Pacific Agriculture and Natural Resources

Diffusion of an Agricultural Innovation: A Case Study Involving Dry Litter Technology in American Samoa

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Abstract: Dry Litter Technology (DLT) is a pig waste management system that was first introduced to farmers in American Samoa over 15 years ago by the College of Tropical Agriculture and Human Resources at the University of Hawaii at Manoa. The system offers adaptable water quality solutions for small-scale piggeries, using composting processes to realize a positive return from the nutrient resources in waste rather than washing it into nearby streams and causing pollution. With almost 100 producers currently utilizing the DLT, the factors that led to the adoption of the DLT in American Samoa were investigated in order to understand how to best facilitate the adoption of this technology in American Samoa, other islands in the Pacific, and in other tropical areas around the world. Interviews were conducted with 30 farmers to explore how the perceived attributes of the DLT contributed to its adoption. Results reveal that a major paradigm shift in the nutrient management system occurred, from a water-based system to a dry litter-based system, and provided a variety of benefits to the immediate family, village, and the community and brought challenges due to the cultural issues associated with the paradigm shift.

Key words: Piggeries, Livestock management, American Samoa, Nutrient management, Dry litter technology, Pacific Islands, Water quality

1. Introduction

The Dry Litter Technology Waste Management System (DLT system) was first introduced to American Samoa by Glen Fukumoto from the University of Hawaii at Manoa (UHM) and Jim Wimberley, a private consultant, in 2001. Fukumoto and Wimberly launched a DLT system training and awareness initiative as part of a multi-agency initiative funded by the U.S. Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) to introduce effective pig manure management and utilization in American Samoa, based on work done in Hawaii in the 1990s. Project activities included technical assistance, information dissemination, and deployment of appropriate technologies (Wimberly and Lynch, 2002). The goal of the project was to introduce pig operators to the beneficial use of nutrients while reducing the potential for adverse environmental and human health impacts from piggery operations (Wimberly and Lynch, 2002).

The purpose of this study was to evaluate the process and outcomes of DLT adoption in American Samoa in order to determine the benefits and challenges associated with its adoption and investigate the attitudes and perceptions among pig producers about the DLT system in order to facilitate future adoption of this piggery management system. As a result of efforts by various change agents, American Samoa has the highest rate of adoption of the DLT system throughout the Pacific (G. Fukumoto, unpublished

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report, September 2014) with over 100 DLT piggeries built since 2009 and 220 new EQIP applications for DLT systems as of July 2014 (D. Ayala, personal communication, July 2014). Understanding relationships among culture, values, existing practices, and political/social/economic relations is a necessary element of understanding what makes technology transfer possible, or not (Rogers, 2003).

This study will cover the significance and management of pigs in American Samoa followed by an overview of the DLT system components and the process by which it was introduced in American Samoa. Then, a 2013 survey developed to investigate this technology transfer is described. Following the survey methodology are the results and discussion, including a socio-economic profile of survey respondents and a summary of the benefits and challenges associated with adopting the DLT system reported by respondents. Conclusion and recommendations are in the last section, which outlines the issues that have a major impact on the adoption of the DLT and details ideas for increasing the adoption rates of the DLT in American Samoa.

The Significance and Management of Pigs in American Samoa

American Samoa is a U.S. territory located in the South Pacific between Hawaii and New Zealand. It is composed of five islands and two atolls with a population of 60,000 people, most of whom live along the coast of the main island, Tutuila. For this population of Polynesians, *fa'a Samoa* (fah-ah-SAH-mo-ah), (two words) "the Samoan way," encompasses attitudes, beliefs, and traditions that symbolize a worldview, shared throughout the Samoan archipelago (Misatauveve, 2013). This phrase explains the appropriate way to live, including traditional ways to grow and cook food.

During a variety of *fa'alavelave,* pigs are consumed, making pig production a culturally significant practice for Samoans. *Fa'alavelave* is anything that disturbs the daily routine in the village. In this context, *fa'alavelave* refers to social events like birthdays, weddings, funerals, farewell parties, church openings and church gatherings, that require traditional gift giving, including pigs (Mageo, 1991). As the islands' population has grown, pig production has increased accordingly and disposing of the resulting animal waste became an issue of concern. To put things into perspective, a 2006 island-wide Geographic Information System database of piggery locations showed 940 piggeries with a total of 7,800 pigs on Tutuila, an island measuring roughly 21 miles (33 km) across and little more than 3 miles (4.8 km) from north to south at its widest point (Figure 1). Until recently, waste was washed out of the pens and allowed to enter the nearest surface water (AS EPA, 2011).

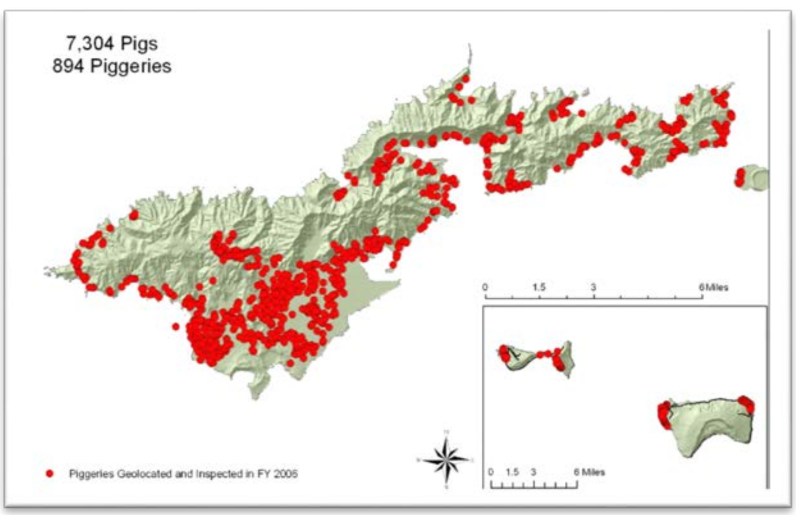

Figure 1. 2006 GIS map of piggeries on Tutuila, American Samoa.

Source: https://www.epa.as.gov/sites/default/files/documents/piggery/gis.pdf

The large volume of untreated urine and feces contaminate drinking water wells, streams, and coastal waters resulting in illness and death due to pig-related diseases, such as leptospirosis (NOAA, 2009). Leptospirosis is a bacterial disease that is commonly caused by exposure to water contaminated by animal urine or fecal matter (Levett, 2001). After seven deaths attributed to leptospirosis occurred from 2000 to 2007 (NOAA, 2009), residents of American Samoa became concerned about the problem.

During January 2009 to June 2011, the incidence rates for leptospirosis among children under 16 years of age in American Samoa were 159 cases per 100,000 population per year with rates peaking in the wettest months (Lau & DePasquale, 2012). In 2010, blood samples from 807 people in 55 villages across American Samoa tested positive for antibodies to leptospirosis, according to the American Samoa Environmental Protection Agency (AS EPA, n.d.). Thus, AS EPA concluded that 15.5% of the overall population in American Samoa had leptospirosis antibodies, indicating they had been infected with leptospirosis most likely from exposure to piggeries or fishing and swimming in streams or at beaches located downhill or downstream from piggeries (AS EPA, 2011).

For the most part, pigs have been raised in makeshift open-sided buildings with concrete slabs or packed-earth floors. Nearly all of the small piggery operations in American Samoa used pressurized water for cleaning pens and directing wastewater into a "septic tank" or directly into nearby surface waters. The tank systems have open bottoms, which make them cesspools rather than septic tanks. Farmers install these cesspools to handle the piggery waste even though many are not adequate for managing the waste, as indicated by the effluent backup at the inlet to the tank and obvious ponding surrounding the tank (Figure 2). In areas with shallow ground or surface water, the cesspool can overflow and become a direct conduit for water contamination.

Figure 2. Piggery effluent backup at the inlet to a cesspool.

Many grievances filed with AS EPA against piggery operators originated from neighbors complaining about flies and the stench of manure. AS EPA is authorized to enforce the laws related to piggeries, and has done so against farmers who allow pigs to run loose; operate their pigpen within 50 feet of human habitation; keep pigs between the highway and sea; operate a pigpen within 50 feet of any body of water or wetland; or maintain pigpens in unsanitary conditions or with an inadequate waste disposal system (AS EPA, 2011).

The Dry Litter Technology System

The DLT system offers a technology for managing small-scale piggery waste that focuses on harvesting the nutrient resources in waste using a method of in situ composting. By incorporating the use of carbon materials, including chipped tree trimmings, leaves, landscape trimmings, or coconut husks, and sloping pen floors, the DLT system eliminates the need for using large amounts of water to clean pig pens. The pigs crush the bedding materials and the manure with their hooves; the mix dries and begins to decompose, and eventually moves down slope into a composting or storage pit. The key to the system are the sloping pen floors that, through a pig's hoof action, mix the waste with the litter and push the resulting material into a holding trench out of the pen; preventing pigs from being exposed to pre-compost material where diseases and parasites may develop. This process also reduces odors significantly. The carbon mix is then removed from the holding trench and properly composted, to produce a rich, organic soil amendment, reducing the need for costly imported fertilizer.

The following information describes a structure for a six-pen dry litter piggery with a footprint of 794 square feet; 949 square feet including the roof and overhang (Figure 3). The structure consists of at least a four-inch thick steel reinforced concrete slab, steel reinforced concrete masonry unit columns, timber structural roof members, and a corrugated metal roof. Each pen is approximately six feet wide by ten feet long. As indicated in Table 1, the estimated cost for DLT systems range from $13,000 to $42,000 (at the time of this study), depending on the number of pens and whether it has a roof and extra concrete.

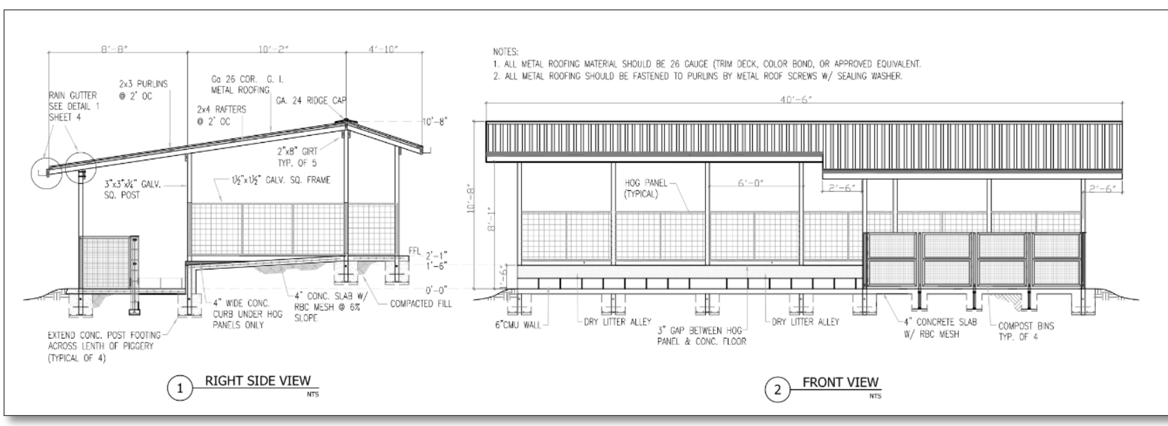

Figure 3. American Samoa EPA 6-pen dry litter piggery design.

Source: http://asepa.gov/_library/documents/water/piggery/portable-piggery-standard-desi/6pendltype2-1.pdf

All pen floors are sloped at least 5% to a concrete waste alley; for every 10 feet in length a pen floor must drop 7 inches in the direction indicated on the construction drawings. The roof must extend at least 2 feet beyond all compost bins, pig pens, and dry litter alleys. Rain gutters must be installed as indicated on construction drawings. New hog panel walls must be reinforced as indicated on construction drawings. All concrete must be at least 3,000 PSI. Concrete columns can be used instead of galvanized 3-inch square tubing as indicated on construction drawings. All weld points must be painted with zinc-based or anti-corrosive paint. Water nipples should be attached to hog panels 2-feet from the dry litter alley. Water nipples must be attached using galvanized fittings and must connect to a pressurized water source. A 3-foot wide walkway is located in front of the pig pens. A gate at the front of the pig pens, that opens either to the left or right, aids in routing pigs in and out of pens.

Table 1. Estimated cost for DLT systems of three sizes and two styles.

System Size	Original design	Roof & Extra Concrete
Four-pen	$13,000	$19,000
Six-pen	$21,000	$27,000
Ten-pen	$35,000	$42,000

Overview of DLT System Diffusion Process

While a pilot project by Fukumoto and Wimberly introduced DLT in American Samoa in 2001, awareness alone is not enough to convinced producers to adopt the technology according to Rogers (2003). Knowledge or awareness of the innovation is the first step in the adoption process. The five characteristics of an innovation, including relative advantage, compatibility, complexity, trialability and observability also affect the pace of adoption (Rogers, 2003). The DLT system, as described above, appears to be relatively complex, expensive to try, difficult to observe given that no system existed in American Samoa in 2001, not closely compatible with current practices, and its relative advantage over the current system is not quickly apparent. These factors made it difficult for the DLT system to diffuse through American Samoa's agricultural sector. This section describes the events that resulted in the wide spread adoption of the DLT system by 2013.

History of the DLT system in American Samoa

The DLT system received the U.S. Environmental Protection Agency's Region IX 2003 Environmental Award for Outstanding Achievement and was identified as a viable solution to American Samoa's growing piggery problem by local change agents (US EPA, 2003). As a result of the growing concerns about to the large volume of untreated pig urine and feces contaminating drinking water wells, streams, and coastal waters, the AS EPA initiated a piggery compliance program to establish guidelines along with a permit system in 2006. The subsequent compliance review revealed that 97% of American Samoa's piggeries were non-compliant with the piggery guidelines with 92% of these lacking permits, 82% discharging directly into surface water, utilizing open-bottom cesspools or improperly constructed septic tanks, and 60% not meeting the 50-foot setback from human habitation or any body of water or wetland requirement (AS EPA, 2011). Two hundred eighty-two piggeries (30%) could not meet setback requirements for pigpens built near other property or away from water or wetlands and were permanently closed (Minshew, Robotham and Scales, 2007). As a result of these closures, and the increase in leptospirosis cases, pressure from community members, government agencies and policy makers began to mount for producers to adopt more sustainable piggery system, such as the DLT.

In an effort to find practical and cost-effective solutions, the American Samoa Soil and Water Conservation District received an Administration for Native Americans grant in 2007 to create examples of inexpensive piggery designs and composting systems, and provide free blueprints to farmers who were struggling to meet various regulatory requirements. The American Samoa Coral Reef Advisory Group and AS EPA provided funding for a wood chipper to support dry litter piggeries throughout Tutuila (Hayner, 2012).

Another significant step that spurred adoption of DLT systems was the 'acceptance' of the technology as one that meets the legal conditions, criteria, and considerations of the Conservation Practice Standards for waste treatment, a waste facility cover, and a waste storage facility by USDA Natural Resources Conservation Service (NRCS) in 2007. Since the high construction cost for a facility was likely the largest barrier that these small farmers faced in adopting the DLT, the ability to access Environmental Quality Incentive Program (EQIP) funds from NRCS provided qualified farmers with funding needed to install the system. According to NRCS staff in American Samoa, the EQIP program will fund the entire cost for three different sizes of DLT systems, including four-, six- or ten-pens and two different styles, including the original design, or a roof and extra concrete. (See AS EPA Piggery

Compliance Program website for pen designs.) In order to receive an EQIP grant to build a DLT system, producers must undergo extensive preparation with NRCS. A farmer must first apply and be granted a Land Use Permit (LUP) from AS EPA and the Samoa Department of Commerce. Then, NRCS begins the process of working with the farmer by inventorying the land to develop a Conservation Plan that will include the DLT system. The optimal size for the system is a function of the producer's current and future production goals and the environmental challenges and resources of the property.

Numerous meetings are held between the farmer, the contractor, and NRCS staff to discuss the details of the design and expectations of both parties for basic operation and maintenance (O&M) of the DLT system. The farmer will undergo DLT training and be given an engineering packet, which includes the design, materials list, site plan, O&M procedures for the structure and specifications for construction, and a Comprehensive Nutrient Management Plan (CNMP), which details how much compost the farmer will be producing; how much to apply based the producer's crop production plan; and a soil analysis. Once construction begins, NRCS staff visit the farm weekly to check the status of the construction and to make sure the DLT system is being built properly with the correct materials.

2. Survey Methodology

The 30-question survey was designed to be read aloud in English or Samoan and was translated into Samoan before receiving UHM's Institutional Review Board clearance. Investigators Castro and Fukumoto fielded the survey, in American Samoa, and were escorted to farms/households by an agent from the American Samoa Environmental Protection Agency (AS EPA) to translate any questions or words that the respondents could not understand and translate the answers back into English. The surveys were administered using in-person interviews with respondents at the AS EPA headquarters in Pago Pago and at their piggeries throughout the island of Tutuila.

The survey was conducted in the summer of 2013 and included interviews of early-, mid- and late-adopters of the DLT system. Categorizing the farmers as based on their willingness to adopt new ideas and technologies is based on Everett Rogers' Theory of Diffusion (2003) that concluded that people's demographic and psychological characteristics also affect the decision to adopt. The percentage of the population that adopts over time is typically illustrated as a normal distribution or "bell curve" (Figure 4) and individuals who use a new product first are called "innovators," followed by "early adopters" followed by the early and late majority with the last people to adopt being referred to as "laggards." Of the 30 farmers surveyed, ten were considered "early adopters" as they had built their DLT between 2009 and 2010; ten were "early majority" as they had built their piggeries using the DLT system between 2011 and 2012; and the last ten farmers could be considered "late majority" as they were starting to build their DLT-based piggeries in 2013.

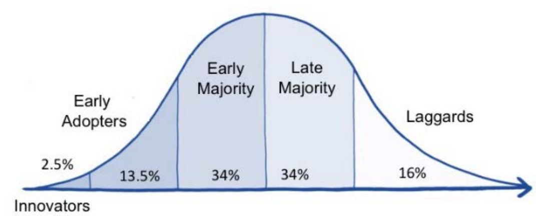

Figure 4. Rogers adoption/innovation curve.

Adapted from Rogers, E. (2003). The Diffusion of Innovations. Fifth Edition. The Free Press, New York.

3. Results and Discussion

Fifty percent of the respondents farmed part-time and were employed off-farm while the other 50% were retired and farmed full-time. The off-farm employment and previous employment varied from blue-collar positions to government employees. Respondents have been raising pigs 25 years, on average, with 90% raising them for family consumption as well as for fa'alavelave. Sixty-three percent of respondents were also marketing their pigs. Some respondents seemed uncomfortable admitting to marketing their pigs, likely because pigs are traditionally raised in accordance with Samoan customs and not privately sold.

The average age of survey respondents was 52 $\pm$ 15.3, (mean, $\pm$ standard deviation, respectively) with the youngest farmer being 20 years old and the oldest being 79 years old. This is consistent with the Census of Agriculture for American Samoa that reports an average age for farmers at 53 (USDA, 2007). The average household size was 8 $\pm$ 1.8 family members with a range between 3 and 25, which is larger than the 5.6 average household size reported by the US Census Bureau (2010). The majority (93% ± 1.8) of respondents had 12 years of schooling or more, which is slightly higher than the 82% of residents 18 years and older with a high school diploma, General Educational Development (GED), or alternative credential (US Census Bureau, 2010).

Seventy-nine percent of the respondents had between one to five breeding sows, and 89% had between one to five breeding boars (Figure 5). "Size 2" are one of the culturally-defined sizes of pigs and are of considerable interest to Samoans as they are the most coveted for their balance of meat and fat, fetching typically between $150 and $200 per animal, if sold (Fukumoto, personal communication, June 2013). "Size 2" pigs normally weigh between 40 lbs. to 60 lbs. Eight farmers had between one to five "Size 2" pigs, five farmers had between six to ten size "Size 2" pigs, three farmers had between 11 and 15 "Size 2" pigs, 1 farmer had between 16 to 20 "Size 2" pigs, and 1 farmer had between 21 and 25 "Size 2" pigs (Figure 6).

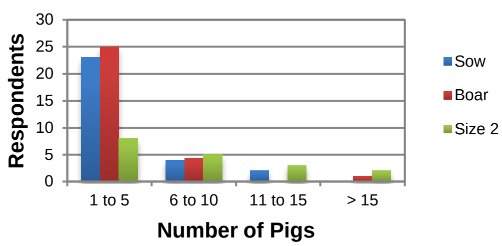

Figure 5: Number and type of pigs reported by respondents.

Forty-seven percent of respondents reported washing pig waste into cesspools before adopting the DLT system (Figure 7). Twenty-three percent washed the waste onto the ground surface and 20% of respondents stated that they used to wash down waste into septic tanks, although septic tanks are usually cesspools that are incorrectly identified by the respondents. Ten percent of respondents admitted to washing directly into streams. Thus, at least 80% of the respondents were managing piggery waste using methods that could result in water quality and safety degradation.

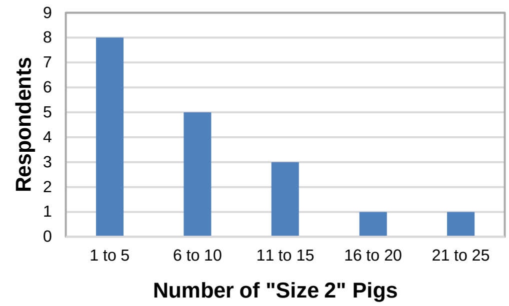

Figure 6. Number of "size 2" pigs reported by respondents.

Two-thirds of the respondents reported that their piggery was not located near any water source. Twenty-three percent of respondents admitted that their piggery was situated near a stream or wetland and 7% indicated that it was near their home or close to their neighbor's property. Almost a third of the respondents' piggeries were located such that waste pollution could degrade the quality of the surface or underground.

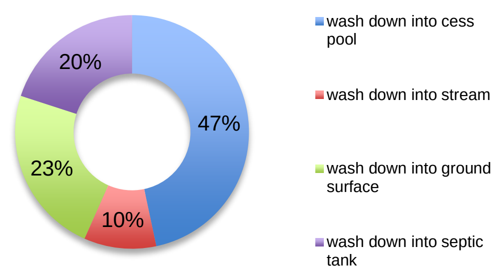

Figure 7: Waste management system used by respondents before adopting DLT.

Seventy percent of the respondents reported that AS EPA had visited their operation and given them a warning to improve the environmental and health conditions of their piggeries. The three best management practices recommended by AS EPA included redesigning pig-holding buildings, moving piggeries at least 50 feet away from surface water, and incorporating pig-waste composting measures. Of the 30% of respondents who voluntarily decided to install a DLT system, 20% stressed their desire to protect the environment and their concerns with water quantity and/or pig waste management.

The majority of the respondents (41%) had heard about the DLT system from the AS EPA, which most likely suggested that they contact the USDA NRCS for information on and assistance in acquiring a DLT system (Figure 8). Only 21% percent of farmers had heard about the DLT system from other farmers, which means that Ryan and Gross' (1943) belief of the importance of interaction among farmers in adopting a technology may not apply to producers in American Samoa. According to the diffusion theory (Rogers, 2003), acceptance by one or more farmers usually helps influence the remaining ones. We assumed that, within the close-knit Samoan community, the farmers who have adopted the DLT system would have had a greater influence on those who have not. However, in this case, threats to close the piggery by the AS EPA largely influenced the early adopters. Only one respondent reported learning most about the DLT system from visiting the American Samoa Community College's (ASCC) DLT System Demonstration Site. Another watched an ASCC television program on the DLT system. This finding indicates that change agents are important in this culture, although these small producers do appear to need a compelling reason to change. Respondents said that they needed more information and assistance with cleaning the pens and with managing the wood chips in moving them from the pen to the alley and then to the composting bins.

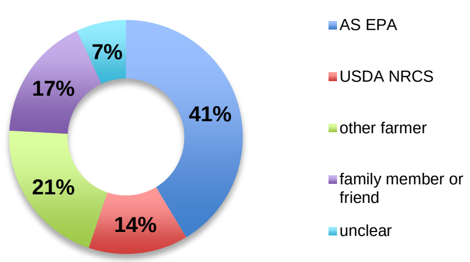

Figure 8. Communication about the DLT system.

When asked about the size of their DLT systems, 53% of respondents had built a six-pen system and 36% had built a four-pen system (Figure 9). One respondent built two adjacent ten-pen systems and another farmer started with a six-pen and then built an adjacent ten-pen. The number of pigs in the various pen sizes varied significantly. For instance, one respondent had 35 total animals in his six-pen system (6 breeding females, 4 breeding males, 25 "Size 2") while another had only five total animals (2 breeding females, 1 breeding male, 2 "Size 2") in his six-pen system.

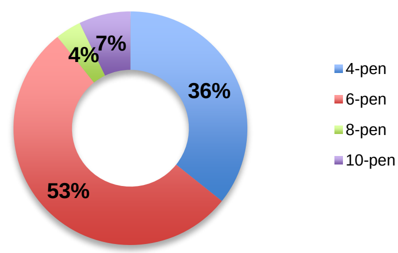

Figure 9. Pen size of DLT system built.

Sixty-seven percent of respondents followed the specifications for a DLT system provided to them by NRCS. However, 33% of the farmers made modifications such as adding entrance ramps, increasing the slope of the floor, increasing the number of pens, adding overhangs to keep rain out, including fencing on top of the walls to prevent theft; reinforcing the feeding troughs and water nipples, and adding storage shelves under the roof of the pens. One respondent reported an adjustment made to the compost management practices by reducing the waiting time for moving the compost from bin to bin from one month to three weeks.

The majority of farmers reported that they had little to no net out-of-pocket expenses. Although the NRCS cannot verify how much each farmer actually received from EQIP funds due to confidentiality, 63% respondents stated that they had paid nothing out of their own pocket to build their system and their expenses included feeding the work crew, buying electricity to run the equipment, and purchasing miscellaneous tools.

Seven respondents reported higher out-of-pocket expenses (11-50%) than their counterparts who claimed only having between 0-10% personal costs. The difference in out-of-pocket expenses among the farmers is unclear, although the question may have gotten lost in translation. Five respondents did not know how much they had spent out of their own pockets. Regardless of the cause, the fact that the DLT construction costs may appear to be partly funded by a producer may serve as a deterrent to adoption.

Eliciting information about how each respondent adapted the system brought to light the difficulty some farmers are having with eliminating the practice of wash down the pens with water. Thirteen percent of farmers reported washing down the pens and/or the pigs and one claimed that his pigs were bored because the wash down activity provided stimulation for the animals. This provides evidence that some farmers may not adopt the DLT system because it is not compatible with their desire to continue with washing down their pigs.

This conclusion is reinforced by the responses to the query about what they would change about the DLT system. Thirty-three percent of respondents would not change anything to the DLT system while thirty percent want to be able to wash down their pigs. These farmers would like to build a special pen and add a septic system to be able to bathe their animals. As one farmer stated, “pigs need to be showered.”

Besides the desire to have added more or bigger pens by 17% of respondents, others mentioned adding more slope, making larger compost bins, adding another bin for food slop, and attaching mesh wire to the pens to prevent pig theft. The majority of the respondents appears to have adopted the DLT system and are learning how to improve the system to better meet their needs. This implies a behavior change on the part of these respondents.

Reduced smells, reduced fertilizer costs, and healthier/happier pigs were the top three benefits of DLT system valued by respondents (Figure 10). This corresponds with the expected benefits of the DLT system reported by Fukumoto and Tulang (2002). Ten respondents said the DLT system saves water and another ten respondents said it saved money on their water bills.

Only one respondent, a late adopter, knew no other pig farmer using the DLT system. The majority were proud to claim that many other pig farmers, along with friends, relatives, and other villagers, have visited their piggery operation and, as a result, these visitors expressed a desire for a DLT operation of their own. Respondents reported that visiting farmers have expressed surprise and appreciation for the DLT system and promptly put in for applications with NRCS. But when asked where these piggery farmers had heard about the DLT system only 21% claimed having heard about it from other farmers. This inconsistency with the information sources used by respondents reported previously may indicate that in this culture openly expressing a reliance on other farmers for information is not acknowledged.

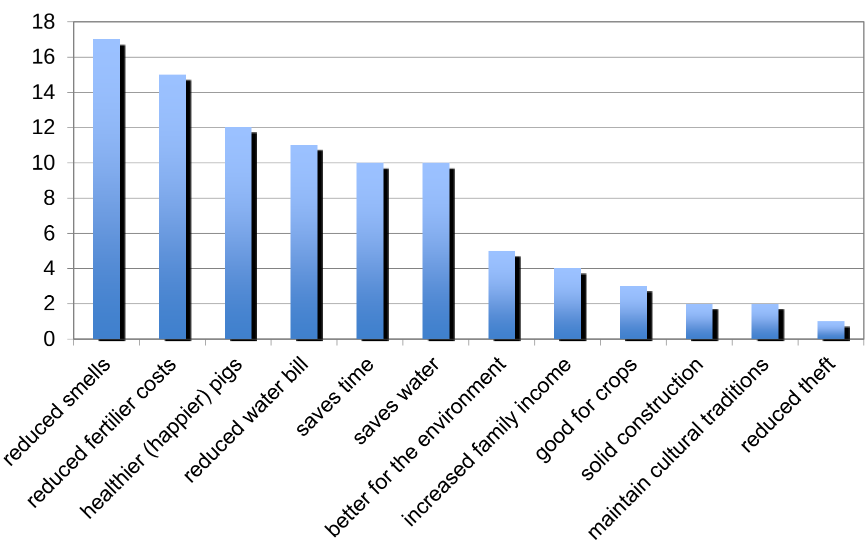

Figure 10: Perceived benefits of the DLT system.

A third of respondents thought that the work involved in maintaining the DLT system would prevent other farmers from adopting this technology. A few said that farmers perceive washing down their pens is easier than engaging in the compost process. But as one farmer stated, "I thought it was going to be hard but now I know that it's easier and saves me time." Twenty-seven percent of respondents could not think of anything that would stop a piggery farmer from adopting the technology while 20% stated that purchasing or making your own wood chips for the compost was difficult. A respondent claimed (inaccurately) that a hindrance to adoption is that the DLT system causes skin conditions for the pigs because it does not provide the animals a bath like a wash down system does. One respondent stated, "If they know how to do it [DLT system maintenance] well, they would like it more."

Survey respondents were not queried about the source of their water used for their piggery operation. According to the NRCS office in Pago Pago, many farmers rely on "village water," which is supplied to a village from a water catchment system in the mountains or a stream or spring that provides free water to everyone in the village. The American Samoa Power Authority (ASPA), a public utility company providing electricity, water, wastewater and solid waste service to over 60,000 residents in American Samoa supplies residential water. Residential water rates, controlled by ASPA, also apply to farmers a rate of $0.00404 for 0 to 10,000 gallons; $0.00454 for 10,001 to 20,000 gallons; $0.00504 for 20,001 to 30,000 gallons; and $0.00554 for over 30,000 gallons (NRCS personal communication, 2013). According to Fukumoto and Wimberly in their piggery assessment of American Samoa (Wimberly and Lynch, 2002), pig farmers used an estimated 296,198 gallons of water annually, on average, to wash down their pens. Based on the 2013 residential water rates, the average cost of water for a pig farmer was estimated to be $1,641. This cost represents a crude assessment of the return to the producer for the time they spent managing a DLT system. This cost incentive for DLT adoption is missing for farmers using village water (small reservoirs constructed on streams for drinking water).

Five questions on the survey addressed the farmer's use of the compost produced by the DLT system. The majority of the respondents said they were using the compost as fertilizer for their crops, with 17% stating that compost had not been created yet. The crops being fertilized include: taro, giant taro or "tamu," banana, yam, avocado, cabbage, pineapple, breadfruit, papaya, cucumber, and coconut. Respondents reported a high level of satisfaction with the compost as a fertilizer, stating that they are seeing a big difference in the growth rate, size of crop, pest resistance, crop health, and number of fruit.

The respondents concluded that making compost is better because it is cheaper than purchasing a commercial fertilizer, is a source or potential source of income if it is sold to others, and is beneficial for the environment, less is needed compared to store-bought fertilizer. The majority of respondents also do not see making compost as difficult, although several responded that it does take time and labor.

4. Conclusion and Recommendations

A representative sample of pig producers who had adopted the DLT system between 2009 and 2013 completed a survey about their operation and their experiences in adopting the technology. Viewing the DLT adopters through the lens of the technology adoption model (Rogers, 2003), a third of the respondents are considered "early adopters" as they had built their DLT systems between 2009 and 2010 (two years after it became an accepted and supported Conservation Practice Standard by USDA NRCS in 2007); ten are in the "early majority" as they had built their piggeries using the DLT system between 2011 and 2012; and the last ten respondents are in the "late majority" as they were starting to build their DLT system based piggeries in 2013. Overall respondents expressed satisfaction with the DLT system. They reported a reduction in odors, lower fertilizer costs, healthier (happier) pigs, lower water usage and lower water costs as the major benefits, respectively of the DLT system.

The largest challenge involved in adopting the DLT system is adapting to the shift from using producer labor to engage in a water wash down to using producer labor to produce compost. Even though respondents were aware of the human health concerns and other contamination issues brought about by washing down the pig effluent, they still wanted to wash down their pigs. The management practice persevered in spite of the high residential water rates paid by some respondents and this issue should be addressed in educational materials used to diffuse DLT system in American Samoa. It also should be considered in any effort to diffuse the DLT in other countries.

Social networks are almost as important as government institutions in informing respondents about the DLT system. Identifying the opinion leader for various producer groups (Rogers, 2003) would be useful. This coupled with the fact that misinformation was cited as a justification for non-adoption suggests that dissemination of information about the DLT should be designed to use social networks effectively. Clearly the wash down management system has become part of the local culture. Use of a farmer mentoring system that involves opinion leaders could help encourage adoption of the DLT and assist in developing the mentors' on-farm expertise in adapting the DLT to local conditions.

Another policy option that should be considered is implementing a fee system for village water users. If village water users continue to get free water, the benefits and costs of adopting the DLT are not distributed evenly across all types of producers. Those who have free water have a reduced incentive to adopt the DLT system and those who are paying residential rates bear an additional cost for not switching. Clearly a wash down system has a labor requirement that appears to be more appealing to many producers than the labor requirement for the DLT system.

The production of compost that allows the producer to avoid purchasing imported fertilizer is a major benefit of the DLT system that could be explored in order to encourage the growth of an industry that provides a sustainable source of plant nutritional supplements. Producers may be able to organize themselves in order to develop a marketable compost product. Small business development assistance could help encourage a supply chain efficient enough to support a market for the locally produced compost.

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