LONG-RANGE PLAN FOR AMERICAN SAMOA

Strategies for Natural Resource Conservation and Agricultural Resilience

Developed for:

USDA NRCS
American Samoa
Service Center

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Natural Resources Conservation Service

Developed by:

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Section 1. Introduction & Summary of Recommendations

Overarching Vision of Success

American Samoa is a unique Pacific island home to rich cultural traditions and remarkable natural beauty. Local food and water security is currently an issue facing many islands including American Samoa. Natural resource concerns that impact ecosystem health, abundant local food production and a strong agricultural economy must be addressed to ensure long-lasting resilience and elevated quality of life for American Samoans. Resilience can be achieved by both aligning NRCS and other funding mechanisms with local priority needs, and supporting grassroots collaborative efforts among local experts, farmers, students, entrepreneurs and cultural champions. Using this top-down and bottom-up approach, American Samoa can achieve 85% food security by 2035. Further, by actively engaging youth and community members in this process, future generations will be well positioned to become passionate stewards of American Samoan culture and environmental health.

Purpose(s) of the Long-Range Plan

This Long-Range Plan is intended to help guide effective allocation of the next five years (2022-2027) of NRCS funding to address priority natural resource concerns facing farmers and ranchers in American Samoa. This plan includes recommendations and input from local natural resource and agriculture experts, as well as farmers, to ensure community needs are met through NRCS programs and funding. Where NRCS programs are not applicable, other funding sources or avenues to success are recommended. The Long-Range Plan is a living document that will be updated throughout the process to reflect progress, report milestones and realign program or funding.

Summary of Recommendations

Several strategies are outlined in *Section 4. Targeted Conservation Plans and Investment Portfolios,* some of which are repeated multiple times in various categories (e.g. conservation practices on farms are cited to support Healthy Production Systems, Water Quality, and Habitat Conservation). The following list of recommendations is a prioritized summary of the immediate needs as determined by the stakeholder interview and research process. It is recommended that NRCS and partners focus funding on these strategies in the short-term to facilitate long-term goals of conservation and food security.

1. **Phase out piggery pollution by piloting community-scale Deep Litter Piggery Systems.** Piggeries currently represent one of the largest sources of water pollution in the territory. Dry litter retrofits have been attempted in American Samoa with limited success. Deep Litter Piggery Systems layer several feet of microbally inoculated organic

material to naturally break down and incorporate liquid and solid pig waste. These systems have been used in Hawai'i with promising results, requiring minimal maintenance while improving pig health and eliminating downstream pollution impacts. The efficacy of this system to reduce water pollution impacts could be amplified by creating fewer, larger piggeries which can be used by many members of nearby villages; currently piggeries are decentralized and difficult to enforce. The centralization of piggery infrastructure would result in fewer regulatory or enforcement costs by AS-EPA or similar agencies, and would simplify education and maintenance requirements. It is recommended that one or more pilots of a Deep Litter Piggery System are tested in American Samoa. The projected cost for each of these systems is $50,000-$75,000, which may include operating costs for 1-2 years. NRCS, Ridge to Reefs, and other agencies such as the Department of Agriculture could collaborate to attain funding, engineer the system(s), install, monitor, and train locals to maintain the system. (Note: subsequent recommendations for organic waste processing facilities support this recommendation for DLPS pilots, as the materials created (e.g. wood chips, shredded coconut husks) will be necessary for the proper maintenance and overall sustainability of Deep Litter Piggeries).

2. **Increase NRCS capacity to facilitate Conservation Technical Assistance on farms.** Additional participation in the EQIP/CSP programs is a high priority for natural resource conservation on farms. In order to meet an increased demand for conservation technical assistance, NRCS must have sufficient personnel to create Conservation/Soil Health Plans, help with implementation of BMPs, direct farmers to relevant programs, and other pertinent tasks. NRCS is hiring a new Conservation Technician with NRCS PIA Strategic Partnership funding in early 2022. NRCS may also need to train more local TSPs to aid in implementation of conservation practices. NRCS should identify these needs and develop a strategy to scale up capacity for sustainable growth. TSP training could provide residents with well paying jobs, and/or internships could be created for community college students to become trained in conservation planning and implementation.
3. **Revitalize the Soil and Water Conservation District and collaborate with other agencies/organizations for higher impact.** When operating, the SWCD serves as a galvanizing entity for all local agencies working on natural resource conservation and agriculture. The District has not been regularly meeting for several years, resulting in a lack of coordination by local agencies to maintain steady progress toward shared goals. The SWCD should be revitalized and personnel hired to coordinate meetings, keep meeting minutes, send relevant materials to board members via email, and other managerial duties pertinent to the SWCD's effective operation. NRCS will be involved in the SWCD, and can therefore use this platform to discuss the Long-Range Plan and how it ties into other agency goals, to inform board members about current initiatives, and foster collaboration. Even without the SWCD operating, NRCS should continue to collaborate with local agencies to achieve natural resource conservation and food security

goals. Nonprofit partnership can also expand NRCS' capacity for attaining funding and working on innovative projects.

4. **Increase economic opportunities for farmers by creating food hubs and farmers markets, and encouraging produce sales to restaurants.** While NRCS' role is more directly tailored to natural resource conservation, the creation of food hubs for the proper processing of produce for sale to consumers, as well as farmers markets and a campaign to promote increased sales to local restaurants, would increase demand for local produce. There are several USDA grant opportunities tailored to the creation of these community commodities which could be leveraged with collaborative support from other agencies or organizations. Further, the creation of a certification program which would award farmers a certificate based on a specified commitment to natural resource conservation and/or organic farming could be leveraged in the sales space to raise awareness to consumers and increase demand for local, intentionally grown food. The certification could be as simple as a review by NRCS staff and a label/certificate to display on produce or on tables at farmers markets.
5. **Collaborate with partners to create/offer technical guidance for natural integrated pest management.** Many local stakeholders raised concerns about pesticide use on farms and its impact on food and water quality. This project could take the form of the creation of a comprehensive field guide outlining effective alternative or natural treatments for American Samoa produce and pests, which is then distributed to farmers and accompanied with workshops. The guide could be offered in English as well as the native Samoan language, and in other languages spoken by immigrant farm workers. Possible collaborators include the Department of Agriculture, American Samoa Community College, University of Hawai'i, or nonprofit organizations. Videos could also be a useful way to display this information.
6. **Support the establishment of local systems that upcycle waste streams into high quality agricultural soil amendments or fertilizers.** While this strategy may be more appropriately led by entrepreneurs, a local nonprofit and/or American Samoa Power Authority, it has many implications for natural resource conservation that contribute to NRCS' goals. For instance, the development of a suite of locally produced soil amendments and agricultural products from local waste streams could reduce farmers' costs, making agriculture more viable for residents, while reducing environmental impacts and improving soil health. Fish hydrolysate could be made using the abundant waste source of fish meal from the tuna cannery, while compost could be easily created at a large scale from organic waste, and deep litter piggeries would also produce a large amount of nutrient dense soil amendments. The processes to make these products could be done on a farm-by-farm scale, industrial scale (e.g. at ASPA's landfill), or both.

Partners and Acknowledgements

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Section 2. Natural Resources Inventory

2.1 Overview

2.1.1 Climate

American Samoa is considered a maritime climate with frequent winds, high rainfall and warm, humid air averaging at 82°F. It is located roughly 953 miles south of the equator. The steep slopes of Tutuila and the Manu'a Islands result in both convective and orographic rainfall, therefore these islands experience more precipitation than the low islands of Swains Island and Rose Atoll. Average rainfall in Tutuila ranges from as high as 300 inches (762 cm) to 120 inches (304 cm), with the capital of Pago Pago receiving 200 inches per year on average. The rainy season extends from October through May, while the drier season is typically between June and September, though the amount of rainfall can vary significantly each year. American Samoa receives rain from the South Pacific Convergence Zone, a band of rain caused by convergence between equatorial and southern hemisphere winds. The climate is impacted by trade winds blowing southeast for most of the year, though monsoon winds blowing from the west are also possible depending on weather conditions, particularly during the rainy season. Extreme weather events common in American Samoa are droughts and tropical cyclones. Droughts often occur during the dry season following an El Niño year, and can reduce seasonal rainfall by over 50%. Tropical cyclones typically occur between November and April. They bring strong winds and heavy rainfall that can cause damage to property, infrastructure and ecosystems. More cyclones tend to occur during moderate or weak El Niño years.

2.1.2 Social Data and Economic Status

American Samoa is a United States territory located in the middle of the Pacific Ocean roughly 2,500 miles Southwest of Hawai'i. The total land area in American Samoa is 76 mi2. Tutuila is the largest island at 54.94 mi2. According to the 2020 Census, American Samoa has a total population of 55,519. Only 1,143 people live on Manu'a and 17 on Swains Island, while 23,030 live in the Eastern District and 31,329 in the Western District of Tutuila. The population has decreased in recent years, most notably from 70,100 in 2009 to 60,300 in 2017 after a devastating tsunami and closure of a cannery which supplied at least 2,000 full-time jobs. The island territory's economy is largely dependent on United States government funding and the Starkist tuna cannery in Pago Pago. The island was flooded with United States defense funds during World War II; afterwards a plunge in government funding resulted in drastic economic downturn. In the early 1960's funds were again invested into the island, boosting the local economy and building critical infrastructure, however the island has remained largely dependent on federal assistance and subject to "an unprecedented level of regulatory oversight" as a result (Department of Commerce, 2018).

In 2017 there were 17,218 workers and a 14.3% unemployment rate compared to a national average rate of 4.1%. GDP has fallen from 2009 to 2017 by $80 million, while consumer prices have increased beyond the rate of employment and wage increases, resulting in a challenging economic situation. The prevalence of natural disasters further exacerbates economic instability and dependency on federal relief funds. For instance, in 2018 Cyclone Gita struck the territory resulting in $462 million in damages, while $60 million was invested in rebuilding economic and social infrastructure. Ultimately, the economy of American Samoa is subject to unstable fluctuations of economic activity based on external factors such as company investments, natural disasters, and other events that trigger changes in federal funds. The possible departure of the last remaining cannery (Starkist) is of economic concern to many business leaders. While metrics for small businesses are not as widely available for this territory, interviews made in 2018 suggest that 75% of small business owners felt confident in investing and developing their businesses. These surveys also point to a wide variation in popular opinions on economic improvements, though 52.7% saw the economy improving over the next five years (Fig. X).

A SWOT analysis made by the American Samoa Comprehensive Economic Development Strategy workgroup suggests that Agribusiness and related industries such as Aquaculture and Ecotourism are potential opportunities for economic growth, though other sectors including Information Technology and Capital Investment Projects were more highly rated. Threats identified include the departure of the Bank of Hawai'i, Political Administration Transitions, Budgetary Constraints, the departure of the Starkist cannery, and the increased prevalence of a drug epidemic.

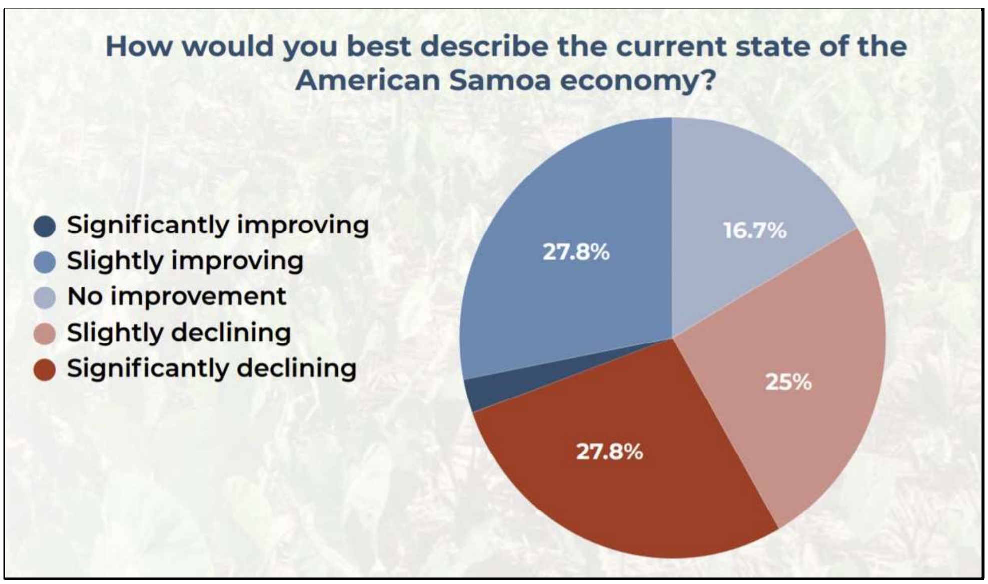


Fig. 1A - Survey results of American Samoa business, government and community leader opinions on economic improvement (Department of Commerce, 2018).

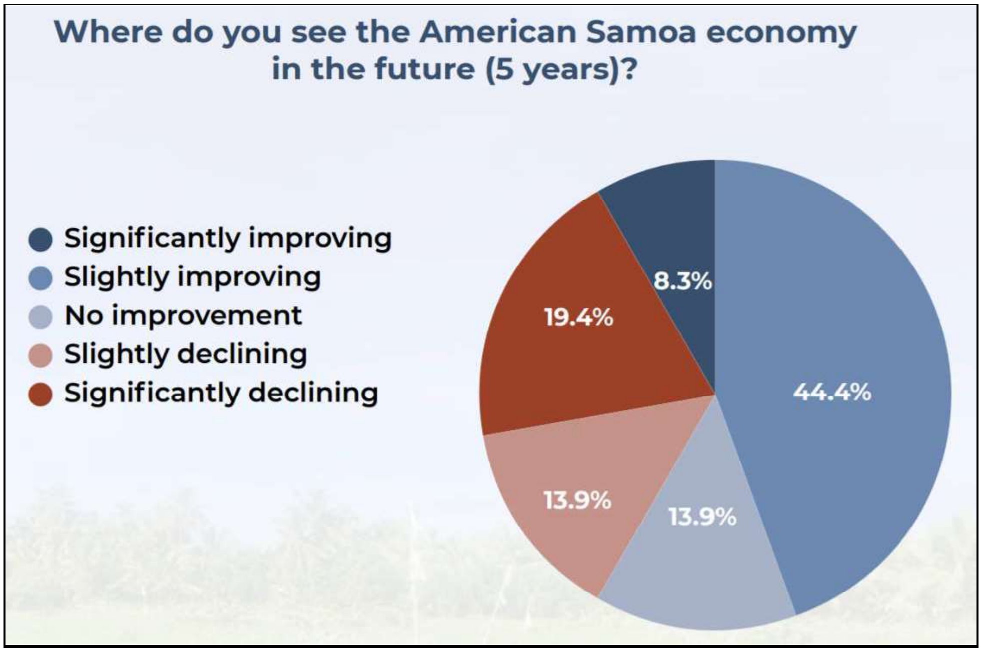


Fig. 1B - Survey results of American Samoa business, government and community leader opinions on economic improvement (Department of Commerce, 2018).

It is clear that American Samoa requires a more resilient, stable business environment for local residents to thrive. While many sectors may be involved in this shift, agriculture is unique in that it provides a service unparalleled by other industries save perhaps water infrastructure. Food access in general, and healthy food in particular, is vital to supporting thriving communities. While agribusiness is not currently considered a prosperous career path in American Samoa, largely due to lingering impacts of long-term foreign dependency on imported goods and services, local proponents of a more resilient agriculture model argue that transformation is possible. Agriculture represents just one sector in the territory's economy, however there are many factors other than economic growth that determine resilience and abundance. That said, agriculture can serve as an economically viable sector that not only physically nourishes the public, but promotes deeper fulfillment through environmental activism and enhanced awareness of traditional cultural practices. Ultimately, a resilient agricultural system could provide a solid base for generating a local economy that is far less vulnerable to external shocks.

2.2 Agriculture

2.2.1 Farm Statistics

According to the 2018 NASS Ag Census, there are roughly 6,329 farms in American Samoa accounting for 14,404 acres of farmland, which represents 30% of all land across the islands. Commercial farms only account for 23% of all farms, whereas the remaining farms are used primarily for subsistence. There was a 24% decrease in farmland between 2008 and 2018 despite an increase (+489) in total number of farms reported. During this time the average farm size decreased by 30% (from 3.3 to 2.3 acres), the number of commercial farms decreased by 483 to

1,485, and the number of non-commercial farms increased by 972 to 4,844. As of 2018, 2,232 farms are less than one acre in size, and roughly 80% of all farms in American Samoa are less than two acres in size. The majority of farm ownership is communal (5,131 farms and 9,570 acres) while 1,184 farms representing 4,615 acres are on non-communal land. Only a small percentage (1.1%) of farms are located on rented land.

Taro is the most abundant crop cultivated, followed by bananas, breadfruit, coconuts, giant taro, papayas, and laupele (edible hibiscus) (Table X). In 2018, fruits and nuts represented the top commodity group with $20.5 million in farm household consumption and sales. Field crops, melons and vegetables also represented a large portion of commodities at $18.3 million in consumption and sales. Other commodities include fish and giant clams ($2.5m), livestock and poultry ($1.6m), and nursery products ($1.1m). Seventy-two percent of farmers were male and 28% were female, with 54% aged 45-64, 25% less than 45, and 21% greater than 65 years old. There is also a considerable population of immigrant farm workers from Asian countries.

2.2.2 Agriculture Sales and Expenditures

In 2018, $24.9m of products were produced and consumed by 4,844 noncommercial farms, while commercial farms sold $11.1m in crops and consumed $8.3m. According to the 2018 NASS Ag Census, investments in Paid Labor ($802,941 annual) were comparable to Insecticides, Fungicides, and Herbicides Purchased ($802,758). The total number of farms purchasing insect/fung/herbicides was 1,945 compared to 307 farms providing paid labor to employees. Fertilizers and manure were purchased by 765 farms for $460,579 total annual spending, and feed purchased for livestock, poultry and fish amounted to $499,667 for 349 total farms.

Table 1. Top Commodities by Number of Farms, 2018 (adapted from American Samoa Agriculture 2018 Census of Agriculture).

Crop	# of Farms
Taro	5,726
Bananas (Other)	5,500
Breadfruit	5,189
Coconuts	4,613
Bananas (Fai Palagi)	4,590
Giant Taro	4,176
Papayas	4,011
Laupele	3,344

2.2.3 Piggeries

Piggeries are a staple in all villages of American Samoa. The 2018 Agricultural Census reports 825 total pig farm operations in American Samoa totalling 22,761 head. This is a marked decrease from previous reports of 35,000 pigs in 1999, potentially due to increased enforcement by EPA or perhaps a lack of reports by residents. Pigs are sold and consumed for cultural purposes in American Samoa, and therefore are not subject to as stringent of husbandry or public health guidelines as more regulated piggeries in other parts of the United States, for instance. Piggeries typically house 10 to 50 pigs each, and the pens generally consist of an open-sided building with a concrete slab or earthen floor. Wastes are hosed off the side of the pen onto the earth or into a cesspool. Pollution from untreated pig waste is a major public health issue in American Samoa; for more information on water impacts, see section *2.4.3 Piggery Impacts on Water Quality*. Previous programs under the EPA have attempted to convert select piggeries to dry litter systems with limited success due to a variety of factors. First, there are very few woodchippers on island to produce the proper bedding material. Second, dry litter systems require proper management protocols which were unlikely to have been followed by operators, especially since woodchip resources were lacking. Many of these systems reverted to washdown protocols either out of necessity or negligence.

2.2.4 Agricultural Pests

The American Samoa Department of Agriculture is responsible for the ordering of pesticides for both household and agriculture use, and is also the agency responsible for regulating excessive pesticide use or smuggling illegal products into the territory. DOA has several protocols in place to prevent the use of illegal or unnecessarily harmful pesticides on farmland. This includes a partnership with Customs and Border Control to confiscate pesticide imports. Asian farmers have often been caught smuggling in illegal pesticides. In recent years, farmers have attempted to skirt these regulations by repackaging products before shipping, however DOA and Customs have remained successful at identifying and intercepting these threats. The following table outlines some of the most common pests and current treatment methods according to the American Samoa Department of Agriculture.

Table 2. Common Plant Pests in American Samoa and Treatment Methods

Crop	Pest	Description	Treatment
Banana	Black Leaf Streak (*Mycosphaerella fijiensis*), aka Black Sigatoka	Necrosis of leaves inhibiting photosynthesis and reduction of bunch weight; causes premature ripening; known to	Current Treatment: A few farms are still using the fungicide Abound in large quantities for control

		develop resistance to fungicides; thrives in moist environments	Other Treatment Methods[1]: ● Regular disease assessments of leaves at various stages of development ● Plant bananas in areas with good drainage; plant for proper air flow through canopy ● De-trashing, i.e. removing severely impacted leaves can be as effective as fungicides ● De-sucker or prune the plant ● Provide proper plant nutrition so crop "outgrows" disease ● If using chemicals, rotate to avoid resistance
Banana	Scab Moth (*Nacoleia octasema*)	Small (25 mm) tan to light brown moth with small black spots on wings lays eggs near bunches. Larvae feed on fruit causing varying degrees of scarring either rendering fruit unmarketable or inedible at worst. Also prevalent on Heliconia spp. and Pandanus spp.	Current Treatment: Control with either Sevin (general insecticide) or Dipel (bioinsecticide) Other Treatment Methods[2]: ● Spiders or ants may predate on larvae but control is often insufficient ● Parasitic wasps, particularly *Chelonus spp.* may provide biocontrol ● Inject insecticide into the flower after first becoming visible
Breadfruit	Breadfruit fly (*Bactrocera umbrosa*)	Medium sized fly with red-brown bands and yellow thorax, T-shaped mark on abdomen. Adult lays eggs in fruit, causing premature ripening and	Current Treatment: no treatment Other Treatment Methods[3]: ● Sanitation, i.e. removing fallen fruits from the ground to prevent breeding and

[1] College of Tropical Agriculture and Human Resources Cooperative Extensive Service. University of Hawai'i at Mānoa. Black Leaf Streak of Banana. Plant Disease. Sep 2008. https://www.ctahr.hawaii.edu/oc/freepubs/pdf/pd-50.pdf
[2] American Samoa Community College. Community & Natural Resources. Cooperative Research & Extension 2005. Banana Scab Moth. Pests and Diseases of American Samoa Number 6. https://www.ctahr.hawaii.edu/adap/ASCC_LandGrant/Dr_Brooks/BrochureNo6.pdf
[3] Food and Agriculture Organization of the United Nations. (2019). Fruit fly management in Palau - Advisory leaflet. http://www.fao.org/3/ca7106en/CA7106EN.pdf

		dropping	either burying or placing in trash bags to sit in sunlight for several days ● Protein bait spray from brewery yeast waste mixed with insecticide ● Fruit fly bait traps, at least five per acre ● Bag healthy fruits on tree (can be time consuming)
Beans, Cucumbers	Aphids (*Aphis spp.)*	Small insects (1-5 mm) that suck plant sap and inject toxins, stunting growth and causing leaves to curl. Can be vectors for other plant diseases including viruses. Multiply quickly but move slowly, resulting in localized infestations.	Current Treatment: Sevin or Bug B Gone insecticide. Other Treatment Methods[4]: ● Biocontrol by beetles, flies, lacewings, parasitic wasps; plant edge-of-field habitat that attracts biocontrol species ● Monitor plants for infestation and apply insecticide if necessary to minimize spread ● Caterpillar stomach poisons ● Rinse off of leaves with hose (may not apply to American Samoa agriculture where irrigation is negligible)
Beans	Leaf Miner (*Liriomyza spp.*)	Yellow and black flies with 1.25-2.25 mm wing length, depending on the species. Larvae are deposited in leaves and "mine" them, i.e. remove mesophyll and feed on leaf exudates.	Current Treatment: Grow resistant varieties. Other Treatment Methods[5]: ● Parasitoid biocontrol (can be disrupted with insecticide application) ● Foliar application of insecticides, however many are not effective and leaf miner infections have been shown to follow chemical applications for other insects

[4] University of California Agriculture and Natural Resources. Statewide Integrated Pest Management Program. Agriculture: Dry Beans Pest Management Guidelines. Aphids. https://www2.ipm.ucanr.edu/agriculture/dry-beans/Aphids/

[5] University of Florida Entomology & Nematology. Featured Creatures: vegetable leafminer. https://entnemdept.ufl.edu/creatures/veg/leaf/vegetable_leafminer.htm

			● Proper weeding
Cucumbers	Powdery Mildew (e.g. *Erysiphe spp., Leveillula taurica, Oidium spp. Sphaerotheca spp.)*	Infection by various fungi producing a white powdery growth of leaf surfaces and other plant parts. Each species targets a specific host. Leaves may die and tissues become infected. Generally not fatal.	Current Treatment: Grow resistant cultivars. Other Treatment Methods[6]: ● Increase air movement with pruning and plant selection since some species of fungus prefer moist environments ● Prune plants and remove dead leaves ● Rotate fungicides or biofungicides
Green Pepper, Tomatoes	Broadleaf Mite (e.g. *Tetranychus spp., Oligonyhcus spp.)*	Often referred to as spider mites. Feed on plants and can cause unpalatable russeting in peppers or other crops.	Current Treatment: Kelthane or Oberon 2C. Other Treatment Methods[7]: ● Rinse off leaves with water ● Introduce beneficial predatory mites ● Chemical miticide

2.2.5 Hydroponics

Lima Ola is the name of a hydroponics group consisting of ten growers on Tutuila. The group has received funding to build greenhouses that grow particular crops that would be otherwise unavailable using traditional farming methods. The group is also outfitting a warehouse to create a food hub as well as a packing and distribution center for local farms to process and sell produce. The American Samoa Department of Agriculture is also providing hydroponics kits to residents. Hydroponics could potentially provide another strategy for food security and resilience.

2.3 Soil

2.3.1 Landscape Characteristics

Tutuila is a narrow mountain range 33,920 acres in size which is 20 miles long east to west, with width varying from 6 miles to just 0.75 miles at the cut-in of Pago Pago Harbor. The highest peak of Tutuila is 2,142 feet at Matafao Peak. There are 5,000 acres of porous plainland on the southwestern part of the island which is composed of lava and igneous volcanic rock. The next largest island Tau has steep cliff sides around most of its perimeter. Tau is about 6 miles long and

[6] University of California Agriculture & Natural Resources. Statewide Integrated Pest Management Program. UC Pest Management Guidelines. Powdery Mildew. http://ipm.ucanr.edu/PMG/r280101011.html
[7] Clemson Cooperative Extension. Home & Garden Information Center. (2017). Integrated Pest Management (I.P.M.) for Spider Mites. https://hgic.clemson.edu/factsheet/integrated-pest-management-i-p-m-for-spider-mites/

3 miles wide, totalling 11,328 acres in size. The twin Manu'a islands of Ofu and Olosega are 1,792 and 1,344 acres, respectively. These islands formed from a single volcano and today these islands are connected by a concrete bridge. Steep cliffs surround much of the islands which have their highest peaks at 1,621 ft on Ofu and 2,095 ft on Olosega. Aunuu, a 384 acre island formed from a volcanic rock cone and containing a marsh and a flat area of coral sand is 0.75 miles east of Tutuila.

2.3.2 Soil Survey

A soil survey was conducted for American Samoa by the USDA Soil Conservation Service in 1984. The survey concludes that the majority of soils in the mountain ranges of Tutuila (19,790 total acres) as well as Ofu and Olosega are Lithic Hapludolls, a rock outcrop type of the Fagasa family. These soils are clayey, deep and well-drained and comprise volcanic ash and residual from igneous rock. They occur on steep to vertical slopes and beneath tropical rainforest vegetation which is mainly preserved for natural habitat due to difficulty of access. The southwest part of Tutuila is composed of low uplands (Sogi-Iliili-Pavaiai soil units) with 0-40% slopes and well drained, loamy soils formed in volcanic ash and vary in depth above a tuff or lava flow layer. These areas are typically used for subsistence or commercial farming as well as residential and urban development. Leafu-Ngedebus soil types which are very deep, clayey and poorly drained (Leafu) or very deep, sandy and excessively drained (Ngedebus) occur along the coast of all islands at 0-5% slopes. Urban land, subsistence farming and residences are common throughout these areas with risks of flooding. In general, soils in American Samoa are rich and well suited for agriculture except on land with steep slopes or inundated with saltwater.

2.3.3 Agricultural Soils and Erosion

In general, arable lands are medium acid to neutral in pH with high organic matter as well as sufficient calcium for plant growth. The main factors affecting land use for crop production are slope steepness, rock content, saturation, and erosion hazards. Soil erosion becomes an issue on steep lands typically exceeding 50% slopes. Erosion can be mitigated by erosion control practices, many of which are included in NRCS' list of Conservation Practices commonly used on participating farms. Contour farming can greatly reduce the risk of erosion as well as utilizing cover crops in fallow periods. Swales and other features can divert water effectively for proper land management in areas with deep soils and moderate slopes. Dense forests are effective at stabilizing steep slopes. Though wood is used for building and other purposes, there is little evidence of large-scale clear-cutting and other devastating forest impacts that have occurred in many other locations around the world. Lands are typically communally owned by villages, therefore options for direct management are limited.

2.4 Water

2.4.1 Freshwater Resources

Water quality is a foremost concern facing American Samoa. Poor drinking water quality due to aging municipal infrastructure, as well as groundwater pollution from agricultural runoff, piggeries and failing wastewater disposal systems (e.g. cesspools) directly impacts human health. Tropical storms and heavy rains also jeopardize water distribution infrastructure and can result in contamination, therefore Boil Water Notices are commonly administered during these yearly events. Bottled water is a huge commodity in American Samoa due to the public's general distrust or inconsistency of water quality; unfortunately, with no recycling facilities on-island, and with limited education regarding proper disposal practices, plastic water bottle pollution has become a widely apparent problem as a result. There is some reported use of non-municipal village water collected from streams and springs, though the quality and quantity of this water is not currently being tracked by agencies. In regards to agriculture, water use for irrigation is generally low due to high rainfall amounts.

The majority of drinking water on the most populated island of Tutuila is extracted from aquifers in the flat Tafuna-Leone plain. As of 2018, the American Samoa Power Authority (ASPA) operates 44 active wells on Tutuila, 1 on Aunuu, 3 on Tau, and 2 on Ofu-Olosega, as well as 8 standby and 9 drilled but inactive wells (Fig. X). Residents are connected to well water through water mains, most of which are PVC with some older asbestos-concrete pipes (Shuler Hydrologic LLC, 2018). As of 2017, water system loss from aging pipes and infrastructure was reported to be 59% in comparison to a 16% national average (EPA, 2017). While local village water collected from streams or springs has become less widely used in favor of municipal water, 61 of 77 villages reported use of village water in a 2010 U.S. Census survey. Though less information is available to gauge exact use or water quality from these systems, this decentralized infrastructure could prove beneficial in times of municipal water uncertainty, thereby improving village-level resilience during storms or other unforeseen events.

2.4.2 Groundwater Resources

Groundwater is the primary source of drinking water on volcanic islands such as American Samoa, therefore managing this resource effectively is vital for overall resilience. According to a 2021 study in the Journal of Hydrology, 57% of rainfall in Tutuila currently contributes to groundwater recharge while 20% becomes runoff. Climate change has already caused a marked increase in temperature in American Samoa, with a 240% increase of days at temperatures above 32F since the 1960's. As temperatures increase in the Pacific Islands, so too should the intensity and frequency of storms. Therefore, water balance models based on future climate scenarios predict an increase of 8 to 14% in groundwater recharge, while an increase in impervious surfaces and urban development could reduce this amount (Shuler, et. al 2021). Despite possible upward trends of groundwater recharge, several issues affecting water quality and quantity must be addressed. For instance, salt water intrusion in wells is a present issue that could become worse with sea level rise. Additionally, water leaks from deteriorating pipes could result in significant loss of groundwater. Finally, surface water contamination in the highly permeable aquifers of the Tafuna-Leone plain from wastewater sources, particularly during high rainfall events, remains a pressing challenge.

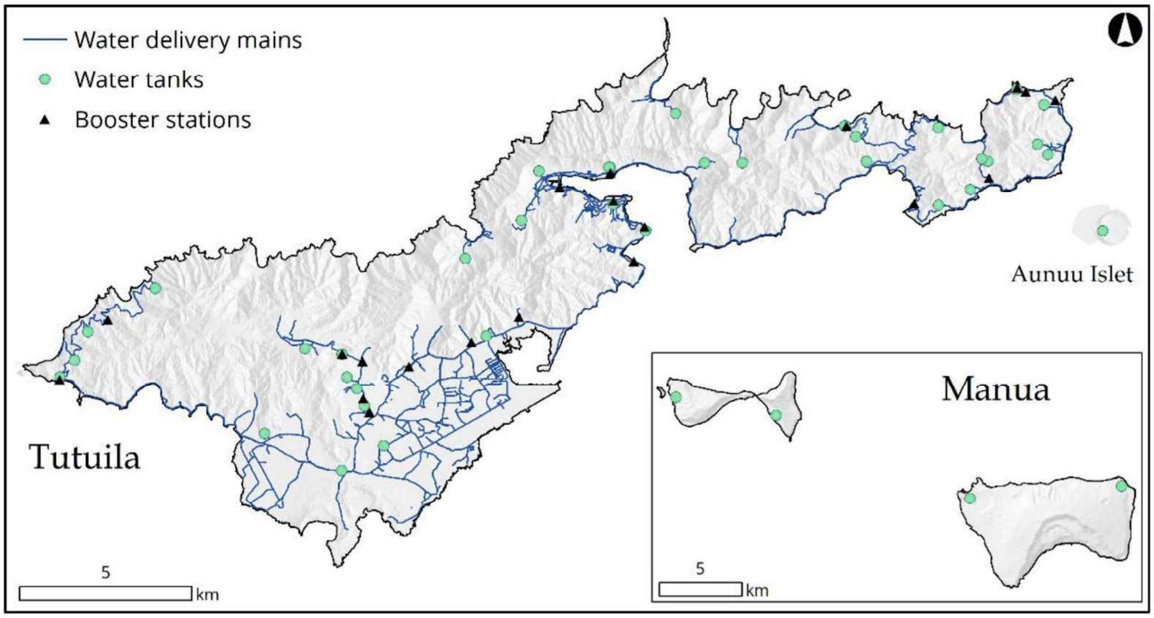


Fig. 2 - ASPA municipal water system as of 2018 (Shuler Hydrologic LLC).

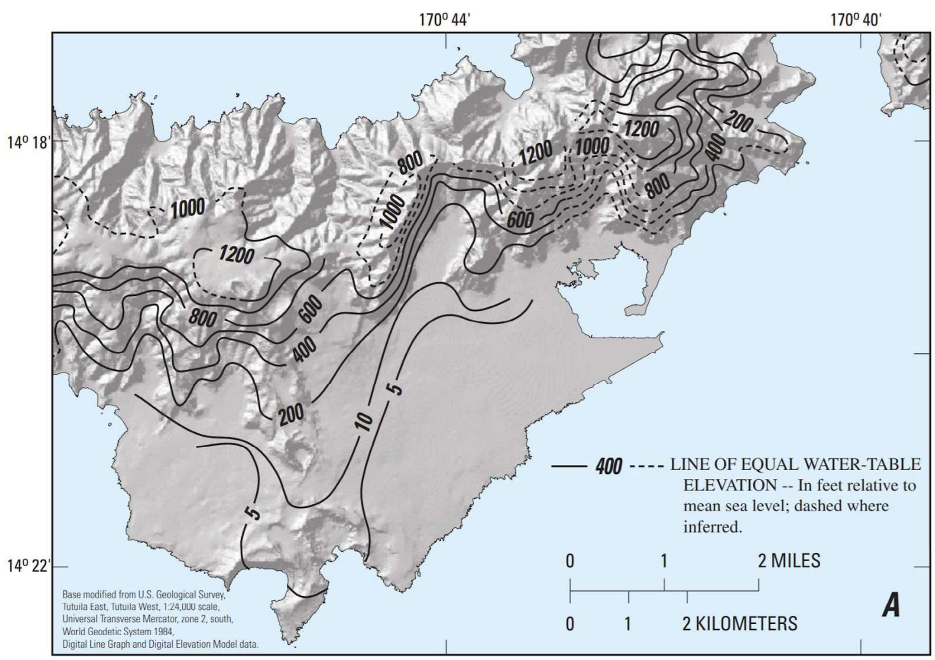


Fig. 3 - Contour map depicting the Tafuna-Leone plain in Southern Tutuila (USGS, 2007).

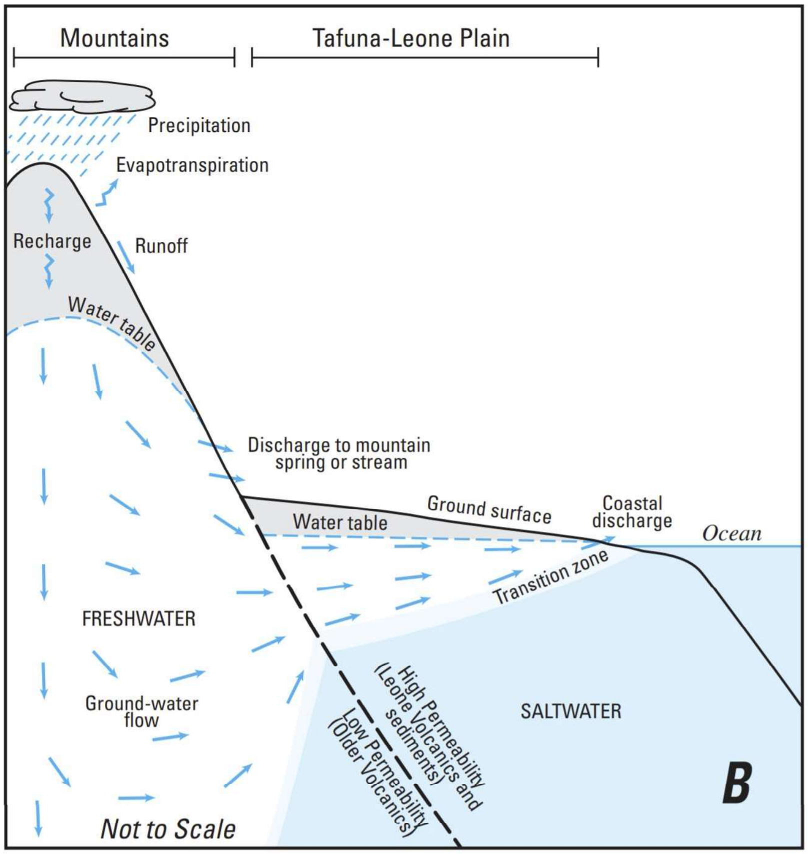


Fig. 4 - Hydrologic depiction of the Tafuna-Leone plain in Tutuila (USGS, 2007).

2.4.3 Piggery Impacts on Water Quality

Wastewater pollution from piggeries is a major water quality concern in American Samoa. In 2010 the AS EPA discovered that 15.5% of the population tested positive for leptospirosis antibodies, likely from direct piggery exposure or swimming in contaminated waters (Castro, et. al, 2017). This has contributed to Boil Water Notices, some of which have been standing for several years. While contamination by *E. coli* and other pathogens has decreased due to increased efforts by local agencies including EPA to enforce NPDES permits, wastewater from village piggeries is still a major issue that must be addressed (AS EPA, 2019). Coral reefs have also suffered from high contaminant input to nearshore waters. As discussed, dry litter piggeries have been attempted with limited success in American Samoa. Other options include deep litter piggeries or using local materials such as coconut husks as bedding in replacement of wood chips. Testing these strategies and ensuring the proper management of piggery waste is a pivotal step in protecting water resources.

2.4.4 Cesspool Impacts on Water Quality

Cesspools are a common type of wastewater management system used in villages that are not connected to the ASPA sewage system. The American Samoa EPA initiated a Cesspool Inventory Project to record cesspools in priority areas near high water tables and aquifers. This inventory includes data for 400 cesspools spanning the villages of Vatia, Aoa, Tafuna, Maleimi, and the Manu'a and Aunu'u islands. The American Samoa Power Authority is the entity responsible for wastewater management and cesspool conversion. ASPA has converted 194 cesspools since 2006 in response to the inventory project. A 2021 study tracing caffeine and sucralose in water samples within Vatia Bay showed direct evidence of human wastewater in coastal waters, indicating the impacts of leaking cesspools on groundwater quality (Whitall, et. al, 2021). The porosity of the densely populated Tafuna-Leone plain leads to quick groundwater transport to coral reefs with minimal time for natural filtration, exacerbating impacts from cesspools as well as piggeries (DiDonato, 2004).

2.5 Air and Energy

2.5.1 Utilities and Power

According to 2020 data from the Energy Information Administration, American Samoa depends on imported petroleum products, including diesel fuel, jet fuel and motor gasoline. Since the installation of more efficient generators and introduction of renewable energy resources after the 2009 earthquake and tsunami, average petroleum use has decreased from 4,100 to 2,300 barrels per day. Approximately 97% of electricity is supplied by almost 40 MW of diesel fuel-burning generators, most of which are located on Tutuila. The American Samoa Power Authority (ASPA) is the only utility in American Samoa. ASPA services 12,300 customers and operates two plants: the Tafuna plant which serves the airport and customers on the western side of Tutuila, and the Satala plant near Pago Pago. The remaining 3% of electricity is powered by solar energy. Tutuila has roughly 5 MW of solar power capacity, including the 4.5 MW PV plant at the airport and 900 kW of rooftop solar. Despite some infrastructure improvements to bury power lines for wind protection, most remain exposed due to cost limitations. Roughly ⅗ of American Samoa households are connected to the electric grid, and residences consume 3/10 of generated power. Industrial and commercial consumers use ⅖ of the power, while the government utilizes ⅙, with the remaining amount lost to utility and system inefficiencies. As may be expected for a remote island, electricity prices are high; currently residents are paying 2.5 times more for electricity than in most other states, with the exception of Hawai'i where prices are similar.

2.5.2 Renewable Energy

The remoteness of American Samoa poses a threat to its energy security which is largely dependent on imported petroleum. That said, this equatorial territory also has abundant solar energy resources which could insulate the islands from power shortages in times of natural disasters, petroleum shortages or shipping delays. Several renewable energy plans and policies have been implemented in recent years to shift the territory to more energy resilience, including the Strategic Energy Plan and Energy Action Plan were produced by the National Renewable Energy Laboratory under direction of the U.S. Department of the Interior Office of Insular Affairs in 2013. These plans were directed by and are regularly monitored for progress by the American Samoa Renewable Energy Committee (ASREC). ASREC was established by

Executive Order 004-2010 in 2010 to promote policies and infrastructure changes to increase energy efficiency and reduce dependence on non-renewable resources.

The group also posed the goal of achieving 50% renewable energy production and consumption by 2025 and 100% by 2040. ASPA, ASEPA and others have followed through with many of the Energy Action Plan's strategies with promising results. For instance, energy production costs in the Manu'a islands of Ofu, Oloseaga and Ta'u were 50% higher than Tutuila due to remoteness and less efficient technology. Today, the island of Ta'u now operates on 100% renewable resources due to the establishment of a 1.4 MW solar photovoltaic and 6 MWh energy storage hybrid system, which has replaced diesel fuel demand of over 100,000 gallons per year. Ofu and Olosega are close to achieving 100% renewable energy as well. Currently these islands are fueled by at least 80% solar energy with 1,000 kWh of battery storage, while efficient diesel generators cover the difference. The daily energy demand for Tutuila is over 20 MW compared to 500 kW for Manu'a, making the shift to renewables more challenging. Other renewable sources including wind, geothermal and hydroelectric continue to be assessed for viability on Tutuila and neighboring islands. Transportation consumes a large portion of petroleum resources, however this sector remains to be studied for energy alternatives. Electric and hybrid vehicles could serve to reduce petroleum use in a 100% renewable energy production scenario, though this would require a large investment not only in EV charging stations but in new vehicles.

Futiga landfill is the only solid waste landfill in American Samoa. In response to the landfill becoming increasingly full in the past decade, ASPA has invested in studies to assess the viability of Waste-to-Energy technologies to reduce landfill volume and produce renewable energy. As of 2019, ASPA has released an RFP for companies to construct, maintain and operate a WTE plant that would convert 80 tons per day of municipal solid waste (MSW) to roughly 2 MW of energy. Gasification has been identified as one feasible technology which can convert MSW, fish waste, oil, biomass and other materials such as shredded tires into electricity while maintaining air quality standards with proper equipment. That said, ASPA is also amenable to WTE technologies that produce other forms of energy including synthetic diesel or clean gas.

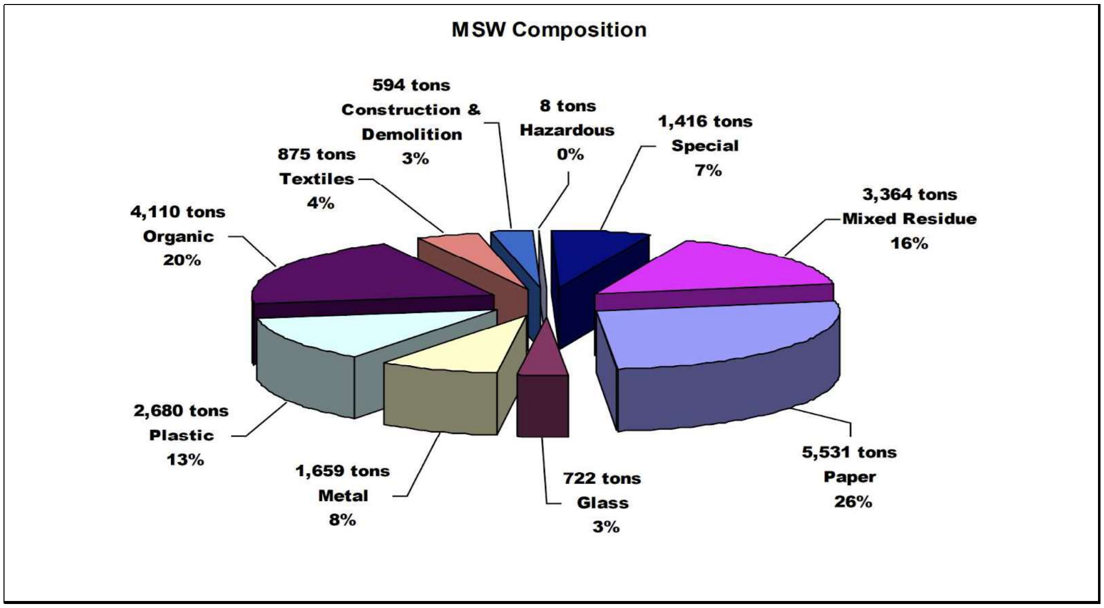


Fig. 5 - Composition of municipal solid waste in American Samoa (ASPA, 2019).

2.6 Plants and Animals

2.6.1 Coral Reefs and Fish

Fishery stocks in American Samoa have been depleting for many years. As recently as 2019, a NOAA study revealed that bottomfish stocks (including 11 species of snapper, emperor, grouper, and jack) were not only overfished but experiencing overfishing (NOAA, 2019). Large fish are often targeted, therefore threatening slow-growing species such as sharks, trevallies, groupers, and parrotfish. Fishing effort is lower now than in previous years, however this reduction in effort is in direct response to an estimated 79% decline in catch rates since the 1950s. Spearfishing while SCUBA diving was banned in 2000 to address a drastic decline in fish abundance.

Fishing pressure is considered the most immediate threat to coastal ecosystems, however habitat loss of coral reefs due to land-based sources of pollution, increasing water temperatures, severe storms and ocean acidification. Bleaching events due to temperature anomalies are becoming an increasing threat to coral reef ecosystems throughout the world which have adapted to fairly stable climatic conditions over many millions of years. Local coral reefs have experienced a multitude of stressors in recent decades, however live coral cover appears to be generally increasing; live coral cover was 29% as of 2019, and surveys suggest coral reefs outside of Pago Pago harbor are relatively healthy. Other coastal ecosystems are of concern in regards to land-based sources of pollution, including mangroves and seagrass beds which serve as nurseries for many species. Coastal development can also have a detrimental impact on coastal ecosystems which provide habitat for wildlife and subsistence fishing, in addition to shoreline stabilization and storm attenuation.

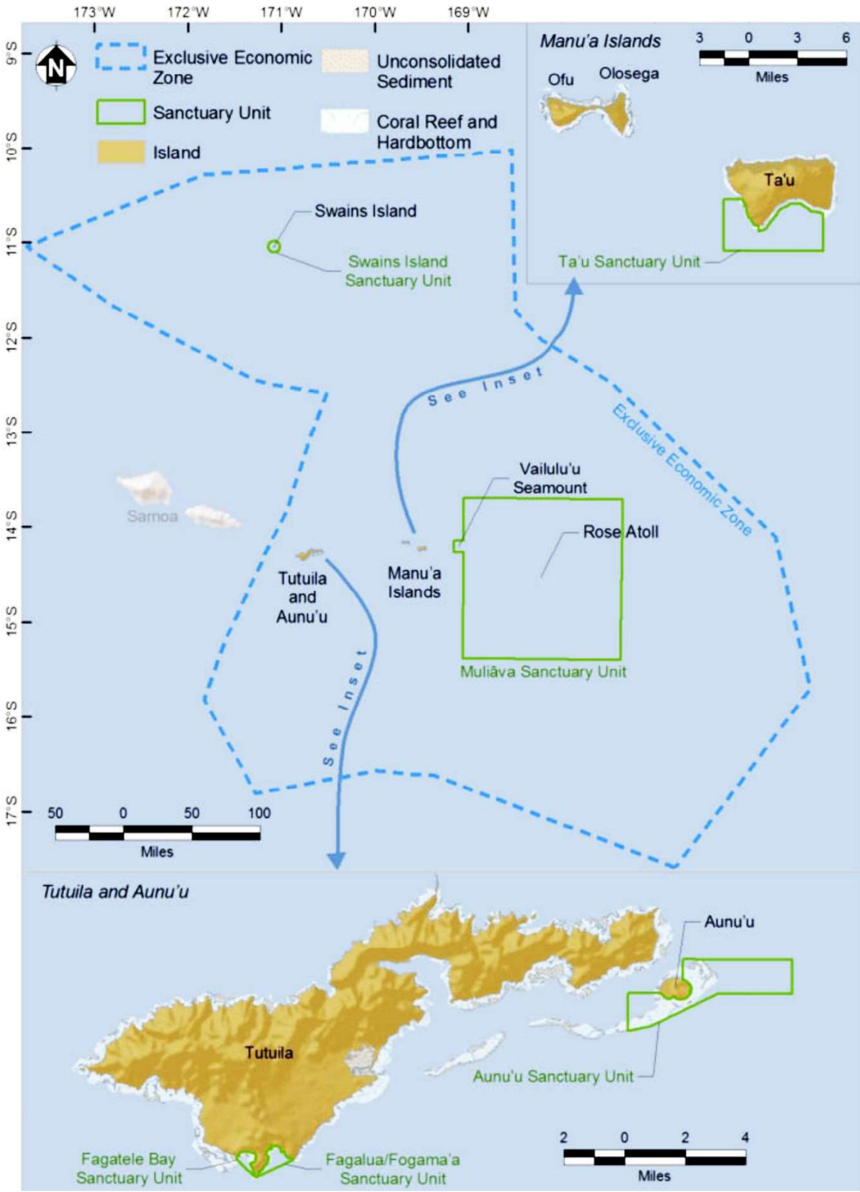


Fig. 6 - Map of the National Marine Sanctuary of American Samoa (NOAA).

2.6.2 Marine Protected Areas and National Parks

Several Marine Protected Areas under varying degrees of either private (e.g. Alega Bay) or federal (e.g. the National Park of American Samoa) management exist to mitigate fishing pressure. Some areas restrict fishing completely while others allow subsistence fishing. Today, the National Marine Sanctuary of American Samoa is the largest sanctuary in the National Marine Sanctuary System at 13,581 square miles (Fig. X). Despite these measures to enhance fish stocks in American Samoa, trends suggest more effective strategies are needed to improve local conditions. In the 2020-2025 *American Samoa's Healthy Reef Strategy,* the Coral Reef Advisory Group recommended improved strategies to ensure adequate fish resources for future generations amidst climate change impacts, invasive species and other unforeseen events. The

American Samoa National Park system includes 9,500 acres of protected land, some of which encompasses communal land and can still be used for subsistence farming.

2.6.3 Endangered and Invasive Species

The bumphead parrotfish (*Bolbometopon muricatum*) which is considered vulnerable globally by the IUCN is nearing local extinction in American Samoa due to overfishing. In 2007, a ban which remains enforced today was placed on the take of several large-bodied reef species including the bumphead parrotfish, sharks, giant trevally and giant grouper. Scleractinian or stony corals which provide structural support for reefs are also reaching their thermal limit, presenting a threat to local coral reef ecosystems as a whole. Outbreaks of the crown-of-thorn starfish (*Acanthaster* sp.) have occurred in 1978/1979 and between 2011 and 2014, resulting in drastic reduction of live coral cover up to 90% in certain areas (CRAG, 2019). Terrestrial invasive species include several species of birds such as the Jungle myna, Common myna, and Bulbul. Feral pigs are also a threat to native forest ecosystems. Invasive rats (*Rattus exulans* and *norvegicus*) predate on native insects and birds, can damage crops, and serve as a vector of disease. There are 56 species of non-native ants in American Samoa and 27 snails. The snail species *Euglandina rosea* was introduced in 1980 as biological control of another snail species, but is now contributing to the extinction of other native species as well. Invasive tree species include the African tulip tree, the Lopa tree, Coral bean, Matoni tree and the Silk or Tamaligi tree which has infested and altered the landscape across 35% of Tutuila forests. The National Park Service is currently working to eradicate the Tamaligi tree within parks. The Manu'a islands are free from most of these species that have infested Tutuila. Air and boat transport represent the largest pathways of concern for invasive species entrance to American Samoa. Communal land ownership also presents challenges to invasive species management (DMWR, 2017).

2.7 Projected Climate Change Impacts

2.7.1 Climate Change Trends

Droughts in American Samoa are predicted to be less frequent as global temperatures rise and rainfall in this region of the world increases. Tropical cyclones are likely to become stronger as humidity and temperature rises in equatorial Pacific regions. Sea level rise is already impacting American Samoa with natural disasters exacerbating these effects (Fig. X). Worsening ocean acidification due to rising carbon dioxide levels is also a threat to the coral reef ecosystems surrounding the American Samoan islands, which already experience stress from rising ocean temperatures and land-based wastewater nutrient inputs. Fishing is a vital component of local subsistence and cultural values, therefore healthy oceans with thriving fish populations are of major importance. Agriculture could become more challenging in areas where saltwater intrusion drastically changes soil conditions. Shifts in weather conditions and increased variability increase the need for a resilient agricultural system which can withstand both acute and chronic climatic changes. Freshwater resources are also of concern as sea levels rise; saltwater intrusion may become a prominent issue affecting the quantity and quality of drinking water sources.

Clearly, climate adaptation in American Samoa is a necessary component of ensuring future generations have access to local food, clean water, stable infrastructure, and healthy ecosystems. Adaptation necessitates the protection of ecosystems and natural resources, establishment of resilient local food and water systems, intelligent planning of infrastructure and development, and collaboration among local agencies and communities to plan effectively while honoring communal values.

2.7.2 Earthquake Impacts

The 2009 Samoa-Tonga earthquake sequence (moment magnitude (M_w) of 8.1) which caused a tsunami has catalyzed sea level rise impacts by increasing land subsidence by 8-16 mm/year in the Samoan islands. The Samoan islands are volcanic islands situated roughly 200 km away from the Tonga subduction zone, where the Lau basin and Pacific plate are converging at unusually high rates (Fig. X). Several geological consequences including megathrust and normal faulting are causing American Samoa to experience sea level rise roughly five times the global average (Fig. X). These trends indicate sea level rise of 30-40 cm (11.8-15.7 in) in American Samoa over the next several decades (Han, et. al). NOAA sea level data clearly shows the increased rate of sea level rise due to quickened land subsidence after the 2009 earthquake event in the coastal capital of Pago Pago (Fig. X). Expected impacts include coastal erosion and flooding which could require relocation of families or businesses and potentially large federal investments in infrastructure improvements. Pago Pago and the airport are two highly populated or trafficked coastal areas that will likely be impacted by sea level rise.

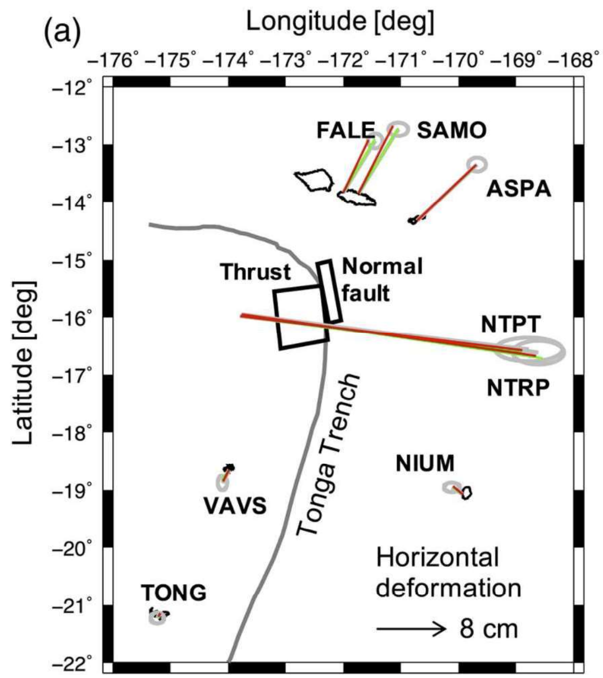


Fig. X - Depiction of Tonga Trench in relation to the Samoan Islands (American Samoa is labeled ASPA) (Han, et. al 2018).

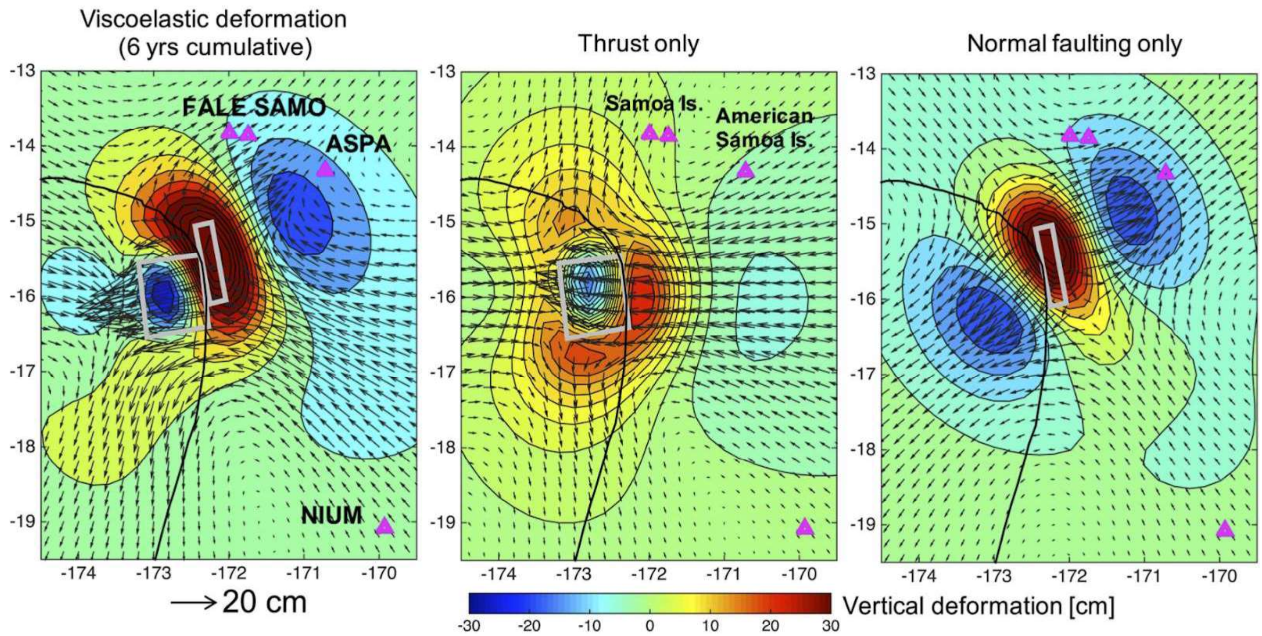


Fig. X - Cumulative and isolated effects of northward and upward thrust and downward normal faulting six years after the 2009 Tonga-Samoa earthquake sequence. American Samoa (depicted by the ASPA GPS station) experiences faster subsidence than other Samoan Islands based on viscoelastic relaxation models (Han, et. al, 2018).

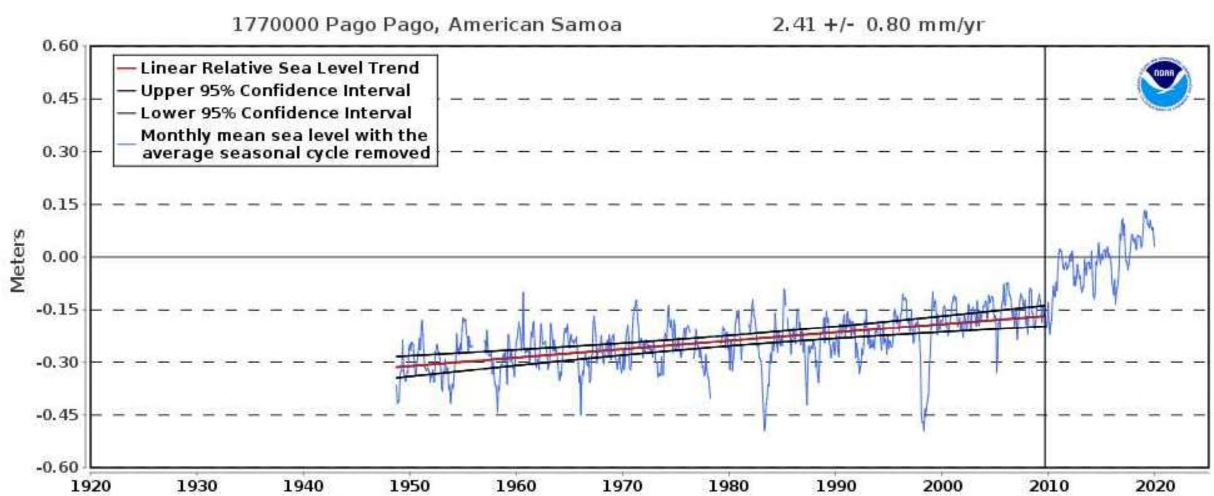
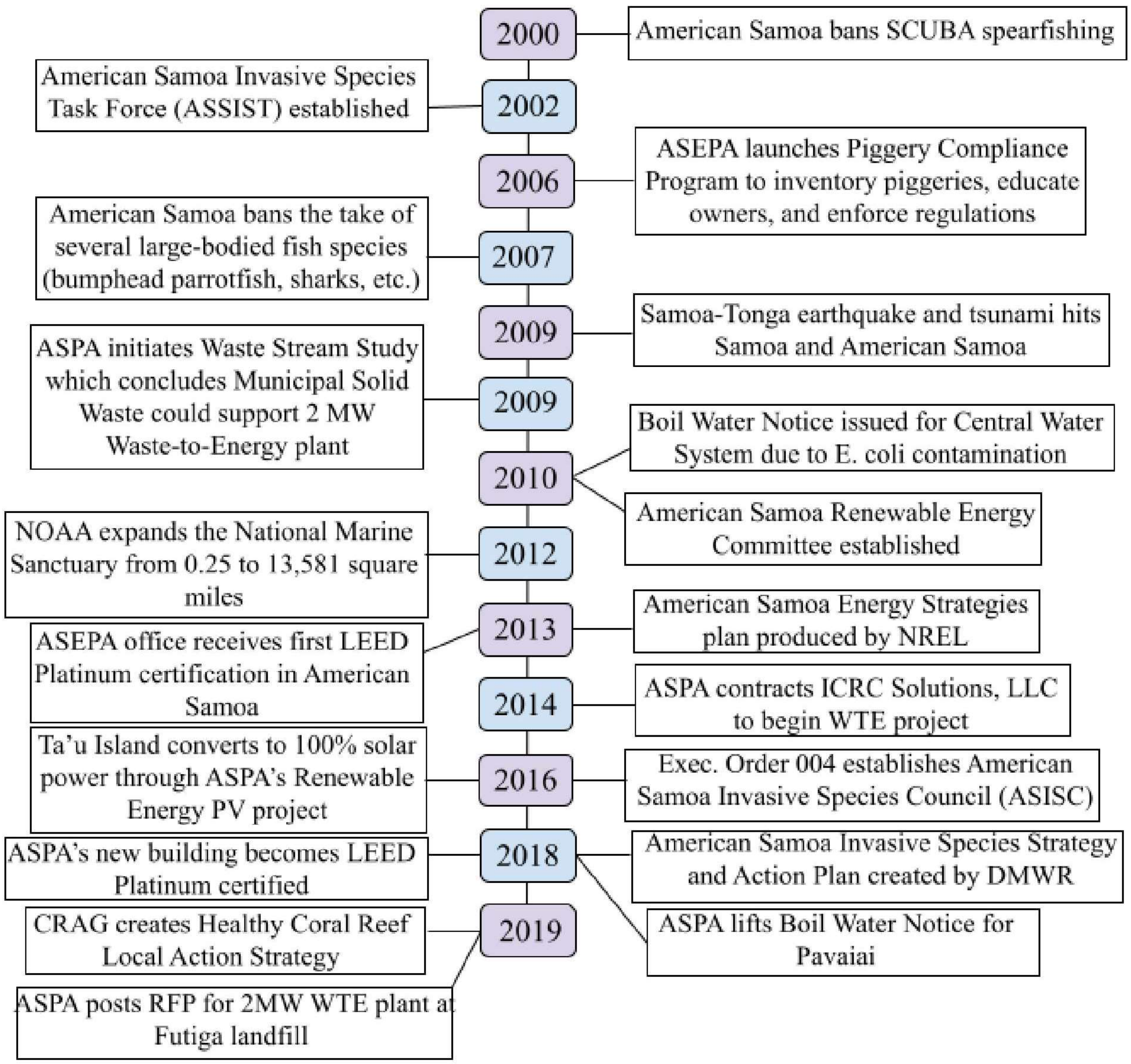


Fig. X - Monthly sea level data as of June 2021 and lines depicting sea level trends prior to 2009 Earthquake in Pago Pago, American Samoa (NOAA, 2021).

Section 3. Recent Conservation Efforts & Existing Concerns

3.1 Conservation Effort and Resources Timeline:

The following timeline outlines major recent events, conservation efforts, or plans created that have contributed to the present state of agriculture and natural resources in American Samoa.



3.2 Outstanding Issues and Resource Needs

3.1 Roundtable Summary

Ridge to Reefs and NRCS held an online roundtable in January 2021 to gather input from local stakeholders. Around fifteen people representing a variety of government agencies, educational institutions and private businesses attended to discuss natural resource concerns and needs. Three subsequent Focus Group Lunches were also hosted to gather more information about three distinct topics: Farmer Outreach and Community Education, Conservation Practices, and Local Agriculture and Food Security. Some general guidance from these meetings included ensuring proper **infrastructure** and offering adequate **resources/education** to support Sustainable Agriculture and Food Security**.** In regards to Environmental Preservation and Conservation, stakeholders highlighted a need for widespread utilization of conservation or improved agricultural practices as well as reduced nutrient or chemical inputs to downstream waters, emphasizing the importance of **incentivization**, **accountability**, and **resource availability**. The major concerns or needs discussed were as follows:

- Address pesticide overuse on farms leading to water quality and public health impacts
  - Enhanced education and enforcement
- Create more regional food hubs
- Increase collaboration between local farmers and restaurants
- Increase educational resources for farmers, including:
  - Responsible fertilizer/pesticide application
  - Alternatives for pesticides (e.g. biocontrol)
  - Traditional methods of farming certain crops
  - Crop-specific best practices for production (breadfruit, bananas, taro, etc.)
  - Composting and improving soil health
  - Agroforestry and permaculture
  - Business skills
  - Providing educational resources for Asian farmers in native language
- Increase youth participation and interest in farming
- Provide certification for farmers who use best practices of pesticides/chemicals to develop more trust with consumers
  - Prerequisite for selling to school lunch program
- Develop individualized farm nutrient management plans (also applies to hydroponics farmers)
- Establish tool share programs in each region
- Apply native tree planting programs
- Develop improved piggery design (dry litter, deep litter) for proper waste management
  - Establish proper enforcement and regulation protocols
  - Leverage incentivization to assure proper management practices
- Establish composting program(s)
- Restore abandoned farmland

3.3 Summary: Existing Challenges and Potential Solutions

3.3.1 Challenge of Note: Federal Agency Turnover and Need for Collaboration

One of the main challenges impacting the effectiveness of conservation efforts is the frequent (2 year) turnover of federal agency appointments. Changes in agency leadership lead to inefficient or incomplete transfer of knowledge and resources to new appointees. There has also been a general lack of **communication, collaboration and efficiency among agencies** regarding issues of water quality, food security and environmental protection. It is clear that a galvanizing force would be useful for **ensuring that positive efforts started in previous administrations are carried through to completion**. Strategic plans created by various agencies share similar interests of improving water quality and preserving natural resources. Agencies should be working together to ensure that **future efforts are in alignment with shared goals** of social, agricultural and environmental resilience. Time-sensitive and lasting change can only be possible by **leveraging the diverse resources** of all stakeholder agencies.

The Soil and Water Conservation District is an entity that many stakeholders have referenced as a vital component of ensuring productive inter-agency and farmer collaboration. Therefore, the revitalization of the SWCD and the maintenance of regular meetings could be a major first step to strengthen the recommendations mentioned below and in Section 4. Targeted Conservation Plans and Investment Portfolios. Further, in order to support goals related to water quality, food security and environmental protection, agencies may need to activate policy changes or apply increased enforcement. It is therefore important to ensure that stakeholders are actively engaged in the decision-making process, and that progress started in previous administrations is maintained regardless of changes in agency leadership. It may therefore be helpful to have a non-governmental organization, such as Ridge to Reefs or otherwise, guide this process. In any case, it is clear that more collaboration, communication, and efficiency is needed within the local government to affect significant change.

3.3.2 Water Quality

The preservation of both drinking and recreational water quality is paramount to ensure proper public health and to conserve coral reefs and other unique ecosystems in American Samoa. **Piggeries** and **cesspools** continue to be the primary contributors to water pollution in coastal areas as well as aquifers. There is also some concern that **pesticides** are contributing to water quality impacts. It is clear that approaches are needed to properly treat both pig and human waste before it reaches groundwater or the ocean. These approaches could include **enhanced technology and infrastructure**. For instance, several stakeholders suggested the development of improved piggery designs which could be used in widespread application throughout the territory. Nature-based wastewater treatment systems such as denitrifying bioreactors could be a potential solution to replace cesspools in a cost-effective way. Green infrastructure practices such as denitrification curtains could also provide **redundant water treatment**, while vetiver grass could help soak up nutrients and excess water near wastewater sources. Edge-of-field agricultural practices supported by NRCS could be of particular use to mitigate pollution impacts from pesticides. Additionally, **public education** is of vital importance to ensure youth and adults alike are aware of the connections between water quality, ocean health, public health, as well as recreation and subsistence (e.g. fishing).

Objectives

1. Reduce wastewater pollution to streams and groundwater with enhanced technology, large-scale investments and public education.
2. Promote best practices for sustainable municipal and village water use.
3. Integrate water quality projects into public school education to enhance awareness and interest of youth.

Potential Partners

- Department of Agriculture
- Coral Reef Advisory Group
- Department of Education
- Ridge to Reefs
- American Samoa Power Authority
- University of Hawai'i
- American Samoa Community College

3.3.3 Food Security

The stability of a global agricultural economy has been put into question by the coronavirus pandemic and its impacts on border closings and travel restrictions. American Samoa imports roughly 95% of its food from overseas, making it especially vulnerable to supply chain disruptions[8]. While much of this food includes fruits, vegetables, and meat, imports also include unhealthy processed foods which are routinely chosen instead of healthier options, largely due to price differences and availability in convenience stores. The scarcity of fresh, local produce in the general population's diet has direct public health impacts, including the highest obesity rates in the world (75%) as well as a high prevalence of diabetes[9]. Climate change is also a pressing issue which could threaten food security in the event of a devastating typhoon , for instance. That said, the wet, tropical climate of American Samoa is a strength; food grows readily and abundantly in most areas, and villages are typically equipped with communal farmland. Food security is therefore within reach. With sufficient collaboration among local agencies, organizations, and other stakeholders including farmers and entrepreneurs, food security, i.e. 50-80% produce grown on island, could reasonably be achieved within ten to fifteen years.

Coupled with proper waste and landscape management, agriculture could be thriving while also protecting natural resources. An **increase in public interest in farming** through educational and community events, as well as increased **collaboration between the restaurant scene and local farmers**, could raise awareness about the importance of local agriculture as well as the economic

[8] College of Tropical Agriculture and Human Resources. (2012). Food Desert: Does it Exist in American Samoa? https://www.ctahr.hawaii.edu/adap/Publications/ADAP_pubs/2012-FoodDesertFactSheet.pdf

[9] World Health Organization, Western Pacific Region and the American Samoa Government. American Samoa NCD risk factors STEPS report. Suva, Fiji: World Health Organization; March 2007.

opportunities that it could support for individuals and communities. Food hubs and a campaign to increase healthy food availability at grocery or convenience stores and restaurants could have a drastic impact on **shifting societal norms in favor of healthier, local options**. According to various first-hand accounts during the roundtables and other stakeholder conversations, there is an **increasing demand for healthy, locally-grown produce** by American Samoans. While the food scene has been slow to elevate locally grown produce, certain pioneers such as the restaurant Ruby Red Cafe are actively raising awareness of public health and local agriculture through their creative, healthy menu and use of locally-grown produce such as salad greens from Tutuila Greens. There is also a group of hydroponic farmers experimenting with this form of agriculture, and some small to medium-sized food markets selling locally grown produce.

Educational events could also highlight best practices for traditional crop cultivation, preserving cultural traditions while supporting a healthy, thriving population. **Educational opportunities for farmers and youth** to learn business skills or make value-added products could greatly benefit the local economy. Youth in particular are an important audience since their participation in agriculture will determine the future of sustainability in American Samoa. Intergenerational exchanges between youth and elders or those with vast experience farming the land or conserving natural resources can support the **preservation of cultural traditions**, which is a vital aspect of social resilience. Workshops could also highlight ways to integrate agriculture into the natural landscape by promoting native tree plantings and providing alternatives to pesticide use. It may also be important to ensure there are appropriate ways to store food and seeds in case of a natural disaster, which could have disastrous impacts for food security, especially in coastal communities. By having **resilient, redundant agriculture systems** in place, the territory could be far more self-sufficient and economically thriving in both the short- and long-term.

In order for American Samoa to become food secure, farmers must be able to make living wages, which could be achievable through a suite of interventions **reducing the cost and amount of agricultural inputs** farmers must use to produce sufficient quantities of food. This could include using fish waste byproducts and staple crops to manufacture locally-produced pig feed; creating fish hydrolysate fertilizer from fish waste; and creating composting programs or equipping communities with proper education and infrastructure for efficient composting practices.

In short, while American Samoan agriculture faces some specific challenges, food security could be achieved relatively swiftly through **collaborative efforts among stakeholder agencies, farmer and community education**, and the **application of appropriate agricultural innovations**.

Objectives

1. Increase inter-agency collaboration to promote best practices for agriculture.
2. Host farmer workshops to enhance local knowledge of natural pest management to reduce overall pesticide use.
3. Establish redundant and resilient agricultural practices to ensure food security, water quality and natural resource conservation.
4. Promote increased collaboration among restaurants, stores, and local farmers.
5. Support the creation of local food hubs for affordable, healthy food distribution.
6. Integrate educational opportunities into public schools to enhance youth interest in farming.
7. Explore and pilot locally sourced agricultural inputs.

Potential Partners

- Department of Agriculture
- Ridge to Reefs
- Soil and Water Conservation District
- Department of Education
- American Samoa Community College
- Local Farmers
- Local Restaurants
- Markets and Convenience Stores
- Starkist Tuna Cannery

3.3.4 Natural Resource Conservation

Conservation of natural resources is a vital component of the strategy to improve social resilience in American Samoa. **Overfishing** and declining fish stocks is of concern as the population relies on fish resources for much of their diet and cultural expression. **Coral reef degradation** is an ongoing concern not only affected by land-based sources of pollution such as piggeries and cesspools, but also by global climate change. It is in the best interest of current and future generations of American Samoa to **invest in strategies that protect and preserve terrestrial, coral reef and other coastal ecosystems** (e.g. mangroves) as they provide many services to the territory such as food security, storm and wave attenuation, shoreline protection, biodiversity, and recreational opportunities.

Goals

1. Integrate educational opportunities into public schools to enhance youth interest in natural resource conservation.
2. Implement conservation practices on farms to mitigate impacts of chemical runoff on water quality.
3. Increase public awareness of proper practices to protect and preserve natural resources.
4. Increase inter-agency collaboration to protect and preserve natural resources.

Potential Partners

- NRCS
- National Park Service
- Department of Marine and Wildlife Resources
- Department of Forestry
- Department of Education (educational opportunities in schools)
- Coral Reef Advisory Group (outreach and education)
- American Samoa Community College

The following section provides further details on various recommendations for addressing the aforementioned problems with various top-down and bottom-up approaches. The tables in Section 4 highlight potential funding sources for various projects and the partners whose involvement would best serve the listed objectives.

Section 4. Targeted Conservation Plans and Investment Portfolios

This section describes the immediate or near-term actions that can be taken to achieve the goal of **85% food security in American Samoa by 2035**. The section includes (2) parts: NRCS Programs, which include programs to be developed and funded under the jurisdiction of NRCS; and Partner-Led Projects, which will require collaboration from other agencies, organizations, or individuals. This section will be regularly updated as a living document to reflect new or changing opportunities and strategies to address the needs of American Samoa agriculture and natural resource conservation.

4A. NRCS-Led Programs

High Tunnel Initiative	
Description	**Project Status**
NRCS will collaborate with local stores and utilize existing technical guidance to develop locally sourced high tunnel kits to help producers significantly enhance the quantity and diversity of their crop yields. These high tunnel kits will be equipped to withstand local climate conditions.	As of Nov 2021, NRCS has received an earmark of $50,000 TCP funding to begin this initiative. Project estimates plan for (15) high tunnels to be constructed from local kits to fit small-scale production settings.
EQIP (Environmental Quality Incentives Program)	
The Environmental Quality Incentives Program (EQIP) provides voluntary financial and technical assistance to agricultural producers and non-industrial forest managers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against drought and increasing weather volatility.	As of March 2022, American Samoa NRCS is currently working with 5 EQIP piggery applications and 27 high tunnel applications.

CSP (Conservation Stewardship Program)	
CSP helps producers build on existing conservation efforts while strengthening their operation. NRCS creates customized CSP plans to help farmers meet their conservation and production goals.	As of March 2022, America Samoa NRCS is currently working with 23 producers utilizing the CSP program for improved conservation and operation.

Note: NRCS submitted (2) additional TCP proposals in 2021 which were not awarded funds, including an Inoculated Deep Litter Piggery pilot project and a Plant Materials Initiative. These projects are included in the Partner-Led Programs section. NRCS is also a lead partner on many of the below initiatives.

4B. Partner-Led Programs

Inoculated Deep Litter Piggeries	
Description/Status	**Relevant Partners/Funding Sources**
IDLPs are a Korean Natural Farming system used in Asia and around the world. The system layers locally sourced, organic carbonaceous materials and applies a locally derived microorganism inoculant to create a natural bedding for the efficient breakdown of pig waste. The system requires no water and has virtually no smell if maintained properly; maintenance is far less intensive than dry litter or washdown systems, requiring occasional sprays of an IMO (inoculated microorganism) solution. As of 2022, RTR has funding for 1-2 pilot projects to construct/retrofit an existing piggery to an IDLP. The team is currently seeking interested producers who are willing to support the project financially and/or with labor. Producers will learn how the system is constructed, be a part of the construction, and will be	● University of Hawai'i College of Tropical Agriculture and Human Resources (CTAHR), Extension Agent - Mike DuPonte (Technical consulting) ● American Samoa EPA (Regulation, enforcement, system adoption/promotion, technical assistance to producers) ● ASPA (Water quality testing, provisioning of waste materials for IDLP construction) ● NRCS (System adoption/promotion, technical assistance to producers) ○ NRCS PIA Strategic Partnerships (grant already underway with RTR/NRCS to facilitate IDLP

expected to maintain the system properly with regular inspections for the first 1-2 years of project completion.	projects) ○ NRCS CIG ○ NRCS CSP/EQIP/CTA ○ Department of Agriculture
Establish Conservation Practices for Water Quality/Quantity	
Various operational conservation/best management practices to capture and treat stormwater runoff from farms or roads can be installed both on farmland and in high visibility areas for flood mitigation and public awareness. These practices should consist of permanent vegetation and could be, but are not limited to, a filter strip, conservation cover, critical area planting, riparian forest buffers, rain gardens, denitrification curtains, vegetated swales, etc. Identifying priority areas for these BMPs and implementing them is a simple way to improve local conditions.	● Ridge to Reefs (fundraising, design, installation) ● NRCS (installation, farmer sign ups) ● ASCC Land Grant (potential site for practice installation) ○ WaterSMART ○ DOI ○ NRCS EQIP/CSP/Conservation Technical Assistance ○ NRCS NWQI ○ US-EPA Green Infrastructure Funding ○ EPA Section 319 Nonpoint Source Management Program ○ PL 566 Watershed Program ○ Bureau of Reclamation ○ FEMA
Enhance Native/Cultural Plant Stock for Vegetative Buffer Practices on Tutuila and Manu'a Islands	
Vegetative buffers are a highly effective water and nutrient management practice used on farms. More availability of buffer vegetation, including vetiver grass and other crops, on both Tutuila and Manua islands would increase the rate at which NRCS and other organizations can support producers and protect water resources.	● ASCC Land Grant ● Ho'olehua Plant Materials Center (HIPMC) ○ Agriculture and Food Research Initiative (AFRI)

Establish Technical Service Provider(s) to generate Comprehensive Nutrient Management Plans for producers	
NRCS/Partners will train/hire at least one TSP professional who is qualified to provide CNMP assistance to producers in order to minimize nutrient and water loss from their landscape. Local agencies will agree upon a program to implement and enforce CNMPs for the mutual benefit of producers (i.e. healthy crop yields) and natural resource conservation.	● NRCS ● Department of Agriculture ● ASCC Land Grant ● Soil and Water Conservation District ○ NRCS CIG ○ NRCS EQIP ○ NRCS PIA Strategic Partnership
Incorporate Water Catchment into (10) New or Existing Production Systems	
Rainwater catchment is a highly effective solution to reduce stormwater runoff and provide irrigation for producers in American Samoa. Rainwater catchment falls under NRCS Conservation Practices 436/636 and 558, and is therefore eligible for EQIP funding.	● NRCS ● Department of Agriculture ● ASCC Land Grant ○ NRCS EQIP ○ NRCS CSP
Establish BMP Certification Program	
A BMP certification program would provide a standardized way for producers to identify their farm as complying with high environmental standards. Producers receive certification by building/maintaining a certain amount of BMPs on their land. This certification could be displayed at farmers' markets as a testament to their commitment to human and environmental health. The idea is to generate more customer awareness about where their food comes from and how it is produced, such that they can make more informed decisions when buying produce. This may encourage other farms to take part in environmental stewardship should demand increase for producers who participate in the BMP certification program.	● Department of Agriculture (enforcement) ● EPA (enforcement) ● NRCS (technical assistance) ○ USDA-Ag Marketing Service Grant

Establishment of Food Hub(s) and Farmers Market(s)	
A coalition of hydroponics growers (Lima Ola) is in the process of outfitting a warehouse to serve as a produce processing facility and food hub for local producers in Tutuila. The center could offer education on safe wash/pack practices and provide a space for educational workshops and collaboration among producers. Producers could benefit from having more business training and establishing relationships with local restaurants to sell their produce. Other such facilities could be constructed throughout Tutuila and Manu'a.	● Ridge to Reefs (grant writing) ● Local farmers (participation, implementation) ○ Beginning Farmer and Rancher Development Program (BFRDP) (training) ○ Community Facilities Direct Loan and Grant Program (food hub) ○ Farmers Market Promotion Program ○ Senior Farmers' Market Nutrition Program
Create and Distribute Locally Sourced Fertilizers	
Fish waste from the tuna cannery can be converted into a high quality organic fish hydrolysate fertilizer. Currently the cannery will give the waste away for free. Local producers, entrepreneurs and innovators can pilot the creation of this fertilizer which can be fertigated in a drip irrigation system, or used hydroponically. Imported fertilizers are expensive; this solution could save producers money while reducing waste.	● Ridge to Reefs (technical assistance) ● Motivated producers/entrepreneurs (pilot projects, business creation, marketing) ● Tuna cannery (providing waste resource) ○ Business Loans/Incubator Funds ○ NRCS CIG
Increase Educational Resources for Producers	
Farmers would benefit from increased access to group workshops and educational materials. Some communities of Asian farmers could be reached with educational materials in their native language. In general, roundtable participants mentioned a need for business skill trainings tailored specifically to producers. Other workshops could include natural pest management strategies, seed collection and storage, water drainage and collection, and more.	● Department of Agriculture (farmer workshops, educational materials) ● NRCS (farmer workshops, educational materials) ● ASCC (student education, workshops) ● Farmers' Markets (advertising educational opportunities, holding public programs)
Increase Youth and Community Education	

Engage school children with conservation, crop production, and/or composting efforts by starting or resuming school programs. Guest speakers can come to the schools to give workshops or students can have their own long-term projects in a school nursery.	● Public schools ● EPA ● NRCS ● CRAG
Increase Stakeholder Collaboration	
Consistent communication among stakeholders in sustainability and food security is crucial to achieve common goals. The Soil and Water Conservation District formerly served as a sort of galvanizing group for all relevant organizations, however the SWCD has not been active in the past few years. It is therefore important for all agencies to have open lines of communication with each other and choose to check in and collaborate with each other when pertinent.	● EPA, ASPA, CRAG, NRCS, National Park Service, ASCC, Department of Agriculture, etc.
Facilitate Restoration of and Production on Abandoned Farmland	
Abandoned farmland that is currently not being used for production could be rehabilitated to high soil health conditions and used to increase food security. This task would require the identification and evaluation of parcels for farmland expansion, and developing relationships/deals with landowners to facilitate this type of land use. These areas could potentially become small or medium farms that youth could grow food on or experiment with different sustainability efforts, such as creating compost. They could serve as community gardens for educational, social and practical purposes.	● NRCS (identifying land when traveling, meeting with landowners) ● Department of Agriculture (identifying land when traveling, meeting with landowners) ● Public schools (engagement with land projects) ● Local entrepreneurs (implementation of production/sustainability projects) ● Village members (leasing of land for production, participation in community garden, etc.) ○ Agricultural Conservation Easement Program ○ Conservation Reserve Program ○ Community Facilities Direct Loan and Grant Program (development of community garden)

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USDA PROGRAMS IN THE LOCAL FOOD SUPPLY CHAIN

Agricultural Conservation Easement Program (NRCS)
https://www.nrcs.usda.gov/acep

Agriculture and Food Research Initiative (NIFA)
https://go.usa.gov/xQEyH

Agricultural Innovation Center (RD)
https://www.rd.usda.gov/programs-services/agriculture-innovation-center-program

Beginning Farmer and Rancher Development Program (NIFA)
https://go.usa.gov/xQEVa

Business and Industry Guaranteed Loans (RD)
https://www.rd.usda.gov/programs-services/business-industry-loan-guarantees

Community Facilities Loans and Grants (RD)
https://www.rd.usda.gov/programs-services/community-facilities-direct-loan-grant-program

Community Food Projects Competitive Grants (NIFA)
https://go.usa.gov/xQEyf

Community Prosperity Funding Opportunity (OPPE)
https://www.usda.gov/partnerships/centers-of-community-prosperity

Conservation Innovation Grants (NRCS)
https://www.nrcs.usda.gov/cig

Conservation Reserve Program (FSA)
https://www.fsa.usda.gov/programs-and-services/conservation-programs/conservation-reserve-program/index

Conservation Stewardship Program (NRCS)
https://www.nrcs.usda.gov/csp

Conservation Technical Assistance (NRCS)
https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical/cta/

Enhancing Agricultural Opportunities for Military Veterans (NIFA)
https://go.usa.gov/xQdzc

Environmental Quality Incentives Program (NRCS)
https://www.nrcs.usda.gov/eqip

Extension Risk Management (NIFA)
https://nifa.usda.gov/program/extension-risk-management-education-program

Farm Microloans (FSA)
https://www.fsa.usda.gov/programs-and-services/farm-loan-programs/microloans/index

Farm Storage Facility Loans (FSA)
https://www.fsa.usda.gov/programs-and-services/price-support/facility-loans/farm-storage/

Farm to School Grant Program (FNS)
https://www.fns.usda.gov/farmtoschool/farm-school-grant-program

Farmers Market Promotion Program (AMS)
https://www.ams.usda.gov/fmpp

Federal State Marketing Improvement Program (AMS)
https://www.ams.usda.gov/fsmip

Food Safety Outreach Program (NIFA)
https://nifa.usda.gov/food-safety-outreach-program

Gus Schumacher Nutrition Incentive Program (formerly FINI) (NIFA)
https://nifa.usda.gov/program/gus-schumacher-nutrition-incentive-grant-program

Grass Fed Small and Very Small Producer Program (AMS)
https://www.ams.usda.gov/services/auditing/grass-fed-SVS

Local Food Promotion Program (AMS)
https://www.ams.usda.gov/lfpp

Noninsured Crop Disaster Assistance Program and Other Disaster Assistance Programs (FSA)
https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/noninsured-crop-disaster-assistance/index

Office of Partnerships and Public Engagement (OPPE)
https://www.usda.gov/partnerships

Office of Urban Agriculture and Innovation Production (NRCS)
https://www.farmers.gov/manage/urban/opportunities

Organic Cost Share (FSA)
https://www.ams.usda.gov/services/grants/occsp

Outreach and Assistance for Socially Disadvantaged Farmers and Ranchers and Veteran Farmers and Ranchers Program (2501 Program) (OPPE)
https://www.usda.gov/partnerships/socially-disadvantaged-farmers-and-ranchers

Regional Food Systems Partnership Grants (AMS)
https://www.ams.usda.gov/services/grants/rfsp

Rural Business Development Grants (RD)
https://www.rd.usda.gov/programs-services/rural-business-development-grants

Rural Cooperative Development Grants (RD)
https://www.rd.usda.gov/programs-services/rural-cooperative-development-grant-program

Rural Energy for America Program (RD)
https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

Senior Farmers' Market Nutrition Program (FNS)
https://www.fns.usda.gov/sfmnp

Small Business Innovation Research (NIFA)
https://nifa.usda.gov/program/small-business-innovation-research-program-sbir

Specialty Crop Block Grants (AMS)
https://www.ams.usda.gov/scbgp

Specialty Crop Research Initiative (NIFA)
https://go.usa.gov/xQEyF

Sustainable Agriculture Research and Education Program (NIFA)
https://go.usa.gov/xQEyM

Value Added Producer Grants (RD)
https://www.rd.usda.gov/programs-services/value-added-producer-grants

Whole-Farm Revenue Protection (RMA)
https://www.rma.usda.gov/en/Policy-and-Procedure/Insurance-Plans/Whole-Farm-Revenue-Protection

WIC Farmers' Market Nutrition Program (FNS)
https://www.fns.usda.gov/fmnp

INOCULATED DEEP LITTER SYSTEM

May 11, 2010

Evaluation by R. David Fischer PE, Hawaii NRCS Resource Engineer

Figure 1 – IDLS Piggery, Kurtistown, Big Island, Hawaii – 30-feet x 60-feet Building

INTRODUCTION

There are various alternatives for managing agricultural animal waste from confined facilities.

Conventional. Conventional methods consist of transferring waste to a storage facility until such time as it might be applied to crop or pasture-land. Instead of applying the waste directly to the land, it could be transferred to a treatment facility, such as an anaerobic or aerobic digester. Nonetheless, this method generates a substantial amount of liquid manure due to the wash-down process of cleaning the concrete pens. This method has been used more on large operations.

Modified Dry Litter. A recent innovation developed in Hawaii that has been effective for smaller operations is the Modified Dry Litter (MDL) waste management system (**Appendix A**). A thin layer (2") of dry litter is placed on the pen's concrete floor. The floor is sloped toward a "gutter" so that waste (litter and manure) migrates toward the gutter and is collected and placed in an adjacent series of compost bins where it is treated and eventually taken out to be applied to crop land.

Inoculated Deep Litter System. Most recently, a method known as the Inoculated Deep Litter System (IDLS), was incorporated into a piggery installed on the Big Island in Kurtistown, Hawaii, and became operational in August 2009. This method incorporates some of the concepts of the MDL system.

The Waste Management Plan for this facility was developed in April 2007, by Buddy Perry, Soil Conservationist with the Puna Soil & Water Conservation District. Mr. Perry is now a Soil Conservationist with the Natural Resources Conservation Service in the Hilo Field Office.

The University of Hawaii: Manoa - College of Tropical Agriculture & Human Resources, Sustainable Agriculture Research & Education, Farm Pilot Project Coordination, Hawaii County Research & Development, and the Big Island Resource Conservation & Development Program provided assistance for this project.

It is based upon principles explored on a fact finding trip in 2008 to Korea, by Mike Duponte, Dwight Sato, David Ikeda, & David Matsuura of the University of Hawaii. This piggery uses a dry deep litter system.

DESCRIPTION

Structure. The building is a 30 feet wide by 60 feet long (**Figure 1**). The pens are 36-inches deep (**Figure 2**). They are filled with a layering of cinder-charcoal mix and litter with the finished product of saw dust-wood chip mixture (**Figure 3**).

There are several structural differences in this building when compared to a conventional wash-down facility. This facility has a reinforced concrete floor and a hollow tile (cement block) wall to contain the bedding (logs, woodchips and IMO treatment). A conventional facility also has a reinforced concrete floor but not the hollow tile containment.

This particular structure cost about $50,000 ($28/square foot) - turnkey. This includes the completed structure, nipple watering system, and the litter with the IMO. One major potential savings in this system is that it would not need a waste storage facility and the capability and space to spread the manure.

Layering. Since this is an aerobic process, air must be present within the litter. The initial IDLS piggery had native soil as the foundation. The Hawaii Department of Health was concerned about contamination of the ground water and required an impermeable layer which consists of a 4" thick concrete floor. An impervious flexible membrane, such as a 60-mil High Density Polyethylene liner attached to the walls, could probably be used instead of the concrete floor.

Because the concrete floor prevented air exchange with the soil, a venting system was devised. Standard 4-inch diameter drain pipe on about five-foot centers was laid on the concrete floor and vented to the side of the building. The first layer, consisting of a mixture of cinder and charcoal six-inches thick, was placed around and on the drain pipe. A layer of wooden posts, four to six inches in diameter and about eight-inches thick is placed on this. The third layer consists of short pieces of wood logs about eight-inches thick laid on the posts. The final layer is a sawdust/wood chip mixture about 12 inches thick. Each layer is inoculated with the Indigenous Microorganism (IMO) developed on-farm and lactic acid is initially sprayed on the top surface until the IMO's take effect. IMO's are added only once for the life of the practice,

Indigenous Microorganisms. The addition of IMO is necessary because the litter most likely does not have a predominance of the necessary microorganisms necessary for the decomposition of the manure. It is a naturally occurring microorganism, cultivated on-farm using a process developed by Master Cho Han of Korea (**Appendix B**). The process is inexpensive to replicate and is considered safe from a biological standpoint, provided standard sanitation procedures are followed, as these organisms are natural and indigenous to the area.

OPERATION

The piggery has been operating since August 2009. There have been no incidents during that time. Even though it has not yet been utilized to full capacity, there is no accumulation of manure, flies are not present to speak of, and the smell is virtually non-existent. The key is to keep the bedding relatively dry.

Figure 2 – Individual Pen before Addition of Litter – 12’ Wide x 24’ Long x3’ Deep

This system has been operating in Korea and elsewhere for at least 12 years with no need to clean or replace the bedding or inoculate with additional IMO.

Bedding needs to be added periodically. For pens with pigs that are 40-100 lb body weight, 3 cubic yards per pen need to be added every 6 months (or 1/2 cubic yard every month). For pens with pigs that are 100-220 lb body wt, 6-7 cubic yards of sawdust needs to be added every 6 months per pen (or 1 to 1-1/2 cubic yards every month).

Capacity. The IDLS piggery is designed to allow the animals more space than some conventional systems. Each 12’ x 24’ pen can accommodate 17 market size (220#) hogs or about one animal per 17 square feet. Each pen can accommodate six breeding sows. Conventional systems usually have up to twice the density. For various reasons, breeding boars should limited to one animal per pen.

Figure 3 – Four of the Five Pens Filled with Litter, 12’x24’ each, Located in a30’x60’ Building

System. The IDLS piggery involves several concepts beyond simple construction. Building orientation (N-S), ventilation, regulated sunlight, and addition of the IMO and lactic acid are also components of the system. The payback is healthier animals that are less susceptible to disease and personal injury as well as higher average-daily weight gain. **Animal health and comfort is a major consideration in this system**.

CONCLUSION

The Waste Management Plan for this facility was developed in April 2007, by Buddy Perry, while he was a Soil Conservationist with the Puna Soil & Water Conservation District. He is now a Soil Conservationist with the Natural Resources Conservation Service in the Hilo Field Office.

The Hawaii Department of Health issued a permit to build the demonstration project in Kurtistown, Hawaii. The piggery was constructed and has been operational since August 2009.

The initial cost of the IDLS would probably be less than the conventional system due to the elimination of the need for storage of waste or the need for land area for application of the nutrients. The cost of IDLS would be similar to the MDL system described elsewhere in this document.

It is very likely that the IDLS could be a preferred method to raise hogs on the scale customarily encountered in the Pacific Island Area, particularly in the areas of high rainfall. It will be totally dependent upon basic operation skills of the farmer as well as making the initial investment to pay for the structure.

There is a real interest in this method, particularly if the agency can assist in its' implementation. Please notice the sketch (**Appendix C**) for the planned expansion of this concept at the Kang Piggery in Kurtistown.

From a technical standpoint, the IDLS will meet conservation concerns of improving air and water quality, reducing water use, and improving the living conditions of the animals.

The process most closely mimics the existing standard for Composting Facility (317).

NRCS supports the implementation of this system and is working to adapt it for inclusion into our Field Office Technical Guide.