

# POLICY RECOMMENDATION

ANALYSIS OF AGRICULTURAL CARBON SEQUESTRATION POLICY IN HAWAII

PREPARED FOR: HAWAII GREENHOUSE GAS SEQUESTRATION TASK FORCE



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## EXECUTIVE SUMMARY

Considering the carbon neutral objective of the State of Hawaii by 2045, promoting climate-smart agricultural practices among farmers has become a relevant policy issue in Hawaii's agricultural and rural development planning. Adapting climate-smart agricultural practices creates benefits to society and helps improve the social welfare of Hawaii. Under current practices, however, private benefits to farmers are limited. While overall social benefits are important, an effective policy needs to take into account individual benefits for farmers. The absence of such benefits may cause farmers to disregard social benefits or positive externalities in his/her production decisions and continue traditional practices that do not lead to a socially optimal level of carbon sequestration. To encourage farmers to adapt climate-smart agricultural practices, we evaluated different policy options such as full-funding, partial funding with cost share system, and payment for ecosystem services. These policy options potentially provide incentives for farmers to adopt climate-smart agricultural practices and to internalize positive externalities.

Due to the unavailability of quantitative data, we conducted a qualitative multigoal analysis in our solution analysis. We defined impact categories for economic efficiency, cost-effectiveness, equity, policy consistency, and political feasibility to evaluate each policy alternative against the status quo. Our policy analysis indicates that such policy options have the potential to provide better outcomes than the status quo. However, these policy options are likely supplementary tools rather than substitutes. For example, payment for ecosystem services may be economically efficient but--unless a public-private partnership can be established--lack political feasibility. Although partial funding is more attractive from an efficiency viewpoint, it might be more difficult when it comes to addressing equity across different agricultural producers (e.g., large producers vs smallholder farmers). Therefore, policymakers should bear in mind that trade-offs exist for each of these policy options.

Generally, agriculture is considered a major source of GHG emissions. However, in this policy analysis, we assume that agriculture creates positive impacts on belowground carbon sequestration and therefore generates positive externalities. Our policy recommendations are based on this assumption. This qualitative cost-benefit analysis also does not provide an accurate and precise analysis of each policy option against the status quo. Consequently, for future work, we recommend a quantitative benefits/costs analysis of the proposed policy alternatives compared to the status quo.

## I. INTRODUCTION

In House Bill 2182, the State of Hawaii set a goal to be carbon neutral by 2045. That legislation also established the Greenhouse Gas (GHG) Sequestration Task Force to help accomplish that goal. This report focuses on the third objective of the Task Force: "*Identify land and marine use policies, agricultural policies, agroforestry policies, and mitigation options that would encourage agricultural and aquaculture practices and land use practices that would promote increased greenhouse gas sequestration, build healthy soils, and provide greenhouse gas benefits*" [1]. Per request of members of the Task Force, this report provides a policy analysis and recommendations of alternative policies to promote the adoption of best management agricultural practices to increase belowground carbon sequestration in agricultural lands. This document is organized into five parts. The first section summarizes background information regarding the agricultural industry in Hawaii, frames and models the problem as a positive externality market failure, and presents the goals defined for the policy analysis. The second section details the methodology used for the policy analysis, including descriptions of the policy instruments and impact criteria. The third section provides the qualitative analysis of the respective policy instruments. The fourth section sets forth the recommendations, and the fifth section provides conclusions.

## II. BACKGROUND

### GHG SEQUESTRATION IN AGRICULTURE

Anthropogenic GHG emissions have altered the global carbon cycle, leading to increasing average annual temperatures, sea-level rise, and extreme weather events. This trend is especially critical for an island state such as Hawaii. In 2016, agriculture accounted for 9% of the US GHG emissions (6,511 million metric tons of CO<sub>2</sub> equivalent) [2]. Hawaii's agricultural sector accounts for about 5% of the state's carbon emissions [3], with most of the acreage responsible for these emissions consisting of ranch land. Considering the goal set by the State of Hawaii of achieving a carbon neutral status by 2045, the adoption of Best Management Practices (BMPs) by the agricultural sector could contribute to reducing emissions and increasing below-ground carbon sequestration. Research indicates that "regenerative agricultural practices can turn back the carbon clock, reducing atmospheric CO<sub>2</sub> while also boosting soil productivity and increasing resilience to floods and drought" [4]. Practices to restore soil organic carbon (SOC) stocks provide an important service of sequestering carbon in terrestrial ecosystems.

### What is Carbon Sequestration?

*"Carbon sequestration implies transferring atmospheric CO<sub>2</sub> into long-lived pools and storing it securely so it is not immediately reemitted. Thus, soil C sequestration means increasing SOC [soil organic carbon] and SIC [soil inorganic carbon] stocks through judicious land use and recommended management practices (RMPs)." [5]*

Belowground soil carbon stocks in agriculture lands depend on a variety of factors, such as the type of soil, the depth of the soil profile, soil texture, climate controls (e.g. precipitation and temperature), below-ground biodiversity, and land management practices adopted by farmers and ranchers [5]. The USDA developed a framework of Building Blocks for Climate Smart Agriculture to "help farmers, ranchers, forestland owners, and rural communities reduce GHG emissions and increase carbon sequestration"[7]. For climate-smart agriculture, as defined by FAO-UN, addressing the Sustainable Development Goals of food security and equity should be a priority [6].

GHG emissions from the agricultural sector can be mitigated by adopting climate-smart practices that reduce emissions and promote carbon sequestration [7], enhance soil health and resilience, and reduce emissions from enteric fermentation and manure management (e.g. no-tillage, cover crops, and anaerobic digesters). The dissemination and adoption of these practices rely primarily on voluntary and incentive-based programs [8]. In this report, we use the terms climate-smart agriculture and best management practices (BMPs) to refer to agricultural practices with the potential to restore soil carbon pools and promote belowground carbon sequestration.

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#### HISTORY OF AGRICULTURE IN HAWAII

Hawaii's agricultural land use has changed dramatically, especially in the last 35 years following the end of the plantation era in both sugar and pineapple production [9]. Hundreds of years ago, Polynesian voyagers landed in Hawaii and brought plants such as taro, bananas and other staples to for subsistence. By the first half of 20th century, Hawaii's economy and agriculture were dominated by the monocrop industries of sugar and pineapple. In the late 1950s, access to Hawaii by relatively inexpensive air travel allowed tourism to emerge as a new economy for Hawaii. The tourism industry encroached upon agricultural land. At the same time, a new labor movement developed in Hawaii seeking better income for workers. These developments, plus the cheaper costs of sugar and pineapple production and shipment from developing countries, lead to plantation closures in Hawaii starting in the 1970s.

Due to these changes in the global production of commodities and competition from developing countries, Hawaii agriculture shifted from a monoculture of large sugarcane and pineapple plantations to more diversified agricultural production with a reduction of cultivated land [10]. In 2015, sugar (38,810 acres) remained Hawaii’s largest crop [9]. However, in early 2016--after operating for 146 years--Hawaiian Commercial and Sugar (HC&S), the largest sugar company in Hawaii and the last remaining plantation, decided to cease operations [11]. Plantation closures caused a major transition of land use from active production to idled land. Part of the former plantation acreage was fenced and converted to pasture. This allowed ranchers to expand operations and diminish weed species. Thousands of acres were sold or returned to longtime lessors, either public or private. Large owners of agricultural land currently include the State of Hawaii, Kamehameha Schools, and Alexander & Baldwin (e.g., HC&S). Unlike the former large sugar and pineapple plantation owners, many smallholder farmers rely on informal and short-term leases [12]. Plantation closures ended the era of large-scale monocrop industry and resulted in more diversified and smaller scale farm activities. Today, many farmers are independent, and are comprised of new immigrants that work the land with family members. Agriculture continues to be an important industry, generating \$2.9 billion to the state’s annual economy and directly and indirectly providing 42,000 jobs [13].

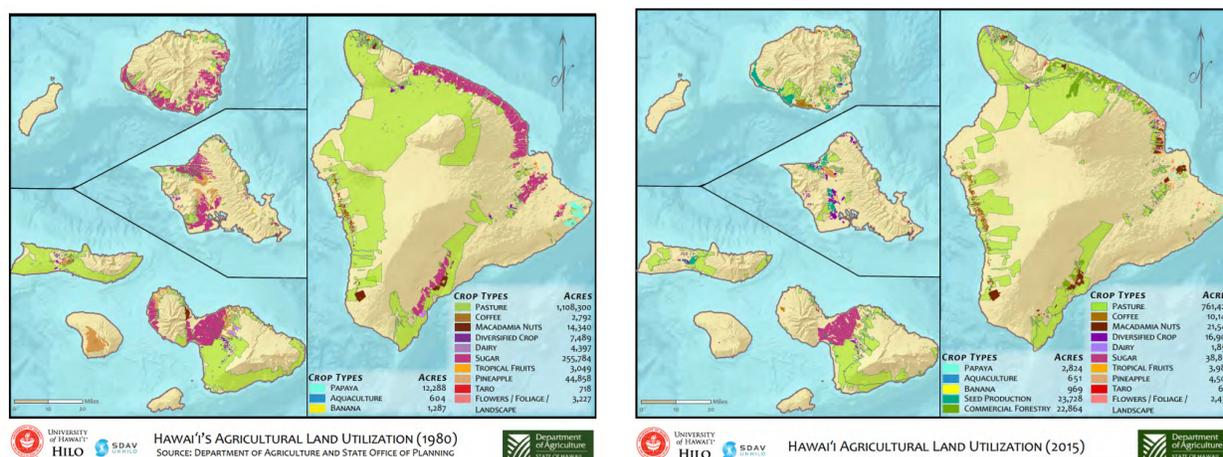


Figure 1 - Evolution of Hawaii's land use for agriculture. The first (top) map refers to the status in 1980 and the bottom in 2015. [9]

### CHARACTERISTICS OF THE AGRICULTURAL SECTOR IN HAWAII

Currently, of the approximately 4,112,388 acres of total land in the State, 47% is designated as agriculture, 48% as conservation, 5% as urban, and less than 0.5% as rural [16]. Hawaii's total cultivated land has decreased by 68% since 1980 [9]. The lack of competitive prices to supply global markets, the high

dependence on imported food from cheaper markets, increased opportunities offered by other industries, and the demand for residential and commercial real estate are some of the forces affecting Hawaii's agricultural industry.

It is also important to consider the diversity that characterizes the State's agricultural sector, as different farmers face different situations and have distinct needs. Demographically, the average age of farmers in 2012 was 60 years old [14] and the majority of them were new farmers [15]. According to Dr. Krisna Suryanata from the University of Hawaii, many of these farmers are retired from other occupations and chose agriculture as their second career. These are the people who can afford to obtain agricultural land but don't necessarily have the capacity to cultivate it.

Although the average size of a Hawaii farm is 160 acres, the median farm size is 5 acres, indicating that the predominance of smallholder farmers compared to large agricultural operations. In Hawaii, ranches represent the vast majority of productive land in acreage [3]. Smallholder farmers and corporate agricultural organizations coexist within the industry. The State is also unique in the diversity of microclimates (possessing 10 of 14 climate zones) [16] and soil orders (having 10 of the 12 soil orders) [17], which affect the potential for belowground carbon sequestration [18].

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#### STATUS QUO POLICIES IN AGRICULTURE - STATE OF HAWAII AND USDA

Currently, the Hawaii Department of Agriculture has several policies and programs to administer and promote agricultural development of the state. The following are some of the important policies and programs:

1. Hawaii Important Agricultural Lands Statutes (Haw. Rev. Stat. § 205-41 to 205-52) [19]

Enacted in 2016, these statutes seek to (1) Conserve and protect agricultural lands; (2) Promote diversified agriculture; (3) Increase agricultural self-sufficiency; and (4) Assure the availability of agriculturally suitable lands.

2. Hawaii Right to Farm Enabling Statutes. (Haw. Rev. Stat. §§ 165-1 to 165-6 (2004)) [20]

These statutes were enacted because the legislature found that, when non-agricultural land uses extend into agricultural areas, farming operations often became the subject of nuisance lawsuits that may result in the premature removal of lands from agricultural use and discourage future investments in agriculture. Under the Hawaii State Planning Act, the legislature declared a State policy to "foster attitudes and activities conducive to maintaining agriculture as a major sector of Hawaii's economy." Accordingly, the

purpose of these statutes is to reduce the loss of the State’s agricultural resources by limiting the circumstances under which farming operations may be deemed to be a nuisance.

### 3. Agricultural Loan Program [21]

The intent of the programs is to help promote agricultural and aquacultural development of the State by providing credit at reasonable rates and terms to qualifying individuals or entities. Through the establishment of a revolving loan fund, credit is made available by supplementing private lender sector loan funds or by providing direct funding.

### 4. USDA Programs [22]

The U.S. Department of Agriculture offers a variety of conservation programs to assist private landowners with natural resource issues (Table 1). Programs were originally focused on reducing soil erosion. The number and scope of programs have increased through successive farm bills and now reflect a broader conservation agenda.

**Table 1 - Selected federal and state policies that support the agricultural sector**

Level	Name	Purpose
Federal	Agricultural Conservation Easement Program (ACEP)	Provides technical and financial assistance to help conserve and protect farm and ranch lands, grasslands and wetlands.
Federal	Conservation Reserve Program (CRP)	Encourages farmers to convert highly erodible cropland and other environmentally sensitive land to vegetative cover including native grasses, trees, filter strips, habitat buffers or riparian buffers
Federal	Conservation Reserve Enhancement Program (CREP)	Helps farmers protect environmentally sensitive land, decrease erosion, restore wildlife habitat and safeguard ground and surface water.
Federal	The Conservation Security Program (CSP)	Provides financial and technical assistance to support conservation efforts on tribal and private agricultural land.
Federal	Environmental Quality Incentives Program (EQIP)	Provides financial and technical assistance through contracts to help plan and implement structural and management practices on eligible agricultural land.
State	Purchase of agricultural conservation easement (PACE)	Compensate property owners for keeping their land available for agriculture.

Source: Department of Agriculture ( <http://hdoa.hawaii.gov/agricultural-resources/>)

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## REDUCING GREENHOUSE GAS EMISSIONS IN HAWAII - LEGISLATIVE FRAMEWORK

Hawaii has been making efforts to reduce GHG emissions and to tackle climate change for over a decade. In 2007, the state legislature approved Act 234 – the Hawaii Climate Adaptation Initiative Act--with the goal of cost-effectively lowering the state's GHG emissions by 2020 to the same levels in 1990 (13.66 million metric tons per year) [23]. As of January 2016, the amount of carbon dioxide emissions was 6,994,636 metric tons. The State goal for 2020 is to reduce this number even further to 6,790,000 metric tons [23]. Act 234 was created to address the following United Nations Sustainable Development Goals: No. 7-affordable and clean energy; No. 10-reduce inequalities; No. 12-responsible consumption and production; No. 13-climate change; and No. 17-partnership for the goals [23]. In 2017, Hawaii's governor enacted House Bill 2182, making Hawaii the first state to commit to the goals of GHG emission reductions defined by the Paris Agreement of the United Nations Framework Convention on Climate Change. To achieve the goal of carbon neutrality by 2045, it established a "Carbon Farming Task Force within the Office of Planning to identify practices in agriculture, aquaculture, and agroforestry to improve soil health, increase forest carbon, and promote carbon sequestration" [24].

Apart from the carbon neutrality goal, there are also other relevant goals under the Sustainable Hawaii Initiative that affect the agricultural sector, such as doubling local food production by 2020. Thus, the evaluation of policies and BMPs to be adopted in Hawaii to increase belowground carbon sequestration in agricultural lands must consider several factors, such as the specificities of the State's agricultural sector, current policies, and market failures.

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## FRAMING AND MODELING THE PROBLEM - CLIMATE-SMART AGRICULTURE - A CASE OF POSITIVE EXTERNALITY

BMPs to improve soil health are considered one of the most cost-effective methods for GHG mitigation [25], and include benefits that improve food security, biodiversity, and water quality [18]. So, why aren't there more farmers adopting them? The problem is that an agricultural production based on climate-smart practices generates societal benefits that does not explicitly affect the farmer, while the costs of switching and implementing BMPs increase the farmers' marginal costs. Multiple stakeholders benefit from a more sustainable production (e.g., through lower GHG emissions and/or higher carbon sequestration), but the burden of the costs is borne by the producer. This is a market failure known as a positive production externality. Farmers' transaction costs are high [26] because it takes time and resources for them to obtain information about these practices (i.e., search costs) and to change from current to new practices (i.e., switch costs).

In the economic framework, we assume that the farmer will want to make the maximum profit from farming operations. In a competitive market, there are a large number of buyers and sellers that participate in the local market (e.g., organic and conventional farmers from Hawaii, the mainland, and from other countries). Therefore, an individual farmer cannot influence the market price, which is set by the demand and supply. Thus, the farmer will produce at a level that his/her marginal cost equal the market price or marginal revenue.

The adoption of climate smart agricultural practices has the potential to generate benefits for the society as a whole because it promotes belowground carbon sequestration that helps mitigate climate change. However, the adoption of climate smart agricultural practices leads to a higher production cost for the individual farmer, which cost is not compensated by a higher market price. Because the price in a competitive market is set by the demand and supply (i.e., prices will remain the same and not incorporate climate benefits of the BMPs), the margins of farmers adopting these practices will decrease. If farmers are forced to adopt climate-smart practices (e.g., through regulation), they will have an incentive to (1) produce less to try to push the prices up by decreasing supply or (2) leave agricultural production and shift to another industry. If nothing is done (i.e., status quo), farmers will likely choose to maintain current agricultural practices, level of production, and profits, and the level of carbon sequestration will remain below the socially optimal level [27,28]. This situation characterizes an under-production of carbon sequestration due to the under-adoption of recommended BMPs. Another market failure to consider is information asymmetry, which occurs because consumers will not be willing to pay a higher price for produce originated from a climate-smart farm unless that practice is explicitly known (e.g., certification label).

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#### PROBLEM DEFINITION AND SCOPE

To address positive externalities created by climate smart agricultural practices, it is essential to provide farmers with incentives promoting the adoption of BMPs that will fully or partially compensate the increased marginal production costs. For example, California and New York provide cost-share incentives that cover up to 75% of the producer's cost to switch to more sustainable agricultural practices. The scope of this report is to provide members of the Hawaii GHG Sequestration Task Force with a comparative analysis of alternative policy instruments that could be used to promote the adoption of climate-smart agricultural practices. Our focus is on policies with the potential to create incentives or reduce barriers to adopting improved agricultural practices by individual farmers and ranchers. Policy options considered include: (1) cost-share and other payment incentives; (2) full subsidization; (3) education, demonstration,

and technical assistance initiatives; and (4) payment for ecosystem services (PES). The scope of this work was limited to policy instruments within the authority of Hawaii state legislators and policy makers. The primary focus of this report was to address the problem of positive externality through incentivization. Due to the limited time and scope of this project, we did not conduct an in-depth analysis of BMPs and funding mechanisms for such incentives.

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## POLICY GOALS

We selected policy goals that considered climate-smart agricultural practices with the potential to enhance soil health and maximize below-ground soil carbon sequestration, address food security, promote increased yield, and improve smallholder livelihoods in Hawaii. We defined the following policy goals: economic efficiency, cost effectiveness, consistency with other agricultural policies, equitable distribution among program beneficiaries, and political feasibility.

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## ECONOMIC EFFICIENCY

Economic efficiency means the situation where the policy's positive impacts (benefits) are greater than its negative impacts (costs). When an economy is efficiently allocating resources, a policy planner cannot reallocate resources to improve one's welfare to the detriment of another. This situation is known as pareto optimality. In this analysis, we will examine the impacts of climate smart agricultural practices on farmers and the wider society through carbon sequestration.

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## COST EFFECTIVENESS

Cost effectiveness refers to using the least amount of resources to achieve a set objective. In policy making, cost effectiveness is used to evaluate alternatives considering the best use of scarce resources [26]. In other terms, it is used to evaluate "the extent to which the program has achieved or is expected to achieve its results at a lower cost compared with alternatives" [29].

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## CONSISTENCY WITH OTHER POLICIES

Consistency with other policies is the concept that the recommended policy will be aligned with, and not contradict, other state or federal agricultural policies. In addressing this issue, we examined current policies to determine whether they addressed considerations such as food security, sequestration of GHGs, and soil health. The *status quo* is the baseline because it represents the Business As Usual (BAU) scenario without implementing any new policy.

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## EQUITY

Equity comes from the principle of moral equality. It is important to consider equity in policy analysis because all people should be taken into account and treated fairly, and individual circumstances should be considered rather than imposing standard, inflexible requirements or benefits. This is because communities have different characteristics, capabilities, and levels of vulnerability and deserve different treatment.

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## POLITICAL FEASIBILITY

Political feasibility examines the ease with which each policy may be approved by the local political system.

## III. METHODOLOGY

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### POLICY INSTRUMENTS ADOPTED BY US STATES

The use of policy instruments to promote the adoption of more sustainable practices is a concern of the US federal and state governments because of the impact on ecosystem services, such as agricultural production, soil health, and water quality. The Soil Health Institute (<https://soilhealthinstitute.org/>) lists on its website policy instruments used by more than 30 states, most of which focus on the dissemination of selected conservation practices, especially cover crops and no-tillage. Four states (California, New York, and Oklahoma) explicitly address the goal of increasing carbon sequestration. However, the Oklahoma program appears to have been discontinued. Three states (California, New York, Virginia) promote a comprehensive list of BMPs based on cost-share policies involving a partnership with the USDA. The incentives take the form of a flat-rate, rate per acre per practice, or a percentage of the total cost (e.g., 75% in Virginia combining state and federal funds). Both the California Healthy Soils Initiative [30] and the Virginia Agricultural BMP Cost-Share (VACS) Program [31] provide detailed information on BMPs (e.g., BMP protocols, cost-share values, and program rules). California allocated \$15 million to its Healthy Soil Initiative in 2018 (only one-third funded by Cap and Trade market), and the NY governor approved a budget of \$14 million to its Agricultural Nonpoint Source Abatement and Control Program in 2017 [32].

Cost-share, grants, and funding are the most frequently used instruments by US states to provide incentives to farmers, corresponding to 50% of the initiatives (n=50) identified by the Soil Health Institute. Other instruments adopted are education, demonstration, and technical assistance (6 initiatives, including Hawaii); equipment rental (4 initiatives); loans (3 initiatives); certification schemes (3 initiatives); tax credits (3 initiatives); and insurance premium reduction (1 initiative). All programs require that farmers apply for the resources.

The USDA categorizes policy instruments for agricultural production as (1) information dissemination tools (e.g., education, demonstration, and technical assistance); (2) economic incentive tools (e.g., government labeling standards for private goods, land use payments, environmental taxes); and (3) regulatory requirements (e.g., bans on specific pesticides) [33]. Three relevant differences that policy-makers should consider when evaluating a policy are (1) if it relies on voluntary participation of the farmer, (2) the role of the government in implementing and enforcing the policy (e.g., technical assistance or funding and monitoring agent), and (3) the nature of change in land management required (e.g., land retirement). In the context of soil health and carbon sequestration in productive agricultural lands, most—if not all—programs in the US rely on voluntary adoption.

### POLICY INSTRUMENTS TO CREATE INCENTIVES FOR FARMERS TO ADOPT CLIMATE-SMART BMPS

In this part, we define the following instruments (Table 2): (1) Cost-share; (2) Education, Demonstration, and Technical Assistance Initiatives; (3) Agricultural loans; (4) Government labeling standards for private goods or certification schemes; and (5) Payment for Ecosystem Services – PES [33].

**Table 2 - A survey of public policy tools for addressing environmental effects of agriculture**

Policy Tool	Participation	Government Role
Subsidies/Incentives paid to offset costs (e.g. subsidies, cost-share, matching grants)	Voluntary	Payments to offset the cost of adopting specified best management practices; contracts intermediate run (5 – 10 years) e.g., Environmental Quality Incentives Program (EQIP)
Educational / Technical assistance	Voluntary	Provide farmers with information and training to plan and implement practices e.g., Conservation Technical Assistance (CTA)
Agricultural loans	Voluntary	Financial overdraft facility that has to be repaid, even if at a low-interest cost.
Government labeling standards for private goods	Voluntary, but standard must be met for certification	Government set standards, which must be met for certification typically involving voluntary “eco-labeling” guidelines e.g., Organic certification
Payment for ecosystem services (PES)	Voluntary	Payments to offset the cost of adopting specified best management practices; contracts intermediate run (5 – 10 years); potential for private-public partnership e.g. Florida Ranchlands Environmental Services Project (FRESP) - water quality

Adapted from Economic Research Service/USDA report [33]

**COST-SHARE AND INCENTIVE PAYMENTS REWARD FARMERS FOR VOLUNTARILY ADOPTING AND IMPLEMENTING DESIRABLE CONSERVATION PRACTICES OR LAND USES.** As a funding mechanism, it refers to the portion not covered by state or federal funds, but by the recipient of the resources. In many instances, this type of arrangement allows for repayment or matching funds for expenses, or in-kind contributions. The percentage of costs covered by public funds for implementing BMPs may range from

50% to 75% of the cost of equipment or practice, paid upfront or as a reimbursement for expenditures. Due to the voluntary nature of cost-share programs, farmers will likely only participate if they perceive the benefits outweigh the costs. Thus, “a participation constraint is included in the regulator's problem to ensure that the farmer finds it profitable to participate in the program” [34]. Examples of federal programs that fit this category include the USDA’s [Environmental Quality Incentives Program \(EQIP\)](#) and the [Conservation Stewardship Program \(CSP\)](#).

**EDUCATION, DEMONSTRATION, AND TECHNICAL ASSISTANCE INITIATIVES** play a key role in disseminating new practices and changing farmers perceptions, attitudes and beliefs. For a more effective use of resources, they should be preceded by understanding farmers perceptions of proposed BMPs compared to current practices, as well as identifying local leaders with respect to adopting new technology. Research indicates that new information is discarded if it contradicts farmers’ perceptions and understandings [35]. Considering the perceptions of potential adopters is critical to the success of spreading innovation [36].

Technology transfer to farmers, especially smallholder farmers, is affected by multiple factors. Firstly, the willingness of a farmer to try and adopt a new practice in the long-term is constrained by economic conditions, such as market demand and price [37], and the farmer's resources (e.g., farm size, land tenure arrangements, available equipment, and labor) [38,39]. The farmers’ decisions are usually bounded by opportunity costs of labor and land [39]. Secondly, the farmers’ decisions are shaped by (1) the relative advantage of the proposed practices compared to current agronomic practices; (2) the complexity of implementing these practices; (3) the compatibility with the farmers’ goals and mental models; (4) the possibility to observe positive outcomes in the short-term; and (5) the ease of trying the practice before engaging in full adoption [40]. Thirdly, the diffusion of an innovation is affected by socio and psychological aspects, including personal perceptions [41], aversion to risk [42], and social pressure. Further, improved agronomic practices and technologies are often location specific, requiring adaptation to local agro-ecological and social contexts [43].

**AGRICULTURAL LOANS** correspond to a financial overdraft facility that has to be repaid, even if at a low-interest cost. Incentives such as loans may be suitable when the benefits to farmers are clear, such as land or equipment acquisition having a direct impact on their income. However, the implementation of carbon sequestration BMPs require change in the farmers’ agricultural present practices, the benefits are extended over time and shared on a global scale. Thus, the benefits for farmers are even less tangible if land lease is the norm. Among the challenges faced by Hawaii farmers are the high cost of land, the short duration of leases, and the restrictions of residences on agricultural lands [1]. In this context, instruments not requiring repayment should be more effective in promoting the adoption of BMPs.

**GOVERNMENT LABELING STANDARDS FOR PRIVATE GOODS OR CERTIFICATION SCHEMES** can be organized by public or private agents. They have the potential of creating new markets for crops produced with environmentally sound practices (e.g., organic products). Through the creation of local, national, or international certification standards, consumers become better informed and can support farmers by paying higher prices for their crops. A key component to reduce the asymmetry of information between producers and consumers is using specialized labels (e.g., "eco-labels"). If producers are able to charge a "premium" price to support the higher costs and/or lower yield associated with more sustainable practices, then more farmers will switch to them. However, the participation is voluntary, involves a bureaucratic process through which farmers become members, and requires adequate monitoring to check if producers are complying with the certification standards. For example, "the USDA has set uniform national standards defining the term "organic" for both bulk and processed products." [33]

Several studies have examined how different certification systems have approached environmental and social concerns, and whether these systems have been successful at generating improvements [44,45]. These studies have found a number of limitations regarding the certification process. Critiques include the limited ability to address a global commodity problem; companies participating in certification in an effort to "greenwash," which suggests a company is making a misleading claim about the environmental impact of a product; collusion and corruption among certifying bodies; and the exclusion of smallholder participation from the certification process [46,47,48].

**PAYMENT FOR ECOSYSTEM SERVICES – PES** PES is a new innovative policy instrument to incentivize conservation and sustainable resource management and improve human well-being [49, 50]. Wunder [49, p. 3] defines a PES as "a voluntary transaction where a well-defined environmental service (or a land use likely to secure that service) is being 'bought' by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision (conditionality)." Currently, PES programs are at the center of conservation efforts and have received strong commitments from international donors (e.g., the World Bank, IFAD), inter-governmental policy bodies (e.g., IUCN), national governments, the private sector, and environmental NGOs (e.g., Conservation International and the World Wildlife Fund).

Although PES is presented as a market, PES does not work like normal trade. In order for the payment to be effective, policy makers need to know accurate estimates of private costs, such as a landowner's willingness to accept (WTA) a "contract." In other words, the minimum price for which they are willing to perform the service. If payments undercompensate landowners, then PES will not influence changes in behavior due to poor participation and a high rate of non-compliance. On the other hand, if

payments over compensate landowners, PES will not maximize the benefits received from the allocated budget.

All policy instruments have advantages and disadvantages some of which are summarized in the Table 3 below.

**Table 3 – Advantages and Disadvantages of Selected Policy Instruments**

Policy Tool	Advantages	Disadvantages
Subsidies/Incentives paid to offset costs <sup>1</sup> (e.g. subsidies, cost-share, matching grants)	<ul style="list-style-type: none"> <li>→ Higher likelihood of adoption of BMPs, as reduces the net cost for farmers.</li> <li>→ Larger payments than net cost tend to provide adequate incentive for farmers on leased land to adopt BMPs.</li> <li>→ Subsidies reduce the impact of adoption on farmers income.</li> <li>→ Contracts that last many years create incentives for the continuity of practices over time.</li> </ul>	<ul style="list-style-type: none"> <li>→ Participation is voluntary.</li> <li>→ Farmers may be reluctant to participate when payment is less than 100% of net cost unless BMPs provide private economic benefits (e.g. increase in yield).</li> <li>→ Requires more funding from the taxpayers because participation tend to increase the higher the payment received by producers.</li> <li>→ Without proper monitoring payment, producers may increase production area instead of adopting more sustainable practices.</li> </ul>
Education, Demonstration, and Technical Assistance Initiatives <sup>1</sup>	<ul style="list-style-type: none"> <li>→ Public information gathering and distribution may increase the use of conservation practices by farmers unaware of their effectiveness or unsure about how to adopt them. Private benefits to producers may include lowering production costs, preserving soil productivity, or reducing damage to their own resources such as ground water.</li> <li>→ Compliance is more challenging when participation is voluntary. It is not clear if conversion is broad enough to achieve the proposed goals.</li> </ul>	<ul style="list-style-type: none"> <li>→ These programs are completely voluntary, with effectiveness largely dependent on whether a given practice creates benefits for farmers that offset the costs of adoption.</li> </ul>
Agricultural loans	<ul style="list-style-type: none"> <li>→ Provides access to funds that will be repaid in installments at low or no interest rate.</li> </ul>	<ul style="list-style-type: none"> <li>→ Farmers will only use loans if they perceive that the private benefits exceed cost.</li> <li>→ Requires repayment by producers.</li> </ul>
Government labeling standards for private goods or certification schemes <sup>1</sup>	<ul style="list-style-type: none"> <li>→ Communicates to the customer that producer adopts more sustainable practices facilitating the capture of price premiums by producers.</li> <li>→ National or international certifications reduces the uncertainty for consumers.</li> </ul>	<ul style="list-style-type: none"> <li>→ Participation will only be effective if producers perceive that private gains will be obtained through premium prices.</li> <li>→ Hard to link program participation and measurable environmental benefits.</li> <li>→ State standards might create confusion in consumers.</li> </ul>
Payment for Ecosystem Services - PES <sup>2</sup>	<ul style="list-style-type: none"> <li>→ Flexibility allows customization to local characteristics.</li> <li>→ Increases cash income for producers.</li> </ul>	<ul style="list-style-type: none"> <li>→ Valuation of ecosystem services is complex and costly.</li> <li>→ Not designed to address poverty, but to provide economic incentives to producer. Might not be sufficient to address equity goals.</li> </ul>

Sources: USDA[33]<sup>1</sup> and UNDP[51]<sup>2</sup>

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## SELECTION OF POLICY ALTERNATIVES TO PROMOTE THE ADOPTION OF CARBON SEQUESTRATION IN AGRICULTURAL LAND IN HAWAII

Due to the lack of quantitative data to analyze each goal, we adopted a qualitative approach to evaluate and recommend policies to incentivize the adoption of carbon sequestration BMPs in the agriculture sector.

Based on the review of the policies adopted by other US states, we selected and bundled three policy alternatives to the *status quo* with the potential to promote the dissemination of climate-smart BMPs in Hawaii's agricultural industry:

- Alternative 1: Partial subsidization of the incremental costs of climate-smart BMPs (i.e., Cost-share through matching grants that cover 75% of the implementation costs) combined with education, demonstration, and technical assistance
- Alternative 2: Full subsidization (i.e., incentive payments that cover the full cost of implementation with 100% of the funding) combined with education, demonstration, and technical assistance
- Alternative 3: Payment for ecosystem services (PES) combined with education, demonstration, and technical assistance
- Status quo: Currently, no specific funding is provided by the State of Hawaii to promote the adoption of climate-smart BMPs by local agricultural producers. However, there is synergy with soil health conservation practices promoted by the USDA-EQIP program.

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### IMPACT CATEGORIES FOR POLICY GOALS

**ECONOMIC EFFICIENCY** -- To measure the economic efficiency, the proposed policy alternatives will be qualitatively compared based on the profits generated by each policy alternative. Then, the policy option generating the highest profitability will be selected as the most economically efficient policy option. For example, government funding may be the most profitable option in promoting carbon sequestration compared with the status quo. Government funding provides a direct subsidy for farmers to adapt climate smart agricultural practices. The direct subsidy reduces the adaptation cost and increases the profitability of farming. Since climate smart agricultural practices lead to increased carbon sequestration in the agricultural sector, it may also create positive impacts throughout the wider society. Thus, the government funding can be considered as a profitable policy option or an economically efficient policy option compared to the status quo.

**COST-EFFECTIVENESS** -- For this goal, the policy alternatives will be qualitatively compared considering the least potential cost and the scalability of the instrument to the State of Hawaii. The potential cost will be

evaluated considering the percentage of incremental cost incurred by the farmer that should be covered by state or federal funds, and the timing of the release of the funds. For example, if the same result (i.e., adoption) can be achieved with 75% (option 1) versus 100% (option 2) government funding, the first option will be rated higher than the second. We approach scalability as the number of farmers reached by a policy, considering the limited resources available at the state level.

**CONSISTENCY WITH OTHER POLICIES** -- To evaluate this goal, the policy alternatives will be qualitatively assessed to check for coherence with other ongoing agricultural policies. Our interest is on current policies that promote BMPs for soil health, GHG sequestration, and food security through local food production. We will examine policy tools that have been effectively implemented. The recommended policy should be consistent with what is currently being done (*status quo*) in order to support the overall goal of carbon neutrality by 2045. The policy should enhance and improve the efficiency of current policies.

**EQUITY** -- Policy alternatives will be assessed on whether the costs and benefits of each policy would be distributed fairly within the target beneficiaries. This includes equity with respect to demographics (age and gender), working experiences as farmers in Hawaii (long time farmer or new farmers), operator status (owner versus renter), physical farm attributes (soil types and crop types), and geographic distribution (whether the policy favors farmers in one state over the other). For example, our policy alternatives should consider older farmers, not only because they are the majority of farmers in Hawaii, but they are more vulnerable to policy changes. Recommended policy should cover equitable distributional outcomes as much as possible [8].

**POLITICAL FEASIBILITY** -- Criteria to evaluate political feasibility include foreseeable popularity with individuals and interest groups (who might be paying for and benefitting from this policy) and the ease of implementation (how easy would it be to measure and regulate this). Judgements were based on background research of Hawaii's political situation, policy-specific research, and interviews.

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## LIMITATIONS

We defined impact categories to compare the different policy alternatives and the status quo. The lack of quantitative data and limited time to produce this analysis constrained our ability to conduct a thorough evaluation before making a policy recommendation. The distinct characteristics of Hawaii's agricultural sector makes it complex to transpose policies adopted in other US states. Our natural environment, economy, and agricultural sector are vastly different than most states. Unlike other states, there is no available data on the current levels of belowground carbon pools or estimates of BMPs potential to

sequester carbon at the farm level. For other states, this information is available at COMET-Farm(<http://cometfarm.nrel.colostate.edu/>). Other states also have different rates of farmers as landowners. In Hawaii, farmers often rent the land they farm, and therefore may be less invested in long term soil health. Further research is needed in Hawaii to provide adequate information for decision making. Nonetheless, policies and BMPs implemented in other states (e.g., California Healthy Soils Initiative, New York Agricultural Environmental Management, and Agricultural Cost-Share and Tax Credit Programs) can provide critical insight and guidance for Hawaii's policymakers. Lastly, we limited the scope of this project to carbon sequestration, even though agriculture, especially ranching, contributes to GHG emissions. Although BMPs may differ, policy instruments to promote them may be similar.

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## METHODS FOR COLLECTION OF SECONDARY DATA AND SOLUTION ANALYSIS

We combined different research methods to conduct the different stages of our policy analysis, including the diagnosis of symptoms and market failure, identification of policy alternatives, and a qualitative evaluation of the outcomes of those policies. The main methods for gathering data used were desk research, literature review, and interviews.

### LITERATURE REVIEW

For the background of this report, we researched secondary sources for information on soil carbon sequestration in agriculture, market failures, and the development of the agriculture industry in Hawaii. We gathered information published by government or private sources describing policies (e.g., The Soil Health Institute) designed to promote the dissemination and adoption of climate-smart agricultural practices and carbon trade markets in US states, and the status quo of agricultural policies in Hawaii. The foci were (1) policies that would fall under the jurisdiction of the State of Hawaii, and (2) potential sources of funding for such policies (e.g., carbon market).

### INTERVIEWS

For the development of this report, we interviewed Jayme Barton (Hawaii Agriculture Research Center), Dr. Susan Crow (NREM Department at UH-Manoa), and Sandy Ma (State of Hawaii Office of Planning). These interviews were key in providing first-hand information on current and planned developments to increase carbon sequestration in agricultural lands in Hawaii. Jayme Barton is leading a Carbon Farming BMP project locally and shared information on the current status of efforts to promote the adoption of BMPs by local agricultural producers. We met with Jayme twice; an initial time to understand how her work was aligned with the goals of the Task Force, and then for a second interview to obtain an update on the progress of her work on carbon farming. Dr. Susan Crow is currently leading research projects in

Hawaii to produce baseline measurements of belowground soil carbon in agricultural lands, as well as a better understanding of farmers' practices and perceptions. Two of the members of our team participated in a meeting with Sandy Ma to better understand the task force's expectation of this report.

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#### POLICY ANALYSIS METHODS

We then analyzed the policies by qualitatively comparing policy options for both incentivizing BMPs based on the criteria of "Cost Effectiveness," "Consistency with other policies," "Equity," "Political Feasibility," and "Economic Efficiency." We compared possible funding mechanisms for these incentives in an accessible table of pros and cons. We then detailed our policy recommendations and presented the qualitative analysis.

The qualitative assessment of each category was determined by the literature review, research of policies adopted by other US states, the goals of the Task Force, and the discernment of our group members. Each group member was responsible for qualitatively assessing the different policy alternatives using one of the five goals. The information was detailed through a narrative and summarized via a matrix in which the X-axis contains the impact categories and the Y-axis contains the incentivizing policy alternatives. We opted for a qualitative approach because we lack the data, such as data on belowground carbon pools, costs of practice (U\$/acre), etc. The funding options were summarized via a table of possible funding sources with listed pros and cons for each. We used the matrix and the table to summarize complex information for the sake of comparison.

Final recommendations were decided by the group based on the evaluation of the potential of each policy to address the underlying problem (carbon sequestration in agriculture as a positive production externality) while meeting the defined goals (cost-effectiveness, economic efficiency, consistency with other policies, equity, and political feasibility.) Recommendations were accompanied by a clear rationale from our analysis, a brief summary of the advantages and disadvantages of these policies, and steps for the future. We consider education, demonstration, and technical assistance an essential component of all three alternatives.

#### IV. SOLUTION ANALYSIS

This section is a comparative analysis of the *status quo* and three policy alternatives to incentivize the adoption of climate-smart BMPs by agricultural producers in Hawaii. The status quo: Currently there is no specific funding provided by the State of Hawaii to promote the adoption of climate-smart BMPs by local agricultural producers. However, there is synergy with soil health conservation practices promoted by the USDA-EQIP program. The three policy alternatives to the status quo are (1) Partial subsidization of the

incremental costs of climate-smart BMPs (i.e., Cost-share through matching grants that cover 75% of the implementation costs), (2) Full subsidization (i.e., incentive payments that cover the full cost of implementation with 100% of the funding), and (3) Payment for ecosystem services (PES).

We qualitatively evaluated the policy alternatives considering the following prerequisites (except for the *status quo*):

- (a) An extension program and technical assistance will be provided by the State to ensure that farmers understand and appropriately implement the recommended BMPs.
- (b) The funding agency will define performance indicators and monitor outcomes to verify that goals have been met. A clear and well-defined monitoring system minimizes the problems of moral hazard and free-riding (i.e., minimizes opportunistic behavior by the farmers as it creates incentives for the farmer to apply the funds as agreed with the funding agency).
- (c) Contracts will be signed for a period of three or more years as the benefits of climate smart agriculture occur in the mid/long-term.

#### ECONOMIC EFFICIENCY

We conducted a qualitative cost-benefit analysis related to our main policy alternatives against the status quo. Full funding is one of the most attractive options for the farmers because it offsets the adaptation cost of climate smart agricultural practices. Therefore, full funding option may create positive impacts on the farm profitability only if the adoption of BMPs increases farmers income. In this case, it increases the producer surplus. Hence, the full funding is an economically efficient policy option compared with the status quo. However, in reality, full funding may be associated with the moral hazard problem. In addition, if full funding is derived only from taxes, this creates negative impacts on taxed citizens. Consequently, the net impact is not clear.

Partial funding (Cost-share) with education and technical assistance may be a good solution for the moral hazard problem. Partial funding also creates positive impacts on farmers and the wider society because it reduces the adaptation costs of climate smart agriculture. Because the farmers' costs increase, reducing profit, the positive impacts created by partial funding option is smaller than the positive impacts created by the full funding option, especially if producers do not perceive positive private benefit from adopting BMPs. However, compared to the status quo, partial funding is economically efficient.

Payment for ecosystem services (PES) also reduces the cost of adaptation, and therefore increases farm profitability. However, this policy option may be associated with high administrative and monitoring costs. PES may be funded by the government using tax money or partnering with private corporations.

Therefore, net impacts on the society not clear. Since this option involves the payment of a premium on top of the increase in costs, this policy option creates larger positive impacts on farmers compared with the status quo.

#### COST EFFECTIVENESS

Cost-share is a popular form of incentive that often combines state and federal funds, reducing the burden on local funds. From a cost effectiveness perspective, we recommend incentives that cover part but not all of the costs of farmers (e.g., Subsidy -- Partial funding), if producers perceive some private benefits from the climate-smart BMPs (e.g., lower costs due to reduced use of fertilizers and pesticides). Since the instruments proposed to address positive externalities rely on the voluntary participation by farmers, we expect that those who apply for funds or participate in the programs will be more committed to the adoption of BMPs than other producers. Cost-share of up to 75% of the net cost of producers also demands less resources in terms of public funds. Generally, we suggest producers be allowed to match funds with expenses or in-kind sources.

Incentive payments should cover 100% of the net costs if farmers do not obtain any private benefits from the adoption of climate-smart agricultural practices. This could be the case if producers have short-term leases on the land and have no incentives to invest in practices that will provide long-term benefits on property owned by third-parties. Because public funds in Hawaii are limited, the more resources invested per farmer, the less farmers will be reached by the policy. Partnerships with local corporations for any of the policies may reduce the burden on government funds. It is also relevant to adopt sound criteria to select producers to prioritize lands having more potential of sequestering carbon, as it is influenced by multiple factors such as micro-climate, soil type, type of crop, etc.

The use of PES in agriculture in Hawaii requires measures of belowground carbon pools before and after the introduction of BMPs for each producer. Another relevant measure is the cost of each practice. While scientists in Hawaii develop mechanisms to map and measure below ground soil carbon dynamics in agriculture, policymakers must develop a better understanding of challenges and opportunities to disseminate BMPs among local farmers and ranchers. Not only is it essential to map a baseline of local belowground carbon pools to be able to measure the impacts of BMPs, current perceptions and practices of local farmers and ranchers must be considered because they have the potential to facilitate or hinder efforts of technology transfer [35,39]. PES also entails payment of a premium that increases the producer's income, demanding more resources to be implemented.

If payment of funds made as an advancement, the incentives for farmers might be higher, but also the risks for the funding agency. If funds are released as a cost reimbursement, farmers may have less incentive to change current behavior.

#### CONSISTENCY WITH OTHER POLICIES

Consistency with current policies to analyze our alternative policy options will be done through a defined scope. This scope will take into account what practices and policies are currently employed within the US, as well as the successes of these policies. Success will be measured by how the policies help to sequester carbon and the response from the states that are implementing the policies.

Analyzing consistency with other current policies, if we keep the status quo there could be some positive changes for agriculture due to the 2020 local food production goals if producers are already adopting, and continue to use, BMPs. With this goal approaching within two years, local food production should increase, which would mean a positive impact in the agriculture sector. The outcome is not clear in terms of carbon sequestration. With agriculture lands being used to grow crops, some carbon has the potential of being sequestered as compared to bare lands. However, the conversion of grasslands to other uses may have a negative impact on below ground carbon pools. If imports of food products decrease, reduced emissions from transportation may occur.

PES is more challenging because it requires a legal and institutional framework to define its rules. For both the partial funding and full funding, they should be directed to promoting BMPs that enhance soil health to help the agriculture sector sequester carbon. There are some policies currently in place, such as funds provided through EQIP for conservation practices, but the focus is not on carbon sequestration. More opportunities of funding options available to ranchers and farmers should facilitate the dissemination and adoption BMPs that improve soil health.

Regarding consistency with other policies, our recommendation is for full or partial (i.e. cost-share) subsidization policies based on grants.

#### EQUITY

Agriculture practice has traditionally focused on maximizing efficiency. However, addressing inequities in agriculture also requires careful consideration. Subsidies, either full or partial, benefit the farmers. These instruments enable farmers to offset the net costs of implementing climate-smart practices without reducing their profits and income. From an equity perspective, with a fair distributional mechanism, agriculture subsidy is able to provide access to all type of farmers, including young or old, experienced or new, local or immigrant farmers, and owner or renter. Location of agriculture land also affects the level of

subsidy, such as distance to market and/or road, and risk of exposure to disaster. Type of crops or agricultural products that are eligible for subsidy should be carefully assessed prior to distribution of subsidies to avoid discrimination. Subsidies, either full or partial, should be designed in way that every farmer in Hawaii can have the same chance of producing good harvest, higher profits, and increased well-being.

PES provides incentives directly to the service providers, which usually are land owners. PES is typically designed as a contract-based scheme between the sellers (service providers) and buyers (e.g. government). It is considered to be a more effective tool with respect to equity issues because the scheme is designed to be provided to poor and vulnerable communities. PES can help eliminate the dominance of large actors and avoid excluding poor and small-scale farmers from obtaining benefits. However, it can also exclude other stakeholders, such as landless residents and women, with a resultant of uneven distribution of PES benefits [52]. Another issue with PES in terms of equity is the possibility of having a free-rider in the scheme, with non-compliance by participants. Thus, it is critical for the state to monitor and measure the efforts of those who provide the service.

#### POLITICAL FEASIBILITY

A cost-share subsidy where the government partially covers costs of adaptation may be popular with farmers who would like to implement BMPs and just need a little help. It would require funding via government revenue taxes. This option may be popular with voters who would like to see climate change addressed. A subsidy that provides full funding for adopting climate smart practices would likely be most popular with farmers who would not otherwise implement BMPs and cannot afford any expense toward this, as well as with voters who would like to see climate change addressed. However, it would likely be unpopular with those who feel that farmers are not as invested or that the cost is too high. This option would require even more funding via government revenue than the cost-share subsidy (e.g. full subsidization or PES).

The political feasibility of PES depends on the political power of those who bear the costs and those who benefit [41]. PES could potentially be funded via voluntary contribution or public-private partnerships (e.g., Hawaiian Airlines, Kamehameha Schools etc.), therefore requiring less financial support from the government and being naturally supported by those who bear the cost. However, it is relevant for the government to participate in the definition of institutions or regulation, such as setting the price for the net increase of belowground carbon pools and ensuring that the providers of ecosystem services are doing their part to sequester carbon. Payment for ecosystem services could also be implemented entirely through government channels, being less complex when applied to forestry than to agriculture [53], since

it is easier to monetize the benefits. Lastly, the *status quo* would be popular with those resistant to change or who don't think that we should address climate change issues. However, this does not address the issue of positive externality for carbon sequestration, nor does it adequately mitigate our carbon footprint as a state. Voters who support efforts to reduce climate change would likely be unhappy with the status quo. Most Hawaii citizens believe that climate change will harm the country, over 70 percent believe that CO<sub>2</sub> emissions should be regulated, and over 40 percent of citizens believe that climate change is not just an issue that needs to be addressed but one that will harm them personally, indicating that the status quo is likely inadequate for most voters in this state [54].

We predict that PES would be the most politically feasible option, followed by a cost-share subsidy and the *status quo* due to its potentially low cost to government while still addressing the issue of climate change. A subsidy that covers the full cost of BMPs would presumably be the least politically feasible due to its likelihood to require the highest tax increase and the lowest investment of farmers who would take part. A summary of these comparisons may be found in Table 4.

**Table 4 - Qualitative summary matrix for incentives**

<i>Policy alternatives</i>	<b>Economic efficiency</b>	<b>Cost Effectiveness</b>	<b>Consistency</b>	<b>Equity</b>	<b>Political Feasibility</b>
Partial subsidization of the incremental costs of climate-smart BMPs (i.e. Cost-share through matching grants that cover 75% of the implementation costs) combined with education, demonstration, and technical assistance	As it internalizes the impact of positive externalities, it leads to economically efficient level of output. Generates socially optimal level of carbon sequestration. Tends to minimize the inefficiencies created by asymmetric information and moral hazard.	Since the producer is responsible to fund part of the costs, it has the potential of increasing his/her commitment to implement the practices and reducing the demand for state funds. Multi-year contracts create incentives for the continuity of practices in time. Allows the producer to match funds with expenses or in-kind sources.	Similar structure to current agricultural funding, limiting the resources provided with public funds.	Positive impact, can help poorer farmers and/or new farmers that don't have sufficient experience in farming	Popular instrument that could be easily implemented, if funds are available. Burden of state funds may be obtained if goals of federal grants are aligned with carbon sequestration goals (e.g., California and New York partnership with EQIP-USDA)
<i>Full subsidization (i.e. incentive payments that cover the full cost of implementation with 100% of the funding through grants) combined with education, demonstration, and technical assistance</i>	Full funding also leads to increase in producer surplus. Thus, consistent with economic efficiency.  Full funding come from tax revenue. Taxes leads to decrease in social welfare of households who are in high income category. Thus, impact of economic efficiency is not clear	Costlier for the public agency since all funds are provided by it. May provide less incentive for farmers to comply since all risk is taken by the government.	Increases the participation of the government, while demanding active monitoring from the government.	Can help poorer farmers and/or new farmers that don't have sufficient experience in farming  Prioritized for farmers that have higher level of vulnerability (older, new farmer, women, etc).	Require higher funds and may face more resistance from voters and policymakers. May attract more farmers, but requires effective monitoring of outcomes, increasing costs for the state.

**Table 4 - Qualitative summary matrix for incentives (cont.)**

<i>Policy alternatives</i>	<i>Economic efficiency</i>	<i>Cost Effectiveness</i>	<i>Consistency</i>	<i>Equity</i>	<i>Political Feasibility</i>
<i>Payment for Ecosystem Services</i>	Increase producer surplus & thereby increases economic efficiency  If the financial resources come through taxes impact of efficiency is not clear	- Requires the estimation of the value of the ecosystem services obtained per dollar spent (eg. increase in belowground carbon pools). If payment of funds made as advancement, the incentives for farmers might be higher, but also the risks for funding agency.	Greatest difference from current agricultural policies. Demands higher funds, the development of norms and regulations, and effective monitoring.	Positive impact as long as policy makers have taken into consideration the possibility of having a free-rider in the scheme  No short-term benefit  Negative impact, can exclude landless residents	Higher complexity and demand for funds. Requires clear valuation of ecosystem services (e.g. net change of belowground carbon sequestration in agricultural lands), definition of institutions, and higher funding. Demand for more resources may be addressed through public-private partnership.
<i>Status Quo</i>	Economically not efficient because of positive production externality.	Requires an assessment of the current practices to identify the status quo mapping the current practices and the impact in terms of carbon sequestration.	No direct change, there might be some positive impacts in future if 2020 local food productions goal is achieved through producers using more sustainable practices. No clear path on natural solution to increase carbon sequestration in agriculture.	Have a positive impact on the land but no clear benefit on the farmers or even the distribution of benefits.	Popular with those resistant to change or who don't think that we should address climate change issues. Not favorable to voters who would like to see climate change actively addressed by our state government.

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## FUNDING OPTIONS

We chose funding policy instruments based on the background information gathered (Table 5). The carbon tax is widely recommended by economists to address climate change. It is regarded as a tax that is equal to the externality costs of emitting carbon and therefore the most efficient way to address this problem. While the problem of sequestration is one of positive externality, the revenue from regulating the negative externality of carbon emissions may be useful to promote carbon sequestration as well. While a revenue-neutral carbon tax--one in which revenue is returned equally to all citizens as to not disproportionately hurt the poor--is often considered to be the most effective and equitable approach to addressing climate change as whole, it does not provide revenue that could be used to promote sequestration [55]. We considered an increased transient accommodations tax based on the disproportionately high carbon emission of tourists in Hawaii, which is over four times the emissions of residents [56]. We also considered an increased barrel tax based on ideas mentioned in our first meeting with clients, and on its power to reduce emissions. Jayme Barton introduced us to the idea of voluntary offsets as another option for funding. These offsets may not produce as much revenue, but they provide a way for concerned citizens to voluntarily offset their personal carbon consumption and emission. The status quo includes the current (negligible) funding available to incentivize BMPs.

Table 5 - Qualitative comparison of funding sources

Funding source	Pros	Cons
<i>Carbon Tax (carbon pricing)</i>	<ul style="list-style-type: none"> <li>- Popular with climate economists as it addresses the problem from an economic efficiency lens (i.e., addressing the negative externality market failure)</li> <li>- May provide non-monetary benefit in reducing emissions</li> <li>- Source government revenue for sequestration efforts which can be used for other state priorities (e.g., auction revenues)</li> <li>- New source of revenue may lead to lower income taxes, increasing resources for low-income residents in periods of negative or low economy growth [56].</li> </ul>	<ul style="list-style-type: none"> <li>- Politically challenging to implement (introduction a new and unfamiliar tax)</li> <li>- Harder to apply in a service-based economy as it is the case in Hawaii</li> <li>- Difficult to implement and monitor (requires putting a dollar sign on carbon emissions and adequately measuring them)</li> <li>- Revenue generating carbon tax may be inequitable (Higher impact in small business and low-income population vs corporations and high-income population; e.g., solar panels and savings in electric energy are more accessible to wealthier residents.)</li> <li>- May increase burden on vulnerable populations located closer to areas of high emission (e.g., may not provide enough incentives for companies to reduce their emissions)</li> </ul>
<i>Voluntary offsets</i>	<ul style="list-style-type: none"> <li>- Politically feasible</li> <li>- Allows conscientious citizens to offset their carbon footprint out of goodwill</li> <li>- Increased funding relative to status quo</li> <li>- May include social and/or environmental benefits</li> </ul>	<ul style="list-style-type: none"> <li>- Uncertainty regarding volume of funds</li> <li>- Potentially lower amount of funds compared to other options</li> <li>- May require high investment in promotion and communication</li> </ul>
<i>Transient accommodations tax increase</i>	<ul style="list-style-type: none"> <li>- Addresses for the disproportionately high carbon emissions of tourists (more than 4 times that of residents per person in 1997) [55]</li> <li>- Politically more feasible with average resident than taxes on residents</li> <li>- Ever increasing numbers of tourists harm environment in general and tax natural resources, this addresses larger environmental issues as well</li> </ul>	<ul style="list-style-type: none"> <li>- Foreseeable push back from tourism industry</li> <li>- Tax increases are generally unpopular</li> <li>- Tax is already in place, may be at a natural maximum</li> </ul>

Table 5: Qualitative comparison of funding sources (cont.)

<i>Funding source</i>	<i>Pros</i>	<i>Cons</i>
<i>Barrel tax increase</i>	<ul style="list-style-type: none"> <li>-Addresses emissions from transportation sector, and 92% of Hawaii's CO2 emissions are from petroleum [46]</li> <li>- helps new farmers to secure debt and equity funding</li> </ul>	<ul style="list-style-type: none"> <li>-Foreseeable push back from transportation industry</li> <li>-Affects everyone on island</li> <li>-Tax increases are generally unpopular</li> <li>-Tax is already in place, may be at a natural maximum</li> <li>-Money needs to be secure in its destination of sequestration, past issues with dipping into funds for other projects</li> </ul>
<i>Public-private partnership</i>	<ul style="list-style-type: none"> <li>- The allocation of different risks to parties most suited to manage them, resulting in reduced costs over project life-cycles;</li> <li>- Empower local organizations to be more efficient in implementing BMPs</li> <li>- Can be implemented at different scales from individual projects to financial fund level.</li> </ul>	<ul style="list-style-type: none"> <li>- contract design can be problematic</li> <li>- unrealistic expectations</li> <li>- potential mistrust between public and private sector</li> <li>- lack of availability and reliability about the private sector service providers and the quality they offer</li> <li>- lack of management capacity of the public sector</li> </ul>
<i>Status Quo</i>	<ul style="list-style-type: none"> <li>-No tax increases</li> <li>-No immediate burden on public</li> </ul>	<ul style="list-style-type: none"> <li>-Does not provide funding for sequestration efforts</li> <li>-Fails to meet goals for climate change mitigation</li> <li>-Even citizens who would like to voluntarily participate in a carbon market or offset program have few options</li> </ul>

## V. RECOMMENDATIONS

Based on the above analysis, we recommend cost share through matching grants that cover 75% of the implementation costs. However, there are trade-offs. Partial funding will not create enough incentives as full funding if farmers do not perceive any benefits from the adoption of BMPs. Suppose that, for both full and partial funding, the producer has the same goal (e.g., implement a no-till practice in 100% of the cultivated area). The main differences are that (1) the government can spend less per farmer with cost-share, but (2) farmers may have less incentive than with full-funding if the private benefits exceed the percent of net costs that have to be paid by the producer. The advantage of partial funding is that the producer has to commit to the remaining cost, which may be in-kind (e.g., labor), which should contribute to increase the farmer's commitment and minimize opportunistic behavior. Many states, including California and New York, partner with EQIP-USDA to promote the adoption of BMPs to increase carbon sequestration.

In terms of economic efficiency, PES has more potential to create incentive to achieve carbon sequestration goals in agriculture. It increases the producer's income and profit. PES also addresses the equity problem better than the other two policy options and the *status quo*. However, this program demands the definition of new institutions and comes with a high administrative and monitoring costs. This implies that if the state would pursue this option, it should allocate a higher amount of budget for the administration of the program and payment of full cost-offsets and premium for producers. We perceive that a PES program can be an option only if the state has available funds for a long-term investment. This could be an adequate opportunity for a public-private partnership.

## VI. CONCLUSION

Pursuant to the request from GHG Task Force, this report provides policy analysis and recommendations to adapt climate smart agricultural practices to increase the below ground carbon sequestration stock. In doing so, based on welfare economics theory, we framed carbon sequestration in Hawaii agriculture as a positive externality, which is not captured by free market mechanism. As a result, a decision to not adapt climate smart agricultural practices creates a net social welfare loss to the society. In other words, a decision to not adapt climate smart agricultural practices or to maintain the status quo creates substantial costs to society. Based on this observation, we modeled the problem to make behavioral changes in farming practices to achieve a socially optimal level of carbon sequestration. Our analysis shows that agriculture is generally not a profitable economic activity in the US, including Hawaii. The high adaptation cost of climate smart agricultural practices serves as the main barrier to adaptation. Since the adaptation

of climate smart agriculture is associated with market failure (i.e., positive externality), we assume that there should be government intervention to the agricultural sector operations through a number of incentive programs, such as full subsidization, partial subsidization of BMP, and PES. All policies should be combined with education and technical assistance. These incentive programs are considered as policy alternatives and are evaluated against five criteria: economic efficiency, cost effectiveness, social equity, policy consistency, and political feasibility. Considering the qualitative nature of our analysis, it is difficult to select the best alternative against the status quo. Although the full funding option may be more attractive to farmers, it may lead to funding problems. PES may require a high level of monitoring and administration costs. Therefore, it is wiser to consider each policy options as complementary measures rather than substitutes in achieving socially optimal level of carbon sequestration. For future work, we recommend conducting a complete quantitative economic benefits/costs analysis to select the best alternative against the status quo.

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## APPENDIX A -- DETAILED VERSION OF PROBLEM MODELLING

*Note:* For the sake of simplicity, this report excluded the following section, but the information is valuable regardless to better understand the problem framing.

### CLIMATE-SMART AGRICULTURAL PRACTICES - A CASE OF POSITIVE PRODUCTION EXTERNALITY (MODELLING THE PROBLEM)

As previously explained, this problem was framed as a positive production externality. Due to the positive externality, the resources are underutilized. A modelling of this problem indicates that the internalization of positive externalities leads to an efficient utilization of scarce resources in the economy. Thus, a policy analyst should select policy variables, that lead to increase the efficiency of resource utilization. In this case, an increase in efficiency of resource allocation implies to raise the level of production up to the point  $Q^*$ . One way to increase the level of production is to give direct subsidies to the farm households. Since our policy problem is related with positive externality, appropriately designed per unit subsidy to the producer increased supply of a commodity. This reduces the undersupply caused by externality and thereby increasing the level of carbon sequestration towards the socially optimal level.

As we mentioned previously, subsidy provides incentives for farm households to follow climate smart agricultural practices which eventually lead to increase the level of carbon sequestration in agricultural sector. However, only the state of Hawaii may not be able to provide such subsidies for farmers because of the lack of financial resources. Hence, one appropriate option may be matching grant. The Federal Government may provide matching grant to induce local government to promote climate smart agricultural practices among farmers. In this case, the Federal government match each dollar that the state of Hawaii spent on promoting climate smart agricultural practices. We refer this approach as a matching grant because it matches local expenditure as some fixed percentage. Matching grant can be shown as a strategy that using subsidies alter incentives among farm households to promote climate smart agricultural practices.

Payment for ecosystem services is other form of subsidy that can be used to promote climate smart agricultural practices among farmers. Using this strategy, the state of Hawaii can provide incentives for farmers to adapt climate smart agricultural practices. Ecosystem services are payments to farmers or landowners who make agreement with the state of Hawaii to adapt climate smart agricultural practices. Payments for ecosystem services is consistent with “beneficiary pay principles” which means compensate individuals whose land use create ecosystem services to generate social benefits. In this case, adopting

climate smart agricultural lead to increase carbon sequestration and thereby creates social benefits to the society.

Due to the market failure (i.e. positive externalities), price mechanism does not allocate scarce resources in efficient way. Such a production decision leads to an inefficiency in resource allocation and creates a social welfare loss to the society (deadweight loss) represented by abc triangle in Figure 2. This is also known as a potential welfare gain if a farm household follows climate smart agricultural practices. A profit maximizing farm household, who adapts climate smart agricultural practices faces marginal private cost curve ( $MPC_{CSA}$ ) and marginal private benefit curve (MPB). Thus, the equilibrium crop production is at Q1 because private farm household does not consider the positive externalities created by climate smart agricultural practices. At the production level Q2, a farm household adapts conventional agricultural practices and faces marginal private cost curve ( $MPC_{CA}$ ) and marginal private benefit curve (MPB). Q2 is an equilibrium level of production when a farm household follows conventional agricultural practices. Under the conventional agricultural practices, a farm household does not consider the social benefits of climate smart agriculture and therefore, produces the level of production, which determine the carbon sequestration below the socially optimal level. When a farm household considers the positive externalities of climate smart agricultural practices, he/she faces marginal social cost curve ( $MSC_{CSA}$ ) and marginal private benefit curve (MPB). Then, the socially optimal level of production is  $Q^*$  where marginal private benefits (MPB) is equal to the marginal social cost ( $MSC_{CSA}$ ). At this level of production, there is a social welfare gain to the society which is equal to the area of triangle abc. The objective of a policy analyst is to propose solutions promoting the dissemination and adoption of climate-smart agricultural practices that increases the level of carbon sequestration, which maximizes social welfare of farm households. In other words, a policy analyst should select policy instruments that are able to reduce the marginal private costs of individual farmers and ranchers [10]. In the next section, we will construct a behavioral model that lead policy analyst to select policy instrument which maximize the social welfare.

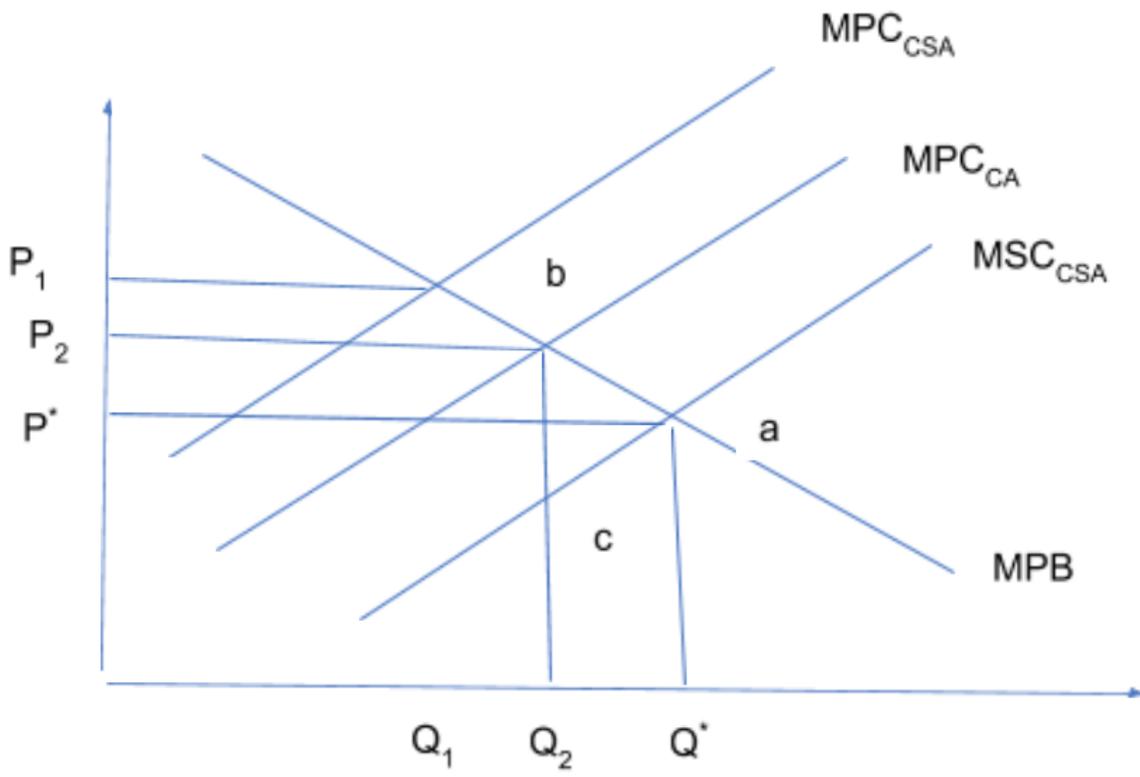


Figure 2 - Climate Smart Agriculture, Positive Externalities, & Social Welfare Loss