An updated inventory specific to Kauaʻi will be necessary to lay the foundation for a CAP. A Kauaʻi specific inventory can better inform GHG mitigation policies by disaggregating emissions into subsectors on the county level. For example, the current statewide inventory does not disaggregate county level emissions in the transportation sector into aviation, marine, and ground transportation. Transportation emissions displayed below thus include all within-county transportation on air, land, and sea; by geography, this is primarily ground transportation.

Figure 2



2007 GHG emissions within Kauaʻi distributed between GPC categories stationary energy 34%, transportation 49%, waste 6%, IPPU 2%, and AFOLU 9%. Adapted from Hawaiʻi GHG Inventory 2007 (ICF, 2008).

Kauaʻi established an inventory of GHG emissions from government operations in October 2012. Developing a comprehensive GHG inventory will help the people of Kauaʻi to understand the major contributing sources of emissions that will help inform mitigation strategies, guide public fiscal priorities, and allow for tracking of advances toward specific goals (Fong et al., 2014; US EPA, 2016). A GHG inventory can educate communities, businesses, and government entities, of their contributions to climate change and thus facilitate private and collective contributions to mitigation goals. The GHG baseline sets the stage for defining explicit emission reduction targets. To aid target setting and account for future consumption it can be helpful to calculate a "business as usual" scenario projecting future GHG emissions in the absence of mitigation strategies. This will allow the County to estimate the net amount of emission reductions needed in each sector by a specific year, relative to probable future consumption patterns.

The GPC acts as a guide to local governments that want to develop an emissions baseline. It was created with the intention to unify GHG inventory methods to generate standardized, comparable inventories on a local scale. The GPC is widely accepted by established institutions such as ICLEI-Local Governments for Sustainability, C40 Cities Climate Leadership Group, United Nations Environment Programme, United Nations Human Settlement Programme, and the Compact of Mayors. It is also founded on the Intergovernmental Panel on Climate Change (IPCC) reporting requirements for national GHG inventories (Fong et al., 2014). The GPCs degree of flexibility also allows for particular local considerations necessary for an island county with unique characteristics. The following sections provide broad guidelines derived from the GPC framework and its applicability to the County of Kauaʻi.

Reporting Requirements: Choosing Your Scope

Emission data is reported in five sectors under the GPC framework: Stationary Energy, Transportation, Waste, Agriculture, Forestry and Other Land Use (AFOLU), and Industrial Processes and Product Use (IPPU). Emissions are also reported as part of three tiers. Scope 1 encompasses all emissions occurring within the geographic boundary. Scope 2 is all grid-supplied energy. Scope 3 is locally induced emissions occurring outside the geographic boundary. In the case of Kauaʻi, scopes 1 and 2 overlap, as KIUC locally produces all grid-supplied energy. For comparability to other jurisdictions, grid supplied energy should nonetheless be reported under scope 2.

Inventories are commonly based on existing data (IPPC, 2006), and the GPC recognizes that data availability differs considerably between different areas. Thus, two broad reporting standards have been established to accommodate local variations: BASIC and BASIC+. The BASIC framework requires reporting of in-boundary emissions (scope 1) under the stationary energy sector, the transportation sector, and the waste sector. It requires reporting of grid supplied energy (scope 2) in the stationary energy sector, and in the transportation sector where charging of electric vehicles contributes to electricity demand. Reporting of transboundary emissions (scope 3) is not required except for downstream emissions in the waste sector, where waste that is treated outside the geographic boundary is considered part of local emissions. These lines are largely drawn based on available data. The BASIC+ framework requires reporting of locally induced emissions occurring outside the geographic boundary in the stationary energy, transportation, and waste sectors, as well as emissions occurring in the IPPU and AFOLU sectors. Producing a GHG inventory within an island county means that there are no trans-boundary emissions related to ground transportation or in the electric sector. Although there are likely upstream emissions related to fossil fuel extraction and production, these are optional to report on under the GPC guidelines and can be reported separately from other estimates.

Local Considerations

Developing county-level capacity tools and updating mechanisms for a GHG inventory could have tremendous value – and learning from Kauaʻi's process could assist other counties within the state. The baseline inventory is also an opportunity to map out needs for more county-level data monitoring. Islands like Kauaʻi pose unique geographic and economic considerations as they relate to political jurisdictions. The following are some initial local considerations for compiling an inventory for Kauaʻi.

An appropriate level of reporting must ultimately be weighted by compilers of the County's GHG inventory, based on local data availability and the relative weight of emissions from sectors included in the BASIC or BASIC+ requirements. However, some early recommendations can be made. Emission data added for Kauaʻi by using the BASIC+ framework might be small considering the natural limitations of transboundary ground transportation of an island community, limited prevalence of the three industrial sectors represented in IPPU requirements in the GPC (mineral-, metal- and chemical industries), and the dominance of locally supplied electricity production. On the other hand, farmland in acres on Kauaʻi is estimated to be roughly 36% of total land area within the County, implying that agricultural land use could be a significant contributor to the County's emissions (DBEDT, 2015a). Further, the multi-resource forest inventory for Kauaʻi from 1988 estimates that woodland covers 54% of the area on the island of Kauaʻi (Buck, Branam, & Stormont, 1988), indicating possible significance of GHG sinks.[2] Statewide it is estimated that an extensive reforestation project of native trees could result in sequestration of 1.48 to 2.96 $MtCO_2e$ per acre per year with a total storage of 148-296 $MtCO_2e$ per acre over a 100-year period (Conte et al., 2009). Kauaʻi specific data is needed to make a proper estimate of whether AFOLU GHG emissions and sinks represent a significant portion of total GHG emissions for Kauaʻi.

Due to limitations on data availability, the most practical approach might be to create the initial GHG inventory under the BASIC framework with the goal to expand in the future if specific data becomes available, particularly around land use. It is common that both accuracy and completeness of GHG inventories increase over time (Fong et.al., 2014). The following recommendations are therefore under the BASIC framework and exclude BASIC+ requirements.

Deciding a Baseline Year

Data collected for inventory estimates should cover either a fiscal or a calendar year. Using the fiscal year format is appropriate according to most administrative and legislative procedures for the County. However, initial investigations into county level data availability suggest that using the calendar year framework is more viable. The State Department of Business, Economic Development & Tourism (DBEDT) releases a comprehensive collection of economic data annually from which a large portion of the data needed for calculation of GHG emissions can be gathered. Much of the published data is available on a county level as recent as 2015.

Data availability, representativeness, and alignment with existing inventories or legislation are key considerations when deciding a baseline year. Selecting the most recent available data as a foundation for establishing a baseline year could be beneficial to creating a picture of the

[2] A GHG sink is natural or artificial entities that absorbs more greenhouse gas or aerosols than it releases to the atmosphere (US EPA, 2015).

most current emission trends. However, the most recent year is not necessarily the most representative for the County. It is therefore advisable to select one or more years in addition to the baseline year to illustrate emission trends. Compilers of the inventory should also assess whether data for the selected year is seemingly representative of emissions within the County compared to other years (Grant et al., 2013); for example, due to the recent 2009 recession.

Further, selecting a baseline year that aligns with existing state targets and inventory baseline years can be advantageous for comparative purposes and alignment with existing or future compliance standards (Grant et al., 2013). In deliberation of Act 234, Hawaiʻi Administrative Rules §11-60.1, Subchapter 11, of the Hawaiʻi Air Pollution Control was amended June 30, 2014 to require all facilities that potentially produce equal to or more than 100,000 short tons[3] per year of CO2e, to establish a GHG reduction plan with a baseline year of 2010.[4] Due to this law, KIUC and other major actors have established a GHG inventory with the baseline year 2010 (KIUC, 2016a). This may be an opportunity to facilitate easy data collection and align strategies with KIUCs reduction efforts. Selecting 2010 as a baseline year with 2015 as the comparison year would also align with midterm milestones of the *Hawaiʻi Clean Energy Initiative Roadmap* to reaching the state's clean energy goal of 100% renewable energy by 2045 for the power sector. Inventory compilers should consider the benefits and tradeoffs of potential baseline years, keeping data availability as the principal criteria for making a selection.

Ground Transportation

Ground transportation emissions can be calculated either in a top-down fashion, usually from fuel sales data, or using a bottom-up methodology, usually by using vehicle miles travelled (VMT) per vehicle type, multiplied by fuel factor. The GPC states that the bottom-up approach better informs mitigation strategies targeted at specific ground transportation modes and accounts for fuel bought outside the city boundary. The latter has little relevance for Kauaʻi, and estimating based on fuel sales will presumably give accurate numbers. For this reason, it might be more practical to start estimating emissions from ground transportation using data on fuel sales and subsequently segregate by transportation mode if data is available. Fuel sales within the County of Kauaʻi are estimated by DBEDT annually. DBEDT also releases VMT data per county but official numbers are not segregated by vehicle type (DBEDT, 2015b). Without this data, the bottom up approach would not be accurate, as it would not account for differences in fuel efficiency.

Aviation

Within the GPC framework, air travel related emissions follow three reporting scopes. Scope 1 is simply all air travel that departs and arrives within the county boundary (presumably tour helicopters and flights between Kauaʻi and Niʻihau). Scope 2 is all grid-supplied charging of aircrafts at airport facilities. Scope 3 includes transboundary flights.[5] Reporting under Scope 3 should also include departures from the airports that serve the city. It is somewhat unclear what this entails, but for Kauaʻi it seems logical that this would include departures from Honolulu airport and other direct flights to the continental U.S. that are associated with

[3] 1 short ton of CO2e equals 0.907184 metric tons of CO2e (U.S. Energy information administration (EIA), 2015).
[4] The provision excludes emissions from municipal waste combustion operations and municipal solid waste landfills.
[5] Scope three for transportation will not be required under the BASIC framework of GPC.

Kauaʻi resident, visitor, and business travels. However, data that allows for this distinction is not currently publicly available from official data sources. Since the GPC does not give clear guidelines for which portion of trans-boundary air travel local inventories should take responsibility, this decision is made during the development of the CAP. Reporting of emissions from international travel in particular varies greatly among local US GHG inventories.[6] Because the geographic and economic characteristics of the Hawaiian Islands induce large amounts of emissions from aviation, data that allows for distinguishing travels induced by each of the counties is needed to make such inventories in the future.

Stationary Energy

KIUC distributes all grid-supplied energy in Kauaʻi. KIUC developed an emissions inventory in 2016 using a baseline year of 2010. Emissions are reported by GHG and fuel type, which corresponds to GPC requirements (KIUC, 2016). The County should still collect information and calculate energy use per subsector including residential buildings, commercial and institutional buildings and facilities, industrial, manufacturing and construction facilities, as well as emissions from grid supplied energy for agriculture, forestry, and fishing activities. Distinguishing between subsectors allows for more specific mitigation actions especially in terms of energy efficiency and renewable energy installations. Any emissions from stationary energy combustion outside of KIUC's operations should also be taken into account.

Waste

Reporting requirements for waste under the BASIC framework differ from those of transportation and stationary energy in that they require reporting of emissions from waste that is transported outside Kauaʻi's boundary. This means that waste that ends up in the waste management facilities, as well as emissions from waste that is treated or disposed at facilities outside Kauaʻi, must be accounted for. Since waste generated in Kauaʻi is treated both at local and external facilities, double counting should be avoided in cases where waste is collected at local facilities before being shipped out. Direct emissions from aerobic and anaerobic treatment of wastewater are to be reported under waste emissions, whereas grid supplied electricity at wastewater facilities is to be reported under stationary energy.

Summary of Recommendations for Implementation of GPC

Planning for climate action starts with an up-to-date inventory of the County's GHG emissions. The GPC is a global standard for GHG emissions accounting that has been developed for local climate action planning. It provides a consistent, transparent and robust framework for development of a GHG inventory, while at the same time allowing for local variations. The BASIC framework of the GPC is divided into three broad sectors – the stationary energy sector, the transportation sector, and the waste sector – each with a range of sources of emissions and opportunities for GHG reductions. A more detailed description

[6] This is partly because international negotiations have failed to resolve how to allot responsibility for international air travel. The US national GHG inventory omits international bunker fuels from its emission totals (EPA, 2016) and US Environmental Protection Agency (EPA) does not provide guidelines for states or local governments on how to allocate responsibility for international or domestic trans-boundary air travel. Without statewide protocols on how to allocate trans-boundary emissions from air travel there is risk of double counting emissions. Although this likely excludes significant emissions within Kauaʻi, the recommendation is thus that Kauaʻi's CAP initially exclude trans-boundary air travel from their emission calculations as allowed under the BASIC framework.

of the GPC framework and data sources for Kauaʻi specific information is provided in Appendix I.

IV. County-Level GHG Reduction Opportunities

Through a review of U.S. local level CAPs as well as scholarly articles and government reports, the following section reviews GHG mitigation strategies that are appropriate at the county level. We broadly categorize the efforts based on the BASIC GPC requirements: Stationary Energy, Ground Transportation, and Waste. Although there are a plethora of potential mitigation measures, there are few studies that assess their effectiveness on GHG emissions reductions – particularly where results can be generalized to other locations. To the extent possible we have selected mitigation strategies that may be relevant to Kaua'i and provide insight into the possible magnitudes of GHG reductions. Where relevant, we showcase Kaua'i's existing plans and policies that relate to GHG emissions reductions within Stationary Energy, Ground Transportation, and Waste. It is outside the scope of this report to study the feasibility or cost-effectiveness of specific GHG mitigation actions for Kaua'i.

Stationary Energy

The 2007 State GHG inventory estimates that electricity and other stationary energy sources accounted for 34% of Kaua'i's emissions. Almost 95% of this comes from the electric power sector (ICF, 2008). This section will discuss emissions related to electricity generation, including water pumping, building energy use, and streetlights. The first is largely governed by state policy: a Renewable Portfolio Standard (RPS) that mandates utilities in Hawai'i to achieve 100% net sales of electricity from renewable sources by the year 2045. It is the responsibility of Kaua'i's only power utility, KIUC, to implement these targets. The building sector is governed by state and county level building codes. Streetlights are operated by KIUC with funding from the County through regulated rates. In this section, we present best practices within the literature and draw policy recommendations from the perspective of county-level actions.

Facilitating Renewable Energy Production

Adopting renewable energy for electricity generation is imperative to achieving substantial GHG emissions reductions within stationary sources. Though this is ultimately within the authority of the utility and the public utilities commission, partnerships are important. One way for county governments to facilitate a transition to renewable energy is by streamlining the county permitting process for the siting of renewable energy projects like wind or solar photovoltaic. A state-level study found that the cost of obtaining a permit for a renewable energy facility in Hawai'i ranges from one to twenty percent of the total project cost. Including federal, state and county permits, some projects involve more than 40 approvals to complete the permitting process (Busche, Donnelly, Atkins, Fields, & Black, 2013). However, perhaps the most time consuming permitting process for renewable energy projects are related to environmental regulations embedded in federal and state policies. Although counties cannot directly influence these processes, they can assure that the county level permitting process does not add considerable time and resource requirements – without, of course, compromising the ecological integrity of the permitting and review process.

To address permitting, first the counties can revise their zoning codes to incorporate larger scale renewable energy generation and storage facilities as acceptable land use in suitable areas (Busche et al., 2013). Zoning for larger scale renewable energy generation should take into consideration local ecological and cultural particularities to avoid spatial conflicts (Kotzebue, Bressers, & Yousif, 2010). Secondly, the state and county can develop standardized permitting "checklists" for renewable energy projects. This will reduce the resources that companies must devote to identifying and traversing permitting requirements. Long and expensive permitting processes can especially affect larger scale projects (Busche et al., 2013).

Intermittency of renewable energies like wind and solar photovoltaic is currently perhaps the greatest obstacle to achieving maximum penetration (U.S. Department of Energy & National Renewable Energy Laboratory, 2008). For instance, the peak of solar-based energy is generated when the sun is at its highest, while no energy is generated after sundown. This type of daily and seasonal cycle is also coupled with minute-to-minute disruptions due to environmental factors like rolling cloud cover. There are several approaches to addressing the integration of intermittent renewable energy sources, primarily the adoption of storage systems and/or demand response. Storage systems, like lithium ion batteries, are coming down in cost (Lazard & Enovation Partners, 2016). Demand response, or price-sensitive load shifting, is aimed at aligning demand to the supply of available renewable energies at varying time scales. Time-of-use pricing uses a block pricing strategy to better align electricity prices to supply on average. Real time pricing, which is more dynamic, has been found to have a substantially higher effect on more granular demand-supply matching (Borenstein, 2005). Similarly, critical peak pricing can be used to bring down demand during higher than typical costs (Coffman, Bernstein, Wee, & Arik, 2016). Though there are additional grid services potentially provided from both storage and demand response, in many ways these are substitute mechanisms to achieve the integration of high penetration of intermittent renewable energy sources.

Kaua'i Today

KIUC has made considerable strides towards a transition to renewable energy as a result of their aggressive goals and innovative project delivery. KIUC generated 38% of its power from renewable sources in 2016 (KIUC, n.d.-a), with a typical daily renewable energy mix of 62% solar, 8% biomass, and 7% hydroelectric (KIUC, 2016b). The 2013 revised statutes HRS Section 205-6 gives jurisdiction to the County Planning Department to issue Special Permits for "unusual and reasonable uses" in agricultural and rural districts (Land Use Commission, 2013). This has opened up a substantial amount of available land of which the Kaua'i Planning Department has jurisdiction to issue permits for renewable energy projects. This has been mainly for the development of solar farms. Although some hydro facilities are generating electricity on the island, these are generally more restricted due to local ecological considerations.

The permitting process within the County of Kaua'i likely comprises shoreline setback variances, special management area use permits, special or general use permits, zoning permits, and construction permits. According to the County Planning Department, close cooperation between KIUC and the County has resulted in relatively fast processing of renewable energy facility applications in the County permitting process.

Perhaps the greatest remaining challenge to achieving the 100% goal is the provision of technology that can stabilize the energy supply. As of 2016 KIUC has installed 10.5MW of battery storage. The utility has also signed an agreement with SolarCity to purchase power from a utility-scale solar array and battery storage system. The facility supplies up to 13MW to the grid during evening hours. A pumped storage hydro facility is in the proposal phase.

KIUC also has over 28000 smart meters to facilitate monitoring of energy use by customers (KIUC, n.d.-c). In 2016-2017 these meters assisted a dynamic pricing pilot study. The study demonstrated a noticeable increase of 0.6 kWh per participating customer during solar hours with a 25% rate discount. Some combination of storage and demand response is likely necessary to cost-effectively meet the RPS target. Possible partnership with the County may be fruitful in rolling out time varying rates, in terms of public education, building awareness, and even county-level pilot programs.

Water Conservation Pricing & Education

Water pumping constitutes a large portion of electricity generation. Water use is responsible for as much as 4% of national energy use, but this number is as high as 19% in certain states. The amount of energy consumed for water consumption purposes depends on local geographic and climatic factors (Copeland & Carter, 2017). Timing water pumping with the availability of renewable energy resources can be critically important to reducing the GHG intensity of water pumping. Though the transition to renewable energy generally will likewise lead to GHG emissions reductions within water pumping, water conservation can also play an important role. Water conservation approaches can be both technological and behavioral. The technological approaches are discussed in the following section on building energy efficiency. Behavioral approaches include educational and pricing strategies. Educational approaches alone do not necessarily lead to reductions in water consumption because there is often a gap between attitude and behavior (National Research Council, 2010a; Roccaro, Falciglia, & Vagliasindi, 2011). Combining educational measures with pricing strategies however, have been found to significantly reduce water consumption (Renwick & Green, 2000; Roccaro et al., 2011), with a relatively greater effect on outdoor uses (Renwick & Green, 2000). The most common conservation pricing strategy used to influence water consumption is increasing block rates. With increasing rates the consumer pays a tariff based on specific consumption blocks, with lower consumption yielding a lower per unit price and higher consumption yielding a higher per unit price (Kenney et al., 2008). This strategy is often viewed as having additional equity or fairness benefits as small users will typically be charged a lower rate, whereas large users such as households with lawn irrigation or pools will typically be charged a higher rate (Monteiro & Roseta-Palma, 2011). Demand for general water use is typically more price-elastic in the long run, as consumers need time to install more efficient appliances and outdoor irrigation equipment (Borisova, 2014). Agricultural water demand has also been found to be responsive to price signals (Schoengold, Sunding, & Moreno, 2006).

Kaua'i Today

Kaua'i's Department of Water services approximately 21,000 accounts. As of 2011, water delivery was the largest source of GHG emissions compared to other County government operations (Office of Economic Development, 2012). However, these operations represent only about 1.6% of the island-wide energy consumption indicating a relatively small opportunity for GHG emissions reductions (Ben Sullivan, County of Kaua'i, personal communications, June 2017). The Department of Water implemented increasing tariffs for general use rates in 2001. Per July 2014, the lowest rate block was $3.80, whereas the highest use rate block was $10.00 per 1000 of gallons. Increasing block rates have not been applied to the agricultural sector. A uniform rate is applied to agricultural customers at $2.20 per 1000 gallons of water (Kaua'i Department of Water, 2015). The Department of Water provides some water conservation information to customers on their website.

One role for the County, working with KIUC, is to help the integration between the power and water sectors. The goal of this is to further leverage complementarities between intermittent renewable energies and water pumping as a potentially "shiftable" load (County of Kaua'i, 2016). In addition, expanding the increasing rate structure to additional sectors can advance water conservation. Studies show that outreach and educational measures can be effective when coupled with pricing strategies.

Energy Efficiency of Buildings

Creating policies to decrease the environmental impact of buildings is possibly the most impactful and cost efficient way to reduce downstream demand of energy and raw materials (Radulovic, Skok, & Kirincic, 2011; United Nations Environment Programme, 2007). About 38% of GHG emissions in the US come from the building sector (Hirokawa, 2009; Millett, 2009). Throughout the lifecycle, roughly 85% of these emissions come from operational activities like electricity consumption (Peng, 2016), thus it is here that the greatest emission reduction potential lies. Although it is generally estimated that energy conservation measures can reduce the carbon footprint of buildings by 16% (Kneifel, 2010), total GHG reductions are likely to vary depending on the climate zone and the combination of energy conservation measures implemented. We focus on potential energy savings from common energy efficiency measures targeting cooling, lighting, and water consumption.

Cooling appliances such as air conditioners demand considerable amounts of energy, especially in hot climates. Reducing the loads from cooling appliances can be done by insulation or reflection. Insulating the building construction can reduce energy demand by 23% (Fang, Li, Li, Luo, & Huang, 2014). Similarly, by functioning as an insulator, green roofs can reduce energy consumption in cooling of non-insulated buildings on an order of magnitude of 22–45% (Niachou et al., 2001). Another way to reduce the thermal load is to increase the amount of sunlight that is reflected off the building. Because light surfaces reflect more sunlight than dark surfaces, high albedo coating for roofs (usually lighter color) can reduce energy consumption from cooling by 20-65% in hot climates (Akbari et al., 1997). However, this effect can decrease rapidly due to dirt assemblage if roofs are not maintained (Bretz et al., 1997).

In addition to average temperatures and expected temperature increases related to climate change, buildings situated in urban areas can be affected by the urban heat island (UHI) effect. The UHI effect occurs mainly due to the replacement of vegetative cover by gray surfaces. This relationship between the built environment and temperature has been found even in small urban areas (Ivajnšič et al., 2014). Increasing tree cover, and the presence of green infrastructure in current as well as planned expansion of urban areas, can significantly reduce local temperatures and thereby reduce cooling demand in buildings (US EPA, 2010).

Lighting has a substantial impact on electricity consumption, depending on technology and usage rates. Installing more efficient light bulbs or reducing consumption through automated control measures are the main ways in which energy savings can be achieved. For instance, replacing traditional light bulbs with light-emitting diodes (LED) can reduce energy consumption of lighting by up to 70% (Ryckaert et al., 2012). Further reductions can be achieved by installing automated or manual lighting control technology, such as sensors or dimmers, so that lighting conditions can be adjusted according to real time use. Results of such measures have varying energy savings of 20% to 76%, depending on existing conditions and technology (Clarke, Hand, & Janak, 1999; Knight, 1998; Reinhart, 2004; Xu et al., 2017).

Installing energy efficient lighting, as well as manual or automatic lighting control systems is a relatively cost effective way to achieve GHG reductions. Because of the high potential for energy savings and the relatively low cost of certain measures, retrofits tend to have a short payback period with potential for additional savings.

Water consumption in buildings can be reduced either through the installation of water saving devices, or non-structural measures such as economic incentives and educational programs discussed in the previous section. The installation of low-flow fixtures in taps, toilets, and showers is relatively simple and can result in a consumption reduction of 10% to 20% in residential buildings and from 25% to 60% in public buildings (Roccaro et al., 2011). For example, the average family could reduce water consumption by 2,900 gallons per year by investing in a low-flow showerhead (US EPA, n.d.-f). This simultaneously saves energy emissions related to water heating. Overall, structural water efficiency measures yield efficient and low cost reductions in energy consumption.

Counties can pursue several policy mechanisms to encourage energy efficient buildings. For example, by regularly reviewing county building codes to make sure they are aligned with up-to-date, ambitious, yet feasible energy efficiency requirements. Building codes that mandate outmoded conservation measures bear the risk of anchoring efforts below what is technically and economically feasible (Klotz et al., 2010). For example, it is estimated that updating building codes to include the 2012 edition of International Energy Conservation Code (IECC) can increase energy savings by almost 10% relative to the 2009 version (Zhang et al., 2013); however, there is an additional 11% gain between the 2015 and 2012 versions (Mendon et al., 2014). Further, county building codes only impact new constructions and major reconstructions. The existing building stock is responsible for the largest portion of current and near term GHG emissions from the building sector. Additional policies that incentivize retrofitting within the current building stock can ensure further reductions from the status quo.

Table 1 gives an overview of county level policies that can be aimed at promoting energy efficiency within buildings. The table also gives an overview of potential effects on GHG emissions as well as major limitations and co-benefits.

Table 1

Policy Instrument	Emission Reduction Effectiveness	Cost Effectiveness	Special conditions for success, major strengths, limitations and co-benefits.
Building codes	High	Medium	Only effective if enforced and periodically updated
Mandatory audit requirement	High, but variable	Medium	Most effective if combined with other measures such as financial incentives
Demand-side management programs	High	High	Tends to be more cost-effective in commercial sector than residential sector – larger due to meter infrastructure.
Labeling and certification programs	Medium/High	High	Mandatory programs more effective than voluntary ones. Effectiveness can be boosted by combination with other instrument and regular updates
Energy efficiency obligations and quotas	High	High	Continuous improvements necessary: new energy efficiency measures, short term incentives to transform markets
Capital subsidies, grants, subsidized loans	High	Low	Positive for low-income households, risk of free riders, may induce pioneering investments
Public benefit charges	Medium	High	Success factors: independent administration of funds, regular monitoring &feedback, simple & clear design
Education and information programs	Low / Medium	Medium/High	More applicable in residential sector than commercial. Best high applied in combination with other measures
Tax exemptions/ reductions	High	High	If properly structured, stimulate introduction of highly efficient equipment in existing and new building

The table shows the effectiveness of possible policy paths to facilitate improvements of energy efficiency in the building sector. Modified from"Builings & Climate Change" United Nations Environment Programme, 2007.

Kauaʻi Today

In 2012 the County made a considerable move towards assuring energy savings in the building sector by requiring all new construction to follow the 2009 edition of the IECC. The County is currently in the process of upgrading codes to comply with IECC 2015. Because buildings typically have a long lifespan, energy efficient construction of new buildings will produce GHG abatement effects decades into the future. These energy efficiency measures usually have a relatively short payback period, an effect that is amplified by the high cost of energy in Hawaiʻi (US Energy Information Administration, 2016). Currently no policies exist to encourage retrofitting of existing building stocks to meet IECC standards. Due to the relatively long lifespan of buildings, existing buildings are likely to represent an important opportunity for additional energy savings. Although the County has made strides to encourage energy efficiency in new buildings, its continued effectiveness is dependent on periodic updates, enforcement, and encouraging participation within existing buildings.

Energy Efficiency of Public Lighting

Management of public lighting can have a significant impact on local GHG emissions (Radulovic et al., 2011). County governments can improve energy efficiency of public lighting in two main ways: improving luminous efficiency with light emitting diode (LED) lighting, and implementing "intelligent" systems. Retrofitting High Pressure Sodium (HPS) streetlights to LEDs can improve energy savings by 19-44% (Juntunen et al., 2015). Intelligent street lighting is a relatively new concept that reduces energy waste by increasing timing efficiency. The lights can shut down and turn on based on real time traffic conditions and alter lighting in line with natural lighting conditions (Jagadeesh et al., 2015). LED and intelligent light systems combined can induce power savings in public lighting by up to 60%, depending on pedestrian usage and landscape of lighting installations (Juntunen et al., 2015).

Kauaʻi Today

Kauaʻi has made tremendous progress towards improving energy efficiency of public lighting. The County of Kauaʻi has 2900 streetlights and an additional 600 owned by the State. In 2017, KIUC completed the process of retrofitting 3500 streetlights with LEDs and time based dimming of the lights. It is estimated that streetlight energy consumption has been reduced by 70% (Ben Sullivan, County of Kauaʻi, personal communications, June 2017). The retrofitting cost will be regained through a revised tariff with the County and State (KIUC, n.d.-b).

Transportation & Land Use

Emissions from the transportation sector account for about 49% of Kauaʻi's total GHG emissions (ICF, 2008). As the number one source of emissions in the County, the transportation sector poses major challenges as well as opportunities for considerable GHG reductions. Air transportation is likely a substantial portion of Kauaʻi's emissions. To actually quantify its contribution, the transboundary nature of air travel requires better protocols for attributing emissions at the county level. With this information, the counties could build awareness within the industry and for passengers. Outside of education, however, it is unclear what policy tools a county has that could effectively address air emissions. Because we are here focusing on within boundary sources of emissions, per the GPC BASIC framework, this section refers predominantly to ground transportation.

Ground transportation is on the precipice of major changes in technology through electrification and alternative fuels, shared services, and autonomous vehicles (Waldrop, 2015). These new technologies offer the potential to reduce emissions substantially, but the outcomes largely hinge on implementation. For example, the GHG impact of electric vehicles is dependent on the fuel sources from which they are charged. For example, with the current energy mix in Hawaiʻi, hybrid electric vehicles emit 7% fewer GHGs than electric vehicles. However, electric vehicles will emit substantially fewer GHGs than hybrid vehicles as the State goes toward its goal of 100% renewable energy generation (Coffman, Bernstein, & Wee, 2017).

Rideshare programs could increase transportation efficiencies, but only if ridesharing is pursued as a substitute for single occupancy vehicles. Moreover, GHG reductions from new technologies could be counterbalanced by increased travel activity and population growth (Systematics, 2012). Reducing overall VMT will thus be imperative for GHG abatement. Local governments are in a strategically advantageous position to influence VMT (Bedsworth & Hanak, 2013; Richardson, 2012) through land use planning and supporting alternative modes of transportation. This section presents land use and transportation planning elements commonly found within CAPs that may be relevant to Kauaʻi County.

Compact & Mixed-Use Development

Compact urban form, supported by land use planning and strategic zoning, has attracted a great amount of research in urban planning for its promise to reduce car dependency and create vibrant communities. The aim of these land use policies is to facilitate the development of a favorable spatial pattern that connects a range of human activities, for example, between their home, work, and daily errands like grocery shopping (Kim, 2013). Increasing the accessibility to these destinations can reduce the amount and lengths of trips made by car, thereby reducing GHG emissions, and make it easier to integrate alternative forms of transportation (Ewing et al., 2007; Systematics, 2012). Specific strategies include zoning that allows for mixed-use development, increasing height restrictions, and adopting urban growth boundaries.

Long range estimates of GHG reduction from compact development relative to the status quo span from 7-10% when averaging across rural and metropolitan areas (Ewing et al., 2007; National Research Council, 2010). When only accounting for metropolitan areas the estimate increases to 12-18% (Ewing et al., 2007). This implies that the effect of compact development on GHG emissions can be expected to be relatively smaller in rural areas. One study, however, found projected long-term GHG reductions as high as 50%, given that all new development in a rural county occurred in already urbanized areas (Wheeler et al., 2013). Estimating the effects of so-called "smart growth," which embodies compact, mixed-use development, combined with transit-oriented development strategies, on GHG reductions is particularly difficult because of long time horizons. GHG reductions are likely to be low in the near term and intensify in subsequent years, with more than 90% of reductions occurring after ten years (Systematics, 2012). Regardless of uncertainties and assumptions, numerous studies affirm and some even insist on compact growth as an imperative for substantial GHG reductions in the transportation sector.

Successful implementation of compact and mixed-use development strategies requires careful analysis of optimal development as well as a selection of supportive policy strategies. For example, in terms of GHG reductions, increasing density might only be better to a certain extent. Urban density can also have other tradeoffs such as reduced access to natural light, and increased need for cooling (see *building energy*) due to the UHI effect (Steemers, 2003). A study using a classic urban economics model found optimal density at 50-150 persons per hectare given that public transit mode shares exceeds 50% (Lohrey & Creutzig, 2016).

Kauaʻi Today

Kauaʻi's General Plan promotes compact development through prescribing clear urban boundaries, and preservation of rural character outside urban areas. The plan also recommends buildings that are relatively small in scale and low in height. In 2009 a Built Environment Task Force was established under the Nutrition and Physical Activity Coalition (NPAC) for Kauaʻi County. The task force promotes complete streets and smart growth initiatives. Further, under HRS § 205-47, each county is directed by the legislature to identify and map potential important agricultural lands (IAL) within its jurisdiction. In 2015 the County of Kauaʻi completed an IAL study, which identified a total of 16,263 acres of land in the County with high agricultural value, as well as potential county level incentives that can encourage voluntary IAL petitions by landowners (Dahilig et al., 2015). Designation of IAL's can contribute to restricting sprawling development in certain areas. Areas already designated for urban development cannot be labeled as IAL.

To achieve more compact development in existing urban core areas like Līhuʻe and Kapaʻa, allowing for shorter commute distances between employment and residential areas is critical. The County can support this by zoning for mixed use and infill developments.

Multi-Modal Transportation

Compact and mixed-use development strategies are most effective when implemented alongside a bundle of policies that are aimed at making alternative modes of transportation more attractive (Systematics, 2012). Such policies include providing urban pedestrian and bicycle lanes, car free zones, raising urban parking fees, and creating residential parking permits. Oregon, as an example of a leader in the field, has adopted a VMT fee as a voluntary substitution for the fuel tax (Jones, Bock, & Oregon Department of Transportation, 2017). Policies that are more suitable on a state or national level, due to issues of leakage (see pages 6 and 7, *Understanding Your Impacts*), such as a carbon tax can also function as important disincentives to car patronage (Systematics, 2012).

Non-motorized mobility predominantly includes bicycling and walking. Infrastructure is critical to supporting these activities. "Complete streets" refers to planning strategies that focus on inclusive mobility, where multiple modes of transportation are integrated within the transportation system and are available to a range of citizens. This means that streets include pedestrian-friendly design as well as adequate space and facilities for bicycles. One study assessing GHG reduction potential in a global "high shift to cycling" scenario found an 11% decrease in urban transport emissions with an increase from 6%-14% in bicycle ridership. The study also found relatively high energy and direct consumer cost savings relative to implementation cost (Mason, Fulton, & McDonald, 2015). Cost-benefit analyses have repeatedly produced positive effects across different types of bicycle infrastructure, when incorporating health benefits (Cavill et al., 2008). Further, residents of neighborhoods with pedestrian friendly street and sidewalk designs report walking 30 minutes more each week (Saelens, Sallis, & Frank, 2003). A 5% increase in walkability of a community can reduce VMT per capita by 6.5% (Frank et al., 2006), with associated reductions in GHG emissions.

Public transit accessibility is imperative to providing alternatives to single occupancy vehicles. The receptiveness of private automobile drivers to reduce driving is low in the absence of accessible and reliable mobility alternatives (Fay & World Bank, 2012). Many studies suggest that mass transit can have a lower GHG impact than single or low occupancy vehicles. In Los Angeles, a door-to-door mass transit trip had 77% fewer GHG emissions than a competing automobile trip (Chester et al., 2013). In Montreal, a 10% increase in mass transit accessibility yielded a 6% reduction in GHG emissions (Zahabi et al., 2013). In another study, GHG emissions were reduced by up to 32% by replacing the transit fleet with hybrid buses or electric rails (Zahabi et al., 2013).

It is important to note that GHG emission reductions related to public transit are dependent on relatively high ridership and efficiency of the system (Fay & World Bank, 2012). Having fewer stops and increasing passenger carrying capacities can help achieve greater fuel efficiency and thus also GHG emission reductions (Dreier, 2015). However, fewer stops decreases accessibility of public transit. On the other hand, having too many stops increases travel time, which is an important factor that influences mode choice (Ercan et al., 2017). Further, if an increase in ridership comes mainly from people who walk and bike, an expansion of the bus system might in fact increase emissions (Fay & World Bank, 2012).

On-demand mobility encompasses a set of vehicle-based transportation strategies that include traditional ridesharing mechanisms like taxis and carpooling as well as newer technology-enabled services. These include ridesourcing systems like Uber and Lyft, where a driver picks up a single passenger or multiple passengers, as well as carsharing systems like Zipcar and Car2Go that are essentially short-term car rental services. The impacts of these services are two-fold. The first can be characterized by the impact to fuel efficiency (and GHGs) of individual rides, where the trip is more efficient with additional passengers. The second can be characterized by the impact to car ownership. This relates to the proliferation of car and ridesharing services, making it more likely for people to forego car ownership if they feel they can easily access a ride or short-term vehicle use when needed for specialized trips (Le Vine & Polak, 2017). Once people forego car ownership they are more likely to switch at least a portion of trips to non-motorized forms (Shaheen & Martin, 2011).

High occupancy ridesharing has been promoted as a way to reduce emissions with minimal public investment (Belz & Lee, 2012). A study done in Dublin found that up to 7.7 billion gallons of fuel was saved annually by adding one passenger to every 10 cars, given that the passenger would normally utilize a single occupant vehicle (Jacobson & King, 2009). A case study of California Polytechnic University found that carpool incentives, coupled with increases in parking prices, increased carpooling by 6% with an estimated corresponding decrease in GHG emissions of 1.5% (Willson & Brown, 2008). Carpool incentives can for example entail rideshare matching programs and centralized information, as well as designated parking spaces for carpool vehicles (ICF, 2005). Like many GHG reduction strategies, the effectiveness of carpool programs is locally relative and many factors influence the success of rideshare programs or policies.

Carpooling programs work best if the end destination has high-density employment in relatively small urban areas (Belz & Lee, 2012). Driving cost considerations do not tend to play a large factor, and knowing other passengers can be important, particularly for women (Belz & Lee, 2012). Because finding a compatible carpool partner is essential, information sharing programs can facilitate rideshare participation. Flexible work hours can also have a positive impact on carpool participation, as well as use of other alternative transit modes (Zaman & Habib, 2011). Some emphasize that high occupancy vehicle (HOV) lanes are necessary to increase ridesharing (Giuliano, Levine, & Teal, 1990). However, studies on the effects of HOV lanes on emission reductions range from no significant reductions (Johnston & Ceerla, 1996) to relatively high emissions reduction (Fontes et al., 2014). Some also suggest that HOV lanes cannot be justified for ridesharing alone, because marginal rideshares are more likely to come from alternative modes of transit (Wang, 2011).

Carsharing services are similar to traditional car rental services, but are intended to be more accessible by eliminating intermediaries. While round-trip services require pick-up and drop-off of the vehicle in the same location, one-way services allow for drop-off at flexible or designated parking spots. A study that surveyed five North-American cities with a one-way car sharing service, found that people used the service mostly sporadically and as a substitute to driving that would have occurred otherwise. However, a minority of users reported disposing of personal vehicles in favor of the car-sharing service. The VMT reduction made by this group exceeded the VMT increase by the majority, thus leading to an overall decrease in VMT and associated GHG reductions. Households using the service had a GHG reduction between 4-18% depending on the city (Martin & Shaheen, 2016). The estimated potential for a transition from private vehicles to carsharing services amongst the population above 21 years of age in the US is about 10% (Shaheen, Cohen, & Roberts, 2006). Enabling policies can help reach or even increase this estimate. For example, building codes and zoning regulations can enable a transition by decreasing the number of required parking spaces, and by requiring designated parking spaces for carshare vehicles in new developments. Existing parking spaces can also be converted. To the degree that such policies allow for reduced space requirements, these could also induce additional GHG reductions related to land use (Shaheen et al., 2006). There are also examples where local governments have substituted portions of their fleet through partnerships with carsharing companies. For example, Philadelphia effectively reduced their fleet by over 400 vehicles by replacing them with gas-electric carshare vehicles (Shaheen et al., 2009).

Ridesourcing systems (also known as transportation network companies) use technology to facilitate real time ride on-demand matching between drivers and riders, much like a traditional taxi service. Ridesourcing services are relatively new and fast expanding, and at this point there is little research investigating their impacts on VMT. In San Francisco, a study found that about half of ridesourcing trips had more than one rider. The average occupancy was 1.8 passengers; exceeding traditional taxi occupancy which was on average 1.1 passengers. Compared to commutes done by private automobile, however, the occupancy was about the same (Rayle et al., 2014). Although ridesourcing trips generally are more time efficient than public transit, the majority of trips are likely to be complimentary rather than substitutionary. However, ridesharing might replace longer transit trips. There is little evidence that ridesourcing replaces private automobile trips in any significant matter, and it is likely that any substitution is offset by an increase in VMT induced by travel between passenger pick-ups (Rayle et al., 2014).

Kauaʻi Today

In 2010 the County of Kauaʻi endorsed a complete streets policy (Resolution No. 2010-48), aiming to encourage non-motorized and public transit friendly development. The County adopted a Multimodal Land Transportation Plan in 2013, with the aim to offset new VMT growth through the planning period. In 2015 the County received a TIGER grant and as a result passed the TIGER traffic resolution (Resolution No. 2016-57) with specific plans to increase non-motorized infrastructure, public transportation accessibility, and restrict car travel and parking. The County has estimated that the project can achieve a 3,156,000 VMT reduction.

The bus system on Kauaʻi currently serves large portions of the Island's coastal residential areas and towns. Expansions of the bus service were implemented in 2011 to allow for later evening departures from Līhu'e town and to increase Sunday services. Bus ridership on Kauaʻi increased by 49% the following year, partly due to service expansion, transit funding for county employees, and a Kauaʻi Community College pilot project (Mahikoa, 2011).

Despite efforts, bus ridership and non-motorized mobility has far from reached its potential. Residents drove approximately 896 million miles in 2012, an increase of about 80 million miles from 2007 estimates. In this same period transit ridership increased threefold, from around 1000 to 3000 passengers weekly. The vast majority of commutes however still happen by car (County of Kauaʻi, 2014).

Though strong plans exist, the time is now for implementation. It is important for the County to improve its public and multi-modal transit systems to provide residents with reasonable mobility options other than the single passenger vehicle. The potential for on-demand mobility options, particularly carsharing services, should be assessed along with possible supporting policies. Improvement of the bus system should include a review of the most efficient balance between the number of stops on specific routes, the role of accessibility in increasing ridership, and the cost of operating the system. This may be a challenge in a more rural, less densely populated region. In addition, the emergence of private vehicle services like Uber on Kauaʻi will almost certainly change the transportation landscape. How tourists and residents will participate in this new market will impact not only private vehicle ownership and usage, but also rental car fleets and transit.

Waste Management

Municipal solid waste is a significant contributor to GHG emissions directly through decomposition. The majority of these emissions are a result of landfilling. Emissions from landfills are produced mainly during decomposition of organic waste including food, cardboard, and yard trimmings. Because the carbon emitted from biologically based products in landfills are assumed to be a part of the natural carbon cycle, these are normally not part of GHG emissions accounting. Methane that is produced in landfills, and to some degree in other waste treatment processes, would however not have occurred outside of waste management processes. These emissions are therefore counted as a result of anthropogenic activities. Methane is a potent GHG with a global warming potential 25 times that of carbon dioxide over a 20 year period (Pachauri et al., 2014). Landfill gas contains approximately 50% methane and 50% carbon dioxide (US EPA, n.d.-a). The production of methane in waste management is especially associated with anaerobic treatment, as occurs mainly during traditional landfilling. Landfilling therefore has in general the highest GHG emissions compared to other waste management practices (Chen & Greene, 2003).[7] According to ICF (2007), waste (and wastewater) accounted for about 6% of Kauaʻi's total GHG emissions. Indirectly, considerations for the full life cycle of products impacts the amount of waste generated as well as GHGs created in the processing and use of the product. Targeting consumer patterns of waste-generating products, increasing waste diversion rates through recycling and reuse, and improving the treatment of wastes can reduce emissions from the waste sector.

Increasing Waste Recovery Rates

Reducing waste that goes to the waste stream does not only lower emissions from the waste sector, but decreases capacity demand for waste treatment. Focusing mitigation efforts on waste recovery policies and programs is considered the preferred priority for reducing negative impacts in the waste sector. For example, the "food recovery hierarchy" shows priorities for how food waste should be reduced and recovered. It is supported by the EPA, where the first goal is to reduce food waste by the primary consumer, the second is to donate food to organizations like food banks and shelters, the third is to recover food through recycling (i.e. animal feed), the fourth to use food waste for energy recovery, the fifth is compositing and, lastly, landfill or incineration (US EPA, n.d.-c). Efforts by local governments to encourage food recovery higher up in the hierarchy are typically based on voluntary measures. Educational campaigns, for example, can inform consumers and businesses of simple reduction steps and cost benefit analysis (US EPA, n.d.-d). Governments can also foster collaborative efforts between food establishments and, for

[7] Concurrent with most waste management literature the following assessments of GHG reduction potential of particular waste management practices use anaerobic landfilling as a baseline for comparison.

example, shelters. Governments can help create clarity around food donation and health regulations, as well as possible benefits. The Federal Bill Emerson Good Samaritan Act of 1996 means to encourage food donations by minimizing the liability of donors. Under section 170 of the Internal Revenue Code certain donations by retailers, restaurants and food manufacturers can also take a tax deduction for donating food to charitable organizations. As an example, France recently passed a resolution mandating all grocery stores sign agreements with food donation organizations. This would increase donations of all sorts, including items like fresh produce that might otherwise be discarded. This resolution is a supplement to a relatively high tax incentive that was already in place (Mourad, 2015).

Waste recovery and reduction is important with wastes other than food. Various waste reduction policies and programs have been implemented with success by local governments. Below is a selection of strategies represented in the CAPs of local governments (namely San Francisco, Vancouver, Portland, Seattle, Eugene, and Fort Collins) that have documented considerable progress in waste reduction.

- Educate businesses and residents about the role of consumption in creating emissions, or partner with a third party organization that can do so;
- Support new state and national product stewardship legislation that requires producers to be involved in end-of-product-life management;
- Enact a local ordinance to increase waste recovery rates from commercial and multi-family buildings;
- Green demolition (deconstruction) practices so building materials can be salvaged and reused, and promote buildings with salvaged and reclaimed materials;
- Improve/implement purchasing policies that prioritize reuse of products and materials, purchasing of durable goods, and avoid disposable goods whenever possible;
- Pursue local product stewardship programs;
- Implement Pay-As-You-Throw;
- Ban cardboard from the waste stream (adapted from westcoastclimateforum.com).

Kauaʻi Today

In 2010 food waste accounted for almost 15% of all waste produced in Kauaʻi (Department of Public Works, 2013). It is estimated that food waste has decreased to about 10% of the total waste stream (Department of Public Works, n.d.). It is also estimated that about 26% of food imported to and produced within the State is wasted (Loke & Leung, 2015), including about 40% of seafood and 50% of fruits and vegetables. In Hawaiʻi this corresponds to a food value of about $700 per person per year (Loke & Leung, 2015). As measured in moneraty losses, food waste is highest in the consumer stage where about 69% of total food waste occurs, followed by the distribution and retail stage where about 30% of total food waste occurs (Loke & Leung, 2015). This indicates that food reduction strategies should be aimed at these two levels in the food supply chain.

The Kauaʻi County Council adopted a law in 2009 that banned non-recyclable plastic bags from all retail establishments, effective January 11, 2011. The efficacy of the program should be assessed. In July 2015 a pay as you throw ordinance came into effect as an economic incentive for customers to reduce waste disposal quantities. The program is expected to increase waste diversion by 17% (Department of Public Works, n.d.), though ongoing evaluation is important.

The County has already made efforts to increase waste diversion rates from other waste sources. Further efforts could include public procurement programs that avoid disposable products, as well as support local productions of low and zero waste products.

Repurposing Waste

Here we discuss recycling, composting, and energy products as secondary options to consumer waste reduction. Recycling is viewed as one of the more effective ways to divert waste from landfills and reduce GHG emissions. This includes recycling of food and other organic waste to composting material. Waste products have different GHG reduction benefits of recycling dependent on the energy requirements of producing a virgin product, the energy required to recycle the product, and the material recovery rate that can be achieved in recycling processes (Cliff Chen & Greene, 2003). Similarly, GHG reductions from composting versus landfilling depend on the composting feedstock as well as energy needed for the composting process (Lou & Nair, 2009). A study by the EPA done across California, Oregon and Washington found the following items to have a combination of the highest landfill GHG emissions as it relates to both emissions factors and tonnage, as well as recycling or composting potential:

- Carpets
- Core Recyclables
    - Corrugated containers
    - Office paper
    - Aluminum cans
    - Magazines
    - PET and HDPE (or mixed plastics)
    - Newspaper
    - Steel cans
- Dimensional Lumber
- Food Scraps *(US EPA, 2011).*

Food has some of the highest GHG impacts, mainly due to the large quantities of food that are sent to the landfill. As discussed above, composting food waste can be a important strategy to reduce GHG emissions next to food recovery. Composting has GHG reduction potential because organics do not release methane when composted. Fairly small amounts of methane are oxidized to carbon dioxide, a much less potent GHG, and released into the atmosphere. Food composting is also more effective than energy recovery and landfill capping strategies, although these also have lower GHG emissions than landfilling. Operational GHG emissions might be higher from composting than landfilling under certain circumstances. However, the total emission reduction is still significant (Lou & Nair, 2009).

Indirect reductions of GHG emissions from plastics, and some carpets, can be achieved when considering the whole life cycle of products. Because the raw material of plastics is oil, and production often is fossil fuel demanding, recycling has the potential to significantly reduce emissions from the production of new materials. Recycling of these materials also emits GHGs however, because collection services require fuel. Efficient planning and strategic weighing of GHG reduction benefits can reduce these emissions. For example, although higher source separation usually leads to a higher recycling recovery rate, co-mingling of materials can sometimes lead to lower total GHG emissions. Separation of materials generally requires separately scheduled waste collection, which can also be fuel intensive (Barrera & Hooda, 2016). Further partial co-mingling of recyclables has been found to generate more recycling activity from the consumer side than full source separation (Fitzgerald, Krones, & Themelis, 2012).

Recycling and composting has significantly greater impact on GHG emissions reduction than waste to energy facilities (Chen & Lo, 2016). However, unless full recovery and recycling rates are achieved, incinerating waste for energy can be a viable option. Incineration, or thermal conversion of waste, has GHG reduction potential for two reasons. First, it can entail a near complete conversion of organic matter to carbon dioxide, reducing the global warming potential of the waste compared to its previous methane content. Some carbon monoxide (CO), various hydrocarbons, and nitrous oxides (N_2O) may also be released to the atmosphere in the process, which contribute to atmospheric GHG levels (Astrup, Møller, & Fruergaard, 2009). As nitrous oxides have a global warming potential 265–298 times that of carbon dioxide (US EPA, n.d.-e), even small emissions may be significant. Secondly, waste to energy technology can have indirect emissions reductions by substituting energy production from fossil fuels. This is largely dependent on the energy recovery rate associated with the technology. Some of the most efficient facilities generate both electricity and heat and can recover over 1000 kWh per ton of solid waste processed (Themelis, 2007). Waste to energy facilities, however, also require energy to operate. Operational emissions would be largely dependent on whether the facility is in a region with high penetration of renewable energies (Astrup et al., 2009).

Landfilling operations can also be made more or less GHG intensive; the methane contained in the landfill gas that is produced during decomposition of organic materials can be captured and then incinerated. Methane incineration is achieved either by using flares (open flame system), or energy producing combustion devices such as boilers, turbines, and internal combustion engines. These processes convert the methane to carbon dioxide that is then released to the atmosphere. Because carbon dioxide is a less potent GHG than methane, this process usually lower total GHG emissions (US EPA, n.d.-a). Landfill gas recovery rates lie between 50-90% (US EPA, n.d.-b). Combustion of landfill gas can have indirect GHG reduction benefits as it can offset energy production from fossil fuels. It is important to note that this should not be considered a "renewable energy", as landfilling in itself is an unsustainable practice. Landfilling materials should thus not be encouraged for the sake of producing energy from landfill gas (Chen & Greene, 2003).

Kaua‘i Today

Kaua‘i had a waste diversion rate of 31% in 2010 and a recycling rate at 44%, which is above the national average. Kaua‘i County adopted an integrated waste management plan in 2010 with the intention to maximize waste diversion. In 2011 the County endorsed a zero waste policy (Resolution No. 2011-73) with the goal of a 70% diversion rate by 2023. Currently no curbside recycling or composting is available. However, the County issues free backyard composting bins, and privately owned recycling stations are available for local residents. While commercially produced green waste and recycling materials are restricted from the landfill as an attempt to increase diversion rates, no such restrictions apply to the residential sector. Although the waste diversion rate in Kaua‘i is above the national average, over half the waste still goes to the landfill, and per capita emissions in the waste sector are above the State average (ICF International, 2008). This is perhaps in part due to the intensity of tourism in Kaua‘i. A more accurate comparison between counties should include de facto population.

There is room for substantial improvements in waste diversion rates within the County. To further reduce emissions related to landfilling the County could implement curbside collection, as well as a central recycling and composting facility. A study was done in 2016 that suggests many gains from constructing a Central Materials Recovery Facility for Kaua‘i with the ability to receive recyclables as well as food and green waste for composting. The implementation of such a facility bears potential for significant GHG reductions estimated to be about 27,500 $MTCO_2E$ annually, partly because energy use of the recycling facility is expected to be fairly low (CalRecovery, 2016).

Because food waste is a potent source of GHG emissions, composting is of particular importance. It is projected that 33,812 ton of food and green waste can be offset per year if a composting facility is implemented in Kaua‘i. This can reduce about 21% of the total waste stream in the County (Department of Public Works, 2013). However, composting should not be viewed as a substitute for reducing food waste at higher levels of the food hierarchy. Recycling plastics and other materials has relatively lower GHG reduction benefits according to GPC accounting protocols, but has other benefits to the County. To reduce additional GHG emissions from the mileage increase associated with pick up of these materials, the County should increase fuel efficiency by finding optimal pick up frequency and routes. Home composting should continue to be encouraged by the County.

While a central waste management facility has important benefits, including potential GHG reductions, it is important to emphasize that the cost of certain technologies might not be suitable for Kaua‘i when considering scale economies. This is particularly the case for most waste-to-energy technologies due to expected composition and volume of waste (Department of Public Works, 2013). Technologies found to be infeasible in the 2013 Department of Public Works study include bio-refineries and internal combustion facilities. However, a landfill gas-to-energy facility was determined be suitable for the County considering current and future waste generation. Long-term, such a facility in Kaua‘i could process a maximum of 1,137 standard cubic feet of landfill gas per minute, producing up to 3.75 MW of electric-generating capacity (Department of Public Works, 2013).

V. Discussion & Conclusions

Considerations for BASIC+

This report has focused primarily on GPC sectors identified within the BASIC framework. GHG emissions from AFOLU, and transboundary air travel are outside of this scope. However, we acknowledge that these could have important roles within the County's total emissions. Further, understanding how activities within Kauaʻi induce upstream and downstream emissions can have important implications for actions within the County. Here we present considerations for how to extend past implications of the BASIC framework towards BASIC+.

AFOLU emissions usually include those from forest fires, manure management, enteric fermentation, agricultural soil management, field burning of agricultural residues, urea applications, and emissions from carbon stock changes in biomass. These emissions accounted for 0.1 MMTCO2eq in Kauaʻi in 2007. AFOLU estimates usually also account for carbon sinks including carbon sequestration of trees and forests. Yard trimmings and food scraps in landfills are also considered carbon storage. Carbon sinks accounted for -0.27 MMCO2eq in Kauaʻi in 2007, thus the AFOLU sector in the County is a net carbon sink. In addition to reducing emissions from the agricultural sector, maintaining or increasing net negative emissions in this sector is thus largely dependent on forest conservation, including forest fire management. Additional gains can be achieved by promoting re- and afforestation, as well as trees within the urban environment.

Localities produce emissions both upstream and downstream from local activities. These are reported as scope 3 emissions in the GPC. Products that are shipped to and from Kauaʻi produce GHG emissions from shipping and production. For example 88% of food consumed in Hawaiʻi is imported (DBEDT, 2012). Whether this induces relatively more or less GHG emissions would depend entirely on relative agricultural practices. Further, the issue of "leakage" should always be considered when thinking about cross-border emissions. For example, one way to reduce externalities related to shipping is to encourage locally produced goods with low-GHG production practices. While this would almost certainly increase a jurisdiction's emissions it may decrease global emissions. An important consideration might be to move away from production-based GHG accounting entirely and towards consumption-based accounting (Afionis et al., 2017). Reporting of downstream and upstream emissions resulting from transmission and distribution losses associated with grid-supplied energy as well as transboundary emissions in the transportation sector is required under BASIC+. The GPC encourages additional accounting of external emissions embodied in, for example, the consumption of fuels, food, or construction materials. This is optional for both the BASIC and BASIC+ (Fong et al., 2014).

Similarly, the existing 2007 GHG inventory for Hawaiʻi does not include estimates of GHG emissions from air travel to Kauaʻi. Domestic air travel to and from the continental U.S. was allocated to counties that operated direct flights – Maui, Oʻahu and Hawaiʻi. Clearly many passengers then traveled to Kauaʻi, but this was not estimated as a source of within-state emissions. Now that Kauaʻi has direct flights outside of the state, any future statewide inventory should capture related emissions. Any bottom-up inventory done per BASIC+ guidelines should also include travel between Kauaʻi and neighboring islands.

Summary & Recommendations

Climate action planning and other climate change abatement initiatives are becoming increasingly common amongst local governments, and there is a growing understanding of the importance of these initiatives in combating climate change. This report considers best practices for developing a CAP, with consideration for Kauaʻi County. This includes understanding protocols for developing a GHG inventory, as well as potential GHG abatement policies and actions that can be taken by the County or at the county-level. Although this report predominantly is focused on GHG mitigation, we have identified benefits to jointly considering climate adaptation strategies when creating a CAP.

To set the stage for future climate action planning we recommend that the County create a detailed GHG inventory including emissions from county operations as well as activities within the island. The BASIC framework of the GPC guidelines was considered as the best option for Kauaʻi based on current data availability and lack of guidelines for allocating trans boundary emissions. Expanding to the BASIC+ framework, which includes GHG emissions from trans boundary travel, AFOLU, and other indirect emissions, is desirable in the future to get a more complete picture of emissions induced by activities within Kauaʻi. To facilitate data collection for the GHG inventory as well as the climate action planning process it is considered best practice to create a climate action team. This team should consist of members with access to decision-making processes and information within relevant county operations and community organizations.

The County of Kauaʻi has made many advances towards developing plans and programs that will lower its GHG emissions and promote environmentally sustainable policies. There is much potential to continue progress within implementation. To lower its emissions in the stationary energy sector, the County can focus efforts promoting energy efficiency in existing and future buildings. Strengthening educational measures focused on water conservation, as well as expanding today's increasing pricing structures for water consumption to additional sectors can further reduce energy demand and associated GHG emissions. Within the transportation sector there is considerable opportunity to reduce GHG emissions through land use and alternative transportation. Taking steps towards implementation of already established policies and plans that promote compact and mixed-use development, as well as "complete streets", can enable a less car dependent future particularly in growing urban areas. Though achieving high penetration of public transit ridership in a relatively rural or non-dense area can pose a challenge, creative and low-cost mobility options in the form of buses/shuttles, rideshare, and non-motorized options are likely to play an important role in reducing overall VMT. The greatest potential for GHG emissions reductions in the waste sector lies in reducing waste at the source. This is particularly the case for consumer food waste, including food wasted at restaurants and other dining services. Source reduction can be targeted through educational measures to promote more conscious food consumption or by incenting and facilitating food donations from retailers and dining services. At the end of life stage there can be additional GHG emissions benefits from implementing curbside collection of recyclable and compostable items together with a municipal recycling and composting facility.

The effectiveness of local plans and policies is always to some degree dependent on State and Federal regulations. Kaua'i has tremendous opportunity to build its CAP around the momentum developed from the State's aggressive renewable portfolio standard and other efforts like complete streets planning. Creating a CAP for Kaua'i can assist the County in better developing these synergies and local strategies in a collaborative and engaging process. The emphasis on stakeholder engagement and collaboration through the development of a CAP in and of itself can be a building block towards developing implementation strategies and often facilitates the identification of additional benefits to GHG abatement policies including adaptation mechanisms and fostering community health.

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APPENDIX I: GPC Framework Guidelines

The GPC framework provides a detailed yet flexible guide to GHG reporting. There is room for local considerations related to data availability. This flexibility, however, can make the guide vague when it comes to data collection methods. It is up to the inventory compilers to find locally available and representative data collection methods. Although most data for inventories is typically derived from existing sources it might be necessary to do some primary data collection where data is missing. For the County of Kauaʻi it seems most practical to create a baseline inventory under the BASIC framework and expand it to BASIC+ as resources and data become available. Moreover, a hybrid between the two is possible. For example, if including out of boundary emissions from aviation is not feasible for Kauaʻi at this point, but including emissions from AFOLU sources is, it could be useful to report under BASIC requirements with available land use emission data as an addition.

"Shall, Should and May's" of the GPC framework

The GPC framework guides the inventory compilers through requirements, recommendations, and permissions by deliberately employing the words *shall, should* and *may* throughout the text. The following descriptions include some important requirements and guiding principles under the BASIC framework.

Relevancy and accuracy must be assured as to create a representative picture of the county's emissions during the period of GHG accounting. This means considering local, state and national regulations relevant for the inventory. The inventory should be constructed in deliberation of local administrative requirements and legislative processes to inform future actions. This assumption applies especially when choosing data sources. Further data collection and methodologies must be done in such a way that it does not systematically make inaccurate estimations of GHG emissions or sinks.

Consistency is a cornerstone of a GHG inventory, as the initial inventory will be employed as a methodological guideline for future inventories and evaluations to secure valid comparisons. A geographic boundary must be established and maintained over time for consistent reporting and comparison. For Kauaʻi this might entail deciding whether to include other islands under the county's jurisdiction (i.e. Niʻihau, Lehua, and Kaʻula), and where to set the boundary for local water transportation. Further, the inventory should be based on data covering either a fiscal year or calendar year so that all reported emissions refer to the same baseline.

Completeness and transparency must be considered carefully when compiling a GHG inventory. Even though the guiding principles of the GPC reporting are relevancy, accuracy, consistency, transparency, and completeness, some tradeoffs between these might be necessary particularly in the beginning when data availability is low. Leaving out certain measurements due to local availability of data or irrelevance of scope is permitted but these shall be clearly *identified, disclosed, and justified* in the final report. An example might be choosing a less accurate calculation method such as downscaling from statewide data to achieve a more complete inventory. Such methodological tradeoffs are also to be reported and justified, hence they should not occur unless clear data restrictions or local considerations apply. Certain data are not exemptible and crucial for a complete report. For instance, GHG emissions data shall be reported as metric tons of each GHG as well as carbon dioxide equivalents according to global warming potentials, and cover the transportation sector, the stationary energy sector, and the waste sector under the BASIC framework.

The following table gives an overview of reporting requirements under each sector for the GPC BASIC framework.

Table I.1: Overview of GPC Requirements

(yellow)	BASIC reporting requirement
(pink)	BASIC+ reporting requirement

Emission source	Scope 1	Scope 2	Scope 3	GHG
Transportation	In boundary trips	Emissions from grid connected electric charging	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	CO_2, CH_4, N_2O
On Road				CO_2, CH_4, N_2O
Cars	BASIC	BASIC	NA	
Light duty trucks	BASIC		NA	
Heavy duty trucks	BASIC		NA	
Motorcycles	BASIC		NA	
Bus	BASIC		NA	
Off Road				CO_2, CH_4, N_2O
Vehicle and mobile machinery at transportation facilities	BASIC	BASIC	NA	
Recreational off-road vehicles	BASIC	BASIC	NA	
Lawn and garden vehicles	BASIC	BASIC	NA	
Aviation	Emissions from the direct combustion of fuel for all aviation trips that depart and land within the city boundary	Grid-supplied energy consumed by aircraft charging at airports	Emissions from departing flights at airports that serve the city, located within or outside the geographic boundary.	CO_2, CH_4, N_2O
International flights			BASIC+	
Domestic flights		BASIC	BASIC+	
Helicopters	BASIC	BASIC		
Small aircrafts	BASIC	BASIC		

Waterborne navigation	Water transportation wholly occurring within a city	Grid-supplied energy purchased and consumed at docks, ports, or harbors (distinguish from other marina grid consumption).	Departing transboundary trips that are attributable to the city and powered by direct fuel combustion.	
Riverine trips				
Marine ferries and boats				
Emission source	**Scope 1**	**Scope 2**	**Scope 3**	**GHG**
Stationary energy use	Emissions from direct fuel combustion and fugitive emissions in the county	Emissions from consumption of grid-supplied electricity, steam, heating and cooling in the county	Distribution losses from grid-supplied electricity, steam, heating, and cooling in the county	CO_2, CH_4, N_2O
Residential buildings				CO_2, CH_4, N_2O
Fuel combustion				
Grid supplied energy consumption				
Transmission and distribution losses from grid-supplied energy consumption				
Commercial buildings				CO_2, CH_4, N_2O
Fuel combustion				
Grid supplied energy consumption				
Transmission and distribution losses from grid-supplied energy consumption				
Institutional buildings*				CO_2, CH_4, N_2O
Fuel combustion				
Grid-supplied energy consumption				
Transmission and distribution losses from grid-supplied energy consumption				
Manufacturing industries and construction*				CO_2, CH_4, N_2O
Fuel combustion				
Grid supplied energy consumption				

Transmission and distribution losses from grid-supplied energy consumption				
Off-road vehicle and mobile machinery				
Energy generation supplied to the grid				CO2, CH4, N20*
Emissions from energy used in power plant auxiliary operations within the city boundary				
Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary				
Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations				
Emissions from energy generation supplied to the grid				
Agriculture, forestry, and fishing activities				CO2, CH4, N2O
Fuel combustion				
Grid supplied energy consumption				
Transmission and distribution losses from grid-supplied energy consumption				
Off-road vehicles and machinery (stationary and mobile)				
Non-specified sources				
Fuel combustion				
Grid supplied energy consumption				
Transmission and distribution losses from grid-supplied energy consumption				
Off-road vehicle and mobile machinery				

within military premises)				
Emission source	**Scope 1**	**Scope 2**	**Scope 3**	**GHG**
Waste	Emissions from in-boundary waste treatment, including treatment of waste that is generated outside the city	NA	Emissions from waste generated in the county but treated out-of-boundary	
Solid waste disposal				CH_4, N_2O, Biogenetic CO_2
Municipal Solid Waste				
Industrial Waste				
Other				
Biological treatment of waste				CH_4, N_2O
Composting				
Anaerobic digestion at biogas facilities				
Incineration and open burning				CH_4, N_2O, Biogenetic CO_2
Municipal Solid Waste				
Industrial Waste				
Wastewater treatment and discharge				CH_4, N_2O, Biogenetic CO_2
Domestic Wastewater			NA	CH_4, N_2O
Industrial Wastewater			NA	CH4, N20

Source: Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

APPENDIX II: Data Sources for GHG Inventory Accounting

Indicator	Reporting Period	Source
VMT and Fuel Consumption Data by County	2014 and 2015	DBEDT, State of Hawaiʻi Databook: Table 18.17
Vehicle Registration Data by Vehicle Type and County	2014	DNEDT, State of Hawaiʻi Databook: Table 18.08
Liquid Fuel Tax Base- Gasoline	2010, 2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Diesel oil, Non-Hwy	2010, 2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Diesel oil, Hwy Use	2010, 2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- LPG, Hwy Use by County	2010, 2015	Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Small boat, Gas by County	2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Small boat, Diesel by County	2010	Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Aviation fuel by County	2010, 2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Liquid Fuel Tax Base- Other fuel by County	2010, 2015	DBEDT Warehouse, Hawaiʻi State, Dep. of Taxation
Electricity Total KWH Sold- Residential by County	2010, 2015	DBEDT Warehouse, Electric utility companies
Electricity Total KWH Sold- Commercial by County	2010, 2015	DBEDT Warehouse, Electric utility companies
Electricity Total KWH Sold- Street Lights by County	2010, 2015	DBEDT Warehouse, Electric utility companies
Diesel Oil- Barrels of oil consumed by County	2010, 2015	DBEDT Warehouse, Electric utility companies
County Municipal Waste Composition Data	2010	County of Kauaʻi Department of Public Works Solid Waste Division: Kauaʻi resource recovery park feasibility study Table 9.
Waste composition and carbon factors	2006	IPPC Guidelines for National Greenhouse Gas Inventories Volume 5, Waste
National Air Emissions Data	2014	EPA National Air Emissions Data
Emission factors	2014	US Environmental Protection Agency: National emissions factor database

APPENDIX III: Data Sources for Climate Action Planning

There is a range of sources that informs climate action planning for local governments. Below is a selection of resources useful to government officials involved in the formation of a CAP or GHG mitigation policies.

Local Climate Action Planning Resources
Association of American Geographers. (2003). *Global change and local places: estimating, understanding, and reducing greenhouse gases*. Cambridge, U.K. ; New York: Cambridge University Press.
Boswell, M. R., Greve, A. I., & Seale, T. L. (2012). *Local climate action planning*. Washington DC: Island Press.
Bulkeley, H. (2010). Cities and the Governing of Climate Change. *Annual Review of Environment and Resources*, *35*, 229–253.
Fong, W. K., Sotos, M., Doust, M., Schultz, S., Marques, A., & Deng-Beck, C. (2014). Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).
UN HABITAT. (2015). *Guiding Principles for City Climate Action Planning*. Available at http://unhabitat.org/books/guiding-principles-for-climate-city-planning-action/
Bloomberg Philanthropies: *U.S. Cities Climate Action Best Practices.* https://www.slideshare.net/johncleveland/5a-us-cities-climate-action-best-practices
Planning Tools
The World Bank: The CURB Tool: Climate Action for Urban Sustainability. http://www.worldbank.org/en/topic/urbandevelopment/brief/the-curb-tool-climate-action-for-urban-sustainability
C40: City Inventory Reporting and Information System (CIRIS). http://www.c40.org/programmes/city-inventory-reporting-and-information-system-ciris

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