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SAGO (*Metroxylon sagu*) Traditional Processing Practices and Challenges: An Exploration for Sustainability, Adaptability, Guidance and Optimisation (SAGO) Training

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ABSTRACT

Traditional sago processing in Aklan, Philippines has never been properly studied or improved. A sequential explanatory approach was used involving 35 sago processors. The study revealed that sago processors still use primitive manual methods, require a lot of hard labour, and harm the environment because of dumping untreated wastewater into local nature. This traditional knowledge leads to their hard conditions to survive. Based on the analysis of the study, sago processors have great technical skill, but they are held back by poor infrastructure, such as 71% lacking farm-to-market roads, and 88% relying on inefficient manual tools. The findings show that the industry survives purely on community teamwork and social bonds, like shared labour (86%), rather than actual support from the government or official institutions. Thus, the SAGO Training program was introduced in order to shift traditional practices into a sustainable business. This 12-month project is divided into three stages: curriculum design in line with RA 10611 and GMPs, hands-on implementation focused on optimising extraction and waste-to-value conversion, and impact assessment. The scalable model aims to save local industries while meeting modern safety and environmental standards. Its expected output includes professional certification for processors, reduced environmental pollutants through better waste management, and improved market access.

Keywords: Challenges, exploration, practices, processing, sago, sustainability, traditional, training

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INTRODUCTION

Sago palm is one of the Genus Metroxylon belonging to the Family Palmae. It has a high starch yield. One palm yields 150 -300 kg of starch, enough to feed a family of 4-5 members for a month (Sago Palm Society, n.d.). Thus, sago is considered by many scientists as the "starch crop of the 21st century" (Singhal et al., 2008). Aside from being nutritious, sago is great for the environment. According to Dewayani et al. (2024) and Purbaningsih et al. (2023), sago can survive weather changes and natural disasters, making it a reliable crop for securing food supplies locally and nationwide. Mohamed et al. (2024) also reiterated that in the Asia-Pacific region, this underused plant has the potential to become a highly valuable product for industries.

Despite SAGO having great industrial potential, its processing creates a lot of waste, such as bark, fibre residue (hampas), and wastewater (Awg-Adeni et al., 2010). According to the results of the investigations by Wee Oy et al. (2017) and Nagarajan & Suresh (2005), when this acidic wastewater is dumped without treatment, it degrades water quality, consumes the oxygen that aquatic animals need to breathe, and damages the tissues of fish and other aquatic life.

According to Teodosio (2013, as cited in Acuna, 2013), who conducted a survey pertaining to SAGO trees, large groups of these stands grow in 12[1] out of the 17 towns in Aklan Province, Philippines. The geographical distribution of sago stands in the Province of Aklan is presented in Figure 10. However, sago processing has never been officially recorded or improved; it still relies heavily on traditional local knowledge and manual labour. Although local laws, such as Republic Act No. 9003 and the Aklan Provincial Environment Code (Aklan Provincial Government, 2009), require proper waste management, actual processing methods remain inefficient.

Though sago has great economic and environmental potential, it lacks proper research and official documentation in the Philippines. In nearby countries like Malaysia and Indonesia, modern sago factories are being built, while the Philippines lacks hard data on how old manual methods, like slow extraction and inefficient tools, cause people to dump waste in ways that harm the environment. At present, there is no proven plan to help sago processors combine these ancient traditions with modern food safety and environmental standards.

This investigation is based on Socio-Technical Systems (STS) Theory. According to Trist and Bamforth (1951), this theory states that how well a business or group works depends on how its Social Part (the people, traditional knowledge, and customs) interacts with its Technical Part (the tools, processing methods, and waste management).

[1]Please see Figure 1 (Geographical map of sago strands in the province of Aklan) above the Subheading: Participants/Informants and sample size of the study

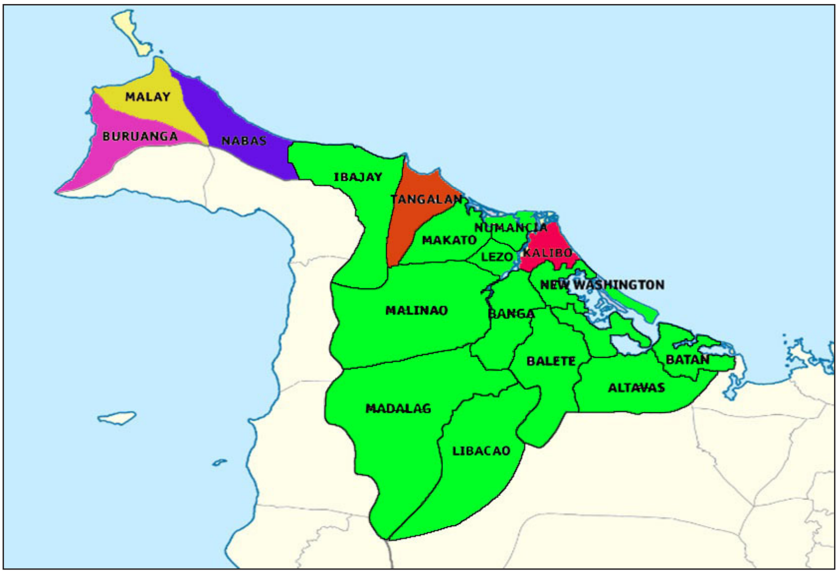

Figure 1. Geographical map of sago strands in the province of Aklan
Note. Green colour on the map is the identified municipalities in the province of Aklan where sizeable patches of sago stands can be found.

Independent variables include Traditional Processing Practices, which encompass Selection, Rituals, and Extraction. These variables interact with intervening factors, such as Internal and External Challenges, which consist of labour intensity, lack of transportation infrastructure, and technical gaps. The dependent variable in this context is the Sustainability of the sago Industry. To address these issues, the SAGO Training Program, focusing on Sustainability, Adaptability, Guidance, and Optimisation, serves as a proposed intervention to align social traditions with technical efficiency.

Statement of the Problem

The main goal of this study is to closely examine the environmental impacts and day-to-day risks of traditional sago (*Metroxylon sagu*) processing. Specifically, it aims to answer the following questions:

1. What are the environmental and socio-economic impacts of traditional sago processing practices in the province of Aklan, Philippines?
2. What are the waste-management challenges and the ecological risks associated with current byproduct disposal?
3. What are the critical governance gaps and resource needs that hinder the efficiency and formalisation of the industry?
4. What training program can be designed to enhance the sago industry based on the results of the study?

MATERIALS AND METHODS

This study used a mixed-methods research design, specifically a sequential explanatory approach. According to Creswell and Plano Clark (2018), it is conducted to improve and explain the first statistics in which this method gathers and examines quantitative data and then a qualitative inquiry. This was chosen because neither approach alone could adequately capture the technical inefficiencies of sago processing as well as the lived experiences and the "why" behind traditional practices. By integrating both datasets, triangulation is achieved, whereby the researcher can check for statistical trends with detailed participant views (Creswell et al., 2003).

Aliaga and Gunderson (2002) reaffirm that the quantitative phase was to quantify technical challenges and baseline socioeconomic data of sago processors. There were 39-target population of sago starch processors in 12 selected municipalities in the Province of Aklan. The researcher used stratified random sampling to ensure representation from different geographic locations. The sample size was determined by using Slovin's Formula, which was 35 respondents. The data were collected by means of a researcher-made structured survey questionnaire that gave statistical data on processing volume, waste output and economic indicators.

After analysing the quantitative data, the researcher focused on the workers' personal stories and how they handle daily hardships (Creswell, 2003). For this part, 12 key experts were handpicked from the original survey group based on their deep knowledge and long experience in the sago industry. The researcher gathered their insights through group discussions and detailed, one-on-one interviews. With this, it gives the researcher a clear picture of why processors use traditional waste disposal methods and where local government support is missing.

Data integration occurred at the interpretation stage, where qualitative narratives were used to "dig into" the quantitative results. Creswell et al. (2003) point out that this triangulation serves to contrast data points and validate whether the statistical trends aligned with the participants' actual experiences in the field.

Since the researcher acknowledges their role as a neutral tool, the researcher practised reflexivity by keeping a research journal to monitor preconceptions and ensuring that the qualitative "voice" of the traditional processors was not overshadowed by statistical goals, that is, to maintain objectivity. Through this awareness, it helped ensure that the proposed SAGO Training remains culturally sensitive and is anchored on the actual needs of the Aklan processors, not a top-down imposition of technology.

Participants/Informants and Sample Size of the Study

Purposive sampling was used by the researcher in identifying the primary participants. The researcher coordinated with the Provincial Agriculture Office for the list of municipal agriculture officers and asked for their assistance to identify sago starch processors in their respective communities. A total of 35 sago starch processors were identified as respondents of the study. They answered the researcher-made survey questionnaire and were allowed to narrate their lived experiences pertaining to sago starch processing. Due to COVID-19 restrictions and health protocols, the researcher used snowball sampling in order to have additional/replacement participants during the conduct of the survey and interview.

Demographic Profile of the Respondents

The demographic characteristics of the respondents are presented in Figures 2 to 10. These figures provide a comprehensive overview of the respondents' profiles in terms of gender, age, educational attainment, marital status, primary occupation, monthly household income, primary sources of income, land ownership status, and land area distribution. Understanding these characteristics provides essential context for interpreting the findings of the study.

Figure 2 presents the distribution of respondents according to gender, while Figure 3 illustrates the age distribution of the respondents.

Figure 4 illustrates the educational attainment of respondents, while Figure 5 displays their marital status.

The figures above (6 and 7) illustrate the primary occupation and monthly household income of the respondents.

Figure 8 illustrates the primary sources of income for respondents, while Figure 9 displays their land ownership status. Additionally, Figure 10 below presents the area of sago palm land owned by the respondents.

As cited by Babbie (1995) and Crabtree & Miller (1992), Snowballing is a method of expanding the sample by asking one informant or participant to recommend others for interviewing. The researcher gave the local agriculture officers the authority to choose the farmers/sago processors that met predetermined criteria and recommend them as appropriate additional participants, especially in dealing with the focus group discussions/in-depth interviews. Local residents and some of the provincial/municipal agriculture officers served as key informants during the interviews.

Research Instrument

In order to address the study's analytical objectives and to capture the technical, environmental, and socio-economic dimensions of the sago industry in Aklan, the research instrument was made comprehensively and divided into four specialised sections. The first section focuses on the General Information of the respondents, consisting of nine items that detail their socio-economic profile, including sex, age, income, and land ownership. It gives basic information about the processors and looks at the resources they can access.

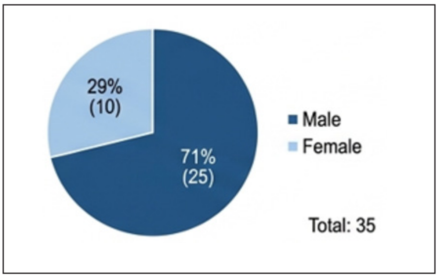

Figure 2. Distribution of respondents according to gender

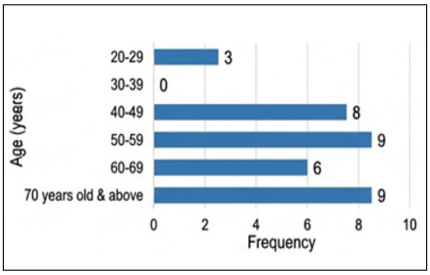

Figure 3. Distribution of respondents according to age

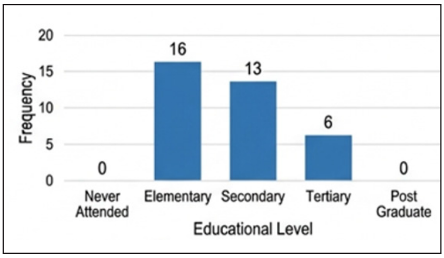

Figure 4. Distribution of respondents according to educational attainment

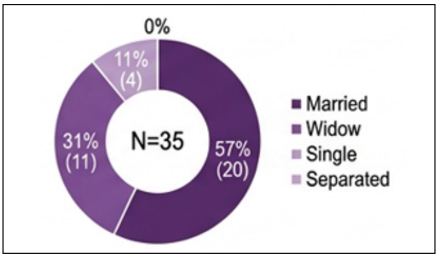

Figure 5. Distribution of respondents according to marital status

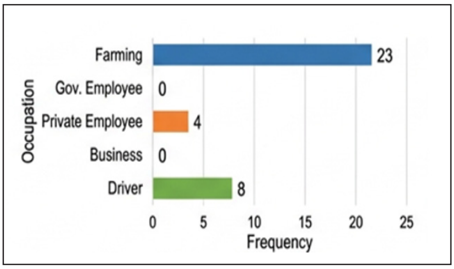

Figure 6. Distribution of respondents according to primary occupation

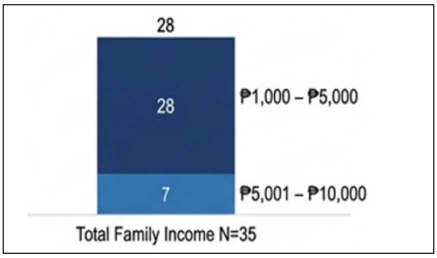

Figure 7. Distribution of respondents according to monthly household income
Note. Family monthly income - P 60.69 Philippine Peso = $ 1 US Dollar (as of March 2026)

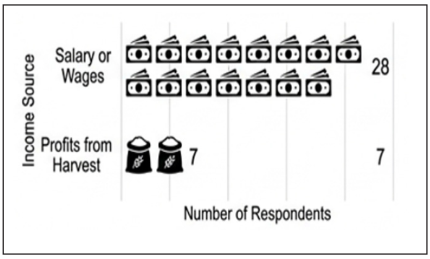

Figure 8. Distribution of respondents according to primary sources of income

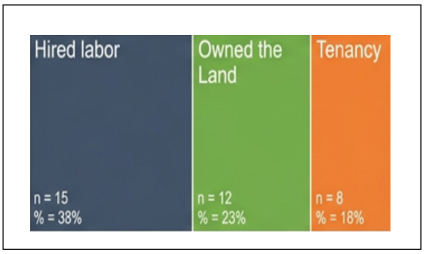

Figure 9. Distribution of respondents according to land ownership status

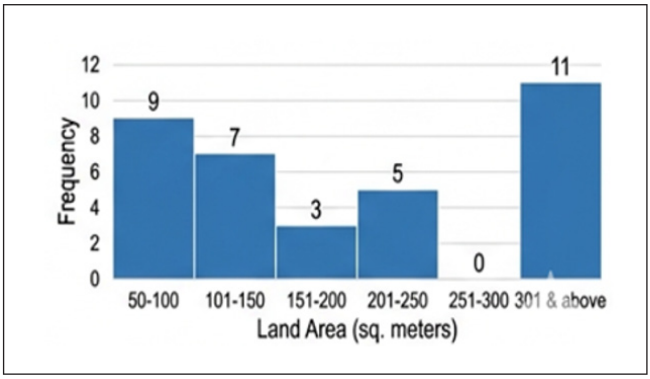

Figure 10. Distribution of respondents according to sago palm land area

The second section is the sago processing audit. It lists 12 main items to track details about labour, tools, time, and how much sago they make. These items helped find where work slows down and how resources are used in both the dry and wet processing methods used in the area. This part of the instrument is practical, almost mechanical, but it reveals where efficiency is lost.

Next comes the waste disposal section. Seven detailed questions explore environmental risks by examining the types of waste produced: bark, hampas (fibre residue), wastewater and recording how much is discarded and where it ends up.

Finally, the fourth section looks at challenges using 10 rating-scale questions and three open-ended questions. It measures major problems, like a lack of government support or poor equipment. It will help design the SAGO training program.

The questionnaire was developed through a three-stage process. Items were derived from the operational definitions of "Sago Starch Processing" and "Waste Disposal Practices". Questions were arranged chronologically to follow the actual flow of production from cutting and debarking to packaging and marketing, ensuring no stage was omitted. Segment here specifically asks about interest in technical knowledge and government-led training, directly feeding into the SAGO Training output.

For the reliability of the survey, experts in Sago processing first reviewed the draft to verify if the questions matched the actual steps and sustainability goals of the study. A pilot test followed, involving a small group of processors from a town outside the main sample. As in the case of the "Challenges" part, Cronbach's Alpha was used to confirm that the questions consistently measured how difficult the tasks felt. Some participants repeated the survey after a short time to confirm their answers stayed stable. Finally, open-ended questions, such as asking about interest in training, were included to add depth and verify the checkbox responses, helping keep the data clean and meaningful.

Data Gathering and Analysis Procedure

Twelve (12) municipalities in the province of Aklan participated in the study. The researcher used a triangulation approach to identify gaps in waste disposal practices and industry challenges. To guarantee a comprehensive dataset, quantitative surveys were paired with qualitative interviews.

Permission was formally secured from both the Provincial and Municipal Agriculture Offices. Self-administered questionnaires and structured, in-depth interviews were used to gather data. While a large number of processors were reached by the primary survey, key informants for qualitative investigations were found through purposive sampling and snowballing. The data collection period was done on June 28 to August 7, 2021.

In adherence with COVID-19 health protocols, social distancing was observed, written consent was required, and respondents were encouraged to rely on gestures and body language to minimise risk during face-to-face interactions. Participants were also briefed on data management and confidentiality and were informed that the intention of the investigation is for research and publication.

A mixed-methods approach was used for analysis. Statistical rigour was combined with the depth of phenomenology. The questionnaire data were totalled and tabulated utilising Microsoft Excel. Descriptive statistics such as mean, rank, frequency, and percentage distributions were applied to disposal practices and industry challenges. Whereas to identify more general patterns and connections in the dataset, inferential techniques were used.

As for the qualitative phase, capturing the "lived experiences" and "adaptive resilience" of sago processors was the goal. It started with bracketing, putting aside the researcher's preconceptions to ensure objectivity, in accordance with Moustakas's (1994) framework. Then, the researcher used a methodical six-step procedure: 1) Familiarisation: Verifying the accuracy of the data and finding any gaps; 2) Coding: Generating initial codes using highlighters on hard-copy transcripts; 3) Thematic Discovery: Identifying significant patterns related to the research questions; 4) Reviewing Themes: Consolidating relevant data points under each theme; 5) Finalisation: Naming and refining themes based on their essence; and 6) Documentation: Relating the themes back to literature and research objectives.

For a holistic view, the researcher developed: textural descriptions by detailing what processors experienced (e.g., difficult extraction tasks) and structural descriptions by detailing how they experienced it (e.g., the impact of poor tools and lack of market access). Figure 11 below shows the flow chart of the data gathering procedure.

All recorded interviews were transcribed on the same day they were conducted to prevent ambiguity or loss of context and to maintain internal validity.

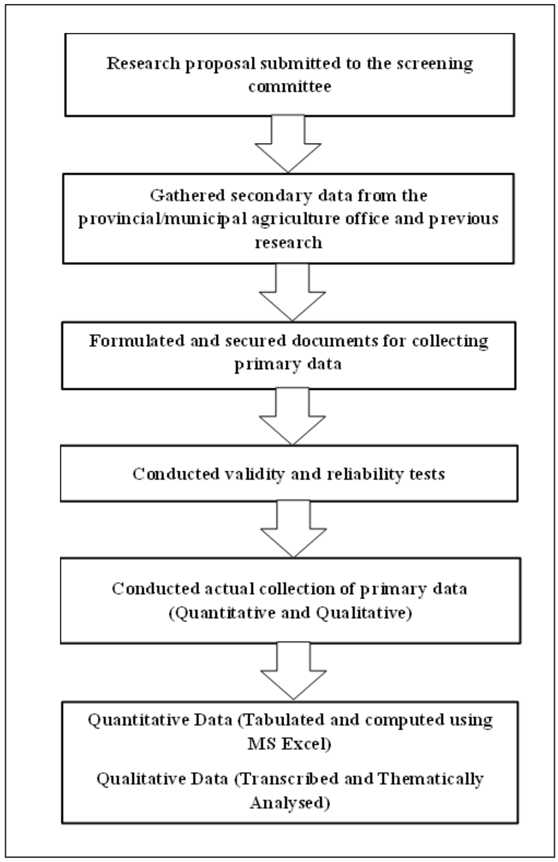

Figure 11. Flow chart of data gathering procedure

The synthesis of these methods was designed to optimise SAGO Training. Through understanding the "human" context behind traditional practices, the researcher ensured that the resulting training programs were both technically sound and culturally adaptable for Aklanon processors.

RESULTS AND DISCUSSIONS

Traditional Processing Practices in the SAGO Starch Production

Based on the interview conducted by the researcher, the sago processors in Aklan enumerated their traditional processing practices in sago starch production by: A) Identifying mature sago palm through different physical inspections; B) Rituals in cutting the sago trunk; C) Using traditional/manual tools/strategies during sago starch processing; and D) Two traditional methods of extracting sago starch. Data gathered pertaining to traditional practices in the sago starch production are presented in Figure 12.

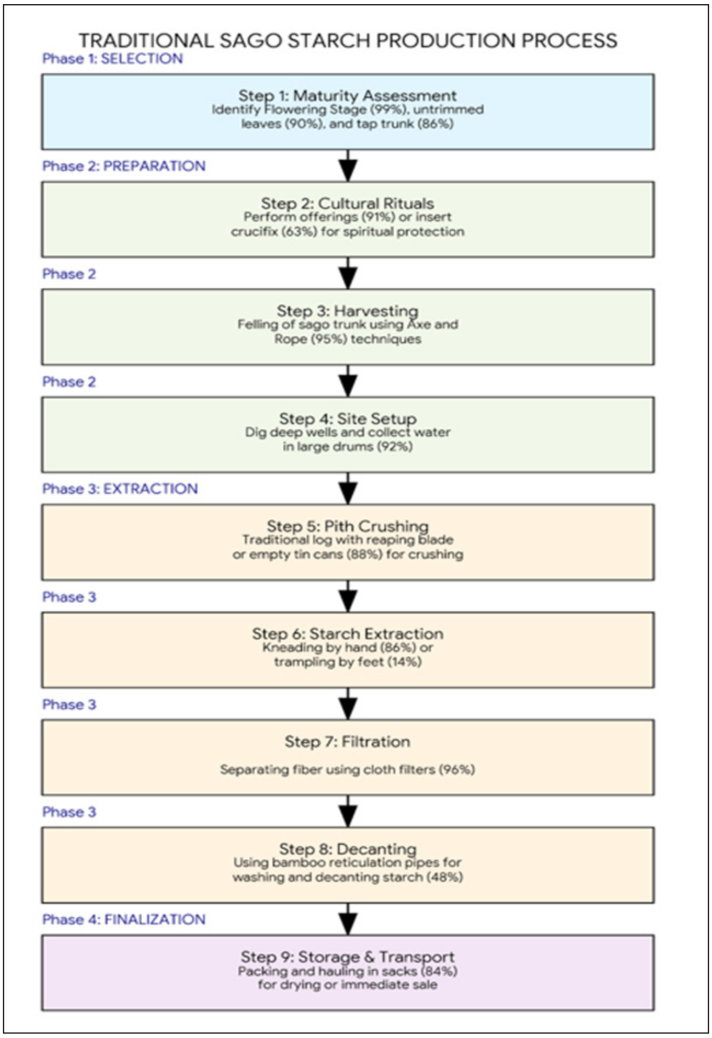

Figure 12. Traditional processing practices in sago starch production

Sago processors did different physical inspections in identifying the most desirable trunks (in terms of age and starch content) through the flowering stage (99%), conditions of leaves (trimmed or untrimmed) (90%), tapping the trunk (86%), water content after debarking (80%), and appearance of roots (43%). Wan (2016) attested that the best harvesting time for sago palm is the beginning of the "*inflorescence stage*" before the "*fruit ripening stage*".

Sago processor also prepare several rituals before they cut the sago trunk such as putting a small bundle of freshly squeezed sago starch as an offering (91%); making a crucifix made from small sago palm dry leaves and inserting it in its trunk (63%); rubbing of ginger on the bit/wedge of the axe (40%); put ginger in the mouth those who will cut the sago trunks (40%) and place two tikog leaves near the sago trunk and tie these tikog leaves (14%). This traditional sago processing in Aklan is governed by spiritual and cultural safeguards intended to ensure an abundant harvest and appease supernatural entities, a practice mirroring the Toradja of Indonesia, who offer sago to deter spirits from processing sites (Adriani & Kruyt, 1951). These customs include strict gender-based taboos, such as the exclusion of pregnant or menstruating women to prevent the perceived failure of starch to settle in water, a belief reflecting broader regional traditions in Papua New Guinea that associate menstruation with impurity and the potential disruption of communal tasks (Mohamed et al., 2018).

Sago processors enumerated their traditional/manual tools/strategies during sago starch processing. They filter sago starch using cloth (96%), employ axes and ropes to cut the trunks of sago palms (95%), and dig deep wells near the processing site to collect large quantities of water (92%). For crushing the sago pith, they attach reaping blades or empty sardine cans to bamboo or wooden logs (88%) and use sacks for packing, hauling, and storing the starch (84%). Additionally, they create reticulation pipes from split bamboo to collect water for washing and decanting starch (48%). These processors prefer manual felling over chainsaws to avoid damage from resin, followed by a critical pounding or rasping stage that breaks down the pith's cellular structure to release starch (Wan, 2016). In regions like Papua New Guinea, metal-reinforced wooden pounders are used (Toyoda, 2018), and the final yield is influenced by the “fineness” of the rasping process to ensure efficient starch washout during rinsing (Darma, 2018). Following extraction, communities employ various storage methods, such as dry, leaf-wrapped bundles or long-term wet storage in canoes or water-filled containers (Greenhill, 2006; Pue, 2013).

Sago starch extraction can be categorised into two types, the traditional and modern. However, principles of sago extraction for both methods are similar, while the differences are only in the scale of operation (Kamal et al., 2007 & Karim et al., 2008) and the processing tools that are used (Greenhill, 2006). According to sago processors, they practised the traditional way of extracting the sago starch by means of kneading by hand (86%) and trampling by feet (14%). They further explained that trampling by feet extracts more starch than kneading by hand and is not tedious.

Sophisticated fusion of indigenous knowledge, spiritual heritage, and economic practical results is reflected in Aklan's traditional sago industry. Sago processors use ecological knowledge to increase starch yields by scheduling harvests during the inflorescence stage. With its cultural customs and taboos that regard the sago palm as a sacred resource, this environmental conservation gives the community a sense of social solidarity and spiritual grounding.

Economically wise, sago processors prefer using simple, low-cost tools instead of expensive machines. Oftentimes, they make improvised equipment, like cloth filters, resin-resistant axes, and scraping devices from household waste. By doing this, it keeps costs low while still producing good results. sago processors also knead the starch by hand or use trampling for higher yield. These methods show a strong production system that balances effort and output.

Sago Waste Disposal Practices and Utilisation of Sago By-Products

Sago waste disposal practices refer to the repeated habitual or regular manner or procedure of an Aklanon in throwing away or getting rid of the substance or material such as bark, hampas and wastewater after its primary use in sago processing.

Data gathered pertaining to sago waste disposal practices and utilisation are presented in Figure 13, as it features the manner of eliminating and utilising these three sago wastes generated after the production of sago starch, namely sago bark, SAGO pith (hampas) and sago wastewater.

The data showed that 43% of the sago processors threw the sago bark in the river or left it on the site; 31% of them did the same for its sago pith (hampas), while its sago wastewater was 100% thrown in the river or left on the site. However, 46% of sago processors used sago bark as fuel, and 11% utilised it as wall for their houses. Meanwhile, there were 49% of sago processors who used sago pith (hampas) as feed for their backyard animals, and 20% of them utilised it as compost for their vegetable garden.

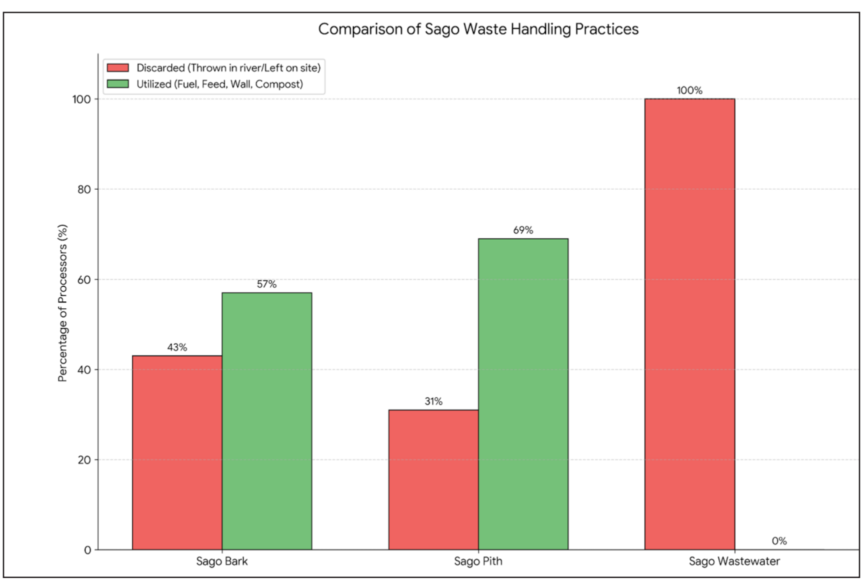

Figure 13. Sago waste disposal practices and utilisation of its by-products

In the research conducted by Murod et al. (2018), sago bark is the main solid waste from sago processing and has traditionally been used for things like machine bases, load supports, or as extra fuel. Nishimura (2015) cited that in large operations, such as in Malaysia, processing about 600 logs in one day can produce around 15.6 tons of bark, along with large amounts of wastewater and fibre waste. However, Amin et al. (2019) and Murod et al. (2018) contend that though sago bark is abundant, it is not fully used, it showed that only about 15% of shredded bark is burned as fuel to dry flour in sago mills, while most of it is simply burned to prevent buildup.

Sago pith, also called *hampas*, is a starchy by-product produced in large amounts during starch extraction. According to the study of Awg-Adeni et al. (2010), in places like Sarawak, Malaysia, daily output of sago pith can reach 50-100 tons. Because it still contains a lot of starch, hampas is often used as a cheap feed for pigs and ruminants, with nutritional value similar to sweet potato waste (Singhal et al., 2008). Aside from being used as animal feed, sago processors also utilise it as compost for vegetable gardens, and leave piles of hampas on-site, which encourages the growth of SAGO worms that thrive in the decaying material.

During the extraction of sago starch, it requires a water-intensive process, with liquid waste comprising 94-97% of the total output. This results in the daily discharge of 10-22 tons of wastewater per factory, characterized by an exceptionally high carbon-to-nitrogen ratio (105:0.12), which leads to the severe contamination of local river systems, evidence provided by Phang et al. (2000). Moreover, current practices reflect an "enormous" waste of water, as SAGO processors continue rinsing until the runoff runs clear, discarding the effluent without treatment.

Awg-Adeni et al. (2010) and Amin et al. (2019) posit that, nonetheless, research into biotechnological advancements suggests that these residues can be transformed into economic assets through value-added product development. Moreover, implementing established waste-utilisation models, such as those developed by Wan Samiati et al. (2010), Shaari (2014), and Umar et al. (2018), offers a pathway to mitigate environmental impact while providing sago processors with sustainable, alternative income streams through proper technical training.

Traditional disposal methods, like dumping waste in rivers or leaving it on-site, lead to conflict with environmental sustainability and are problems faced by Aklanons. These practices are cheap for sago processors but cause issues such as water pollution, eutrophication, and harm to local fisheries. There is a better option, where sago waste can be turned into useful products like eco-friendly building materials, compost, or renewable energy from biogas and bio-ethanol. So as to make this shift possible, training and workshops are needed to help local processors learn how to turn waste into economic opportunities.

Challenges and Issues of Sago Processors in Sago Starch Processing

Challenges and issues feature the difficult tasks or problems encountered by the respondents during sago processing from cutting to marketing. Figure 14 condenses the challenges and issues of sago processors in relation to sago starch processing.

The researcher summarised the challenges and issues extracted from the interviews, identifying several internal and external factors. Internal challenges included time consumption, rated at 100%, followed by the need for substantial manpower at 86%, limited water sources at 57%, poor tools and equipment at 46%, and limited technical knowledge at 26%. External challenges featured inadequate farm-to-market roads, rated at 71%, a lack of government support at 37%, an absence of a clear market at 26%, and insufficient waste management systems, along with a lack of political will and motivation, both rated at 14%.

Traditional sago starch processing faces significant internal operational challenges, particularly due to its intensive time and labour requirements. According to Pue et al. (2018), the process can take more than a full day, depending on the proximity to water and the available workforce. Loreto et al. (2006) noted that completing the extraction of a single sago log can take between 5 to 6 days and requires a team of 10 to 12 workers, which underscores the tedious nature of traditional methods.

Water scarcity poses a major challenge in the Aklan sago industry, compounded by limitations in resources and technology. Research studies by Nishimura (2015), Karim et al. (2008), and Singhal et al. (2008) indicate that transitioning from traditional manual horizontal methods to vertical mechanical water-flow systems can enhance efficiency. This shift has the potential to produce starch that is cleaner, of higher quality, and more hygienic.

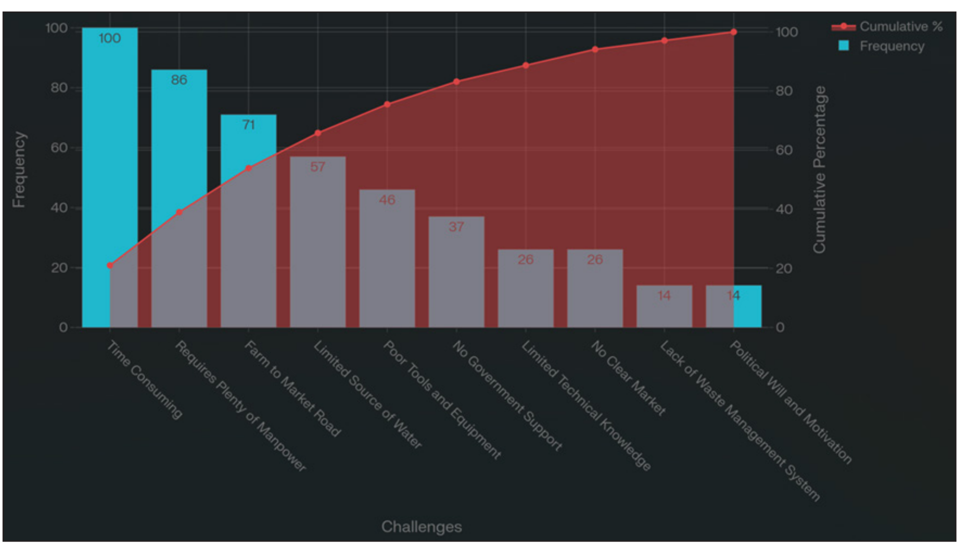

Figure 14. Challenges and issues of sago processors in sago starch processing

Sago processors are forced to spend excessive time on kneading and washing due to the use of substandard and traditional tools. This reliance on outdated methods is often attributed to a technical knowledge gap, as processing techniques are typically inherited from previous generations rather than informed by modern optimisation (Loreto et al., 2006).

Furthermore, the sago industry in Aklan has significant external pressures that threaten its sustainability, primarily because of logistical isolation and institutional neglect. Because sago palms thrive in swampy, interior forest regions, the lack of adequate farm-to-market roads remains a critical barrier to efficient transport. Saediman and Taridala (2006) note that this is compounded by a lack of government support and the absence of a clear market, forcing sago processors to rely on limited buyer information, which often prevents them from making profitable decisions.

Systemic issues further marginalise the industry despite demand spikes from Boracay's tourism sector. These include market volatility and inconsistent orders, which often result in mature palms being left to rot in the field. In addition, social and generational decline, where a growing "generational gap" exists, as modern youth show little interest in sago farming, leading sago processors to harvest primarily for subsistence or small-scale local sales. Lastly, governance & environmental gaps, in which lack of political will among local officials has resulted in sago concerns being excluded from community priority projects, leaving the industry without essential waste management systems or modern infrastructure.

Overall, the sago industry in Aklan is struggling both inside and outside the processing sites. Internally, workers rely on slow traditional methods that they find difficult to manage, made worse by limited water supply and outdated tools. Switching to mechanical washing could improve speed and cleanliness. Externally, the industry suffers from weak infrastructure, unclear markets, and little political support, forcing processors to depend on informal buyers. This neglect, combined with declining interest from younger generations, threatens the future of the industry. Without modernisation and better market access, sago processing will likely remain a small-scale, subsistence activity.

Sago Processors Coping Mechanisms in Sago Starch Processing

Processors of sago in Aklan have developed various strategies to cope with the challenges of starch production. Some of these strategies are practical, while others are more adaptive, showcasing how communities manage to sustain themselves despite limited support.

Figure 15 illustrates these coping mechanisms. For internal challenges, time management stands out, with 100% of processors relying on it. Next, division of labour was rated at 86%, highlighting the importance of teamwork. Resourcefulness received a score of 57%, innovation 46%, and seeking advice from experts only 26%. For external challenges, 71% of respondents noted the use of initiatives, while adaptability was mentioned by 37%.

Resilience and responsibility, along with optimism, were each indicated by 14%. These numbers tell a story: processors primarily rely on collaboration and initiative. In contrast, optimism and resilience, while present, are less commonly utilised.

Aklanon sago processors utilise a variety of coping mechanisms, characterised by resourcefulness, social collaboration, and local innovation, to navigate the significant challenges of starch production. Facing the time-consuming nature of sago processing, workers have adapted their schedules by cutting trunks into smaller logs, allowing them to manage their workload without having to finish an entire tree in one day. They also lessen labour demands through teamwork and by scheduling production during less busy periods in the rice farming cycle. To address the issue of limited water access, they dig deep wells near processing sites and use large drums to collect water for washing. Additionally, when tools are inadequate, sago processors create their own equipment, much like practices in Papua New Guinea, where wooden pounders are reinforced with metal tips or nails to enhance efficiency (Darma, 2018; Toyoda, 2018).

However, there are knowledge gaps among sago processors that need to be addressed. Through peer learning and community consultations, there is an identified urgency for formal technical training, particularly in processing and waste management, in order to modernise the sago industry (Rasyid et al., 2020).

Sago processors in Aklan face numerous challenges from both their operational systems and the surrounding environment. Despite these obstacles, they manage to continue their work by relying on local solutions, demonstrating strong resilience, and maintaining personal optimism to sustain their livelihoods.

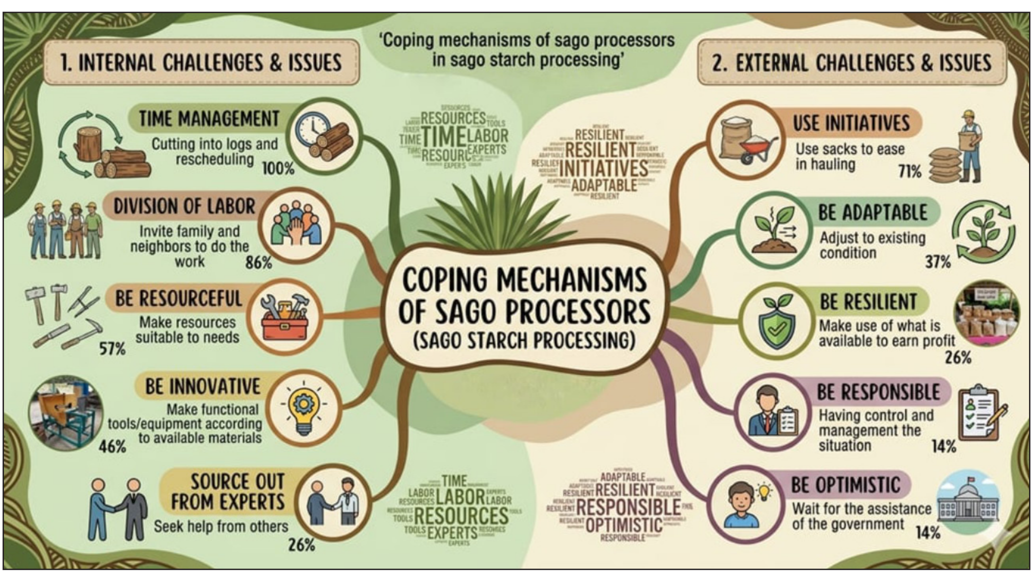

Figure 15. Coping mechanisms of sago processors in sago starch processing

As Jong (2018) noted, common challenges for sago industries include geographical remoteness and poor farm-to-market roads. In response to these issues, sago processors employ resourceful methods for storage and transportation. They safely manage and transport their starch using woven natural fibre bags, plastic containers, or ceramic pots (Greenhill, 2006).

In the absence of government support and clear markets, sago processors have adopted an adaptive coping strategy, perceiving these stressors as conditions to be managed rather than insurmountable threats (Southwick et al., 2005). However, long-term sustainability requires a shift toward "greener technology," such as the Argao dry-processing method, which minimises waste (Flores, 2016), alongside formal training for farmers in waste management (Rasyid et al., 2020).

Despite a lack of formal waste management systems and poor regulatory enforcement on effluent disposal (Awg-Adeni et al., 2010), processors take individual responsibility by piling waste in specific areas to mitigate immediate environmental damage. Sago processors maintain a mindful, optimistic outlook to navigate the lack of political motivation in their communities (McKee et al., 2008). Nevertheless, research concludes that true industry sustainability is impossible without government-led incentives, capacity building, and improved financial institutional support (Girsang, 2018).

Sago processors in Aklan keep their livelihoods going through teamwork, creativity, and resilience, adapting to the hard work of starch extraction with careful scheduling and improvised tools. They deal with poor infrastructure and little government support by taking responsibility for environmental impacts themselves. Still, long-term sustainability will depend on proper technical training, the use of greener technologies, and government incentives. Many processors believe the sago palm could help drive economic recovery if supported with modern machinery and better ways to use waste.

Output of this Study for Sago Industry Enhancement

This study presents an overview of traditional sago processing, waste disposal, and the challenges faced in Aklan, Philippines. The primary aim is to strengthen the sago industry and enhance waste management by proposing training programs for sago processors and their families. The training will emphasise sustainability, adaptability, guidance, and efficiency, while also addressing the use of waste, mental health concerns, and providing additional livelihood opportunities. Drawing inspiration from initiatives in other countries, the study seeks to demonstrate how sago waste can be transformed into valuable products that benefit both the community and the environment.

Furthermore, the study highlights that while sago processors in Aklan are resilient in coping with challenges, their efforts tend to focus on mere survival. Poor tools and limited market access keep them trapped in a cycle of poverty. To transform sago from a small,

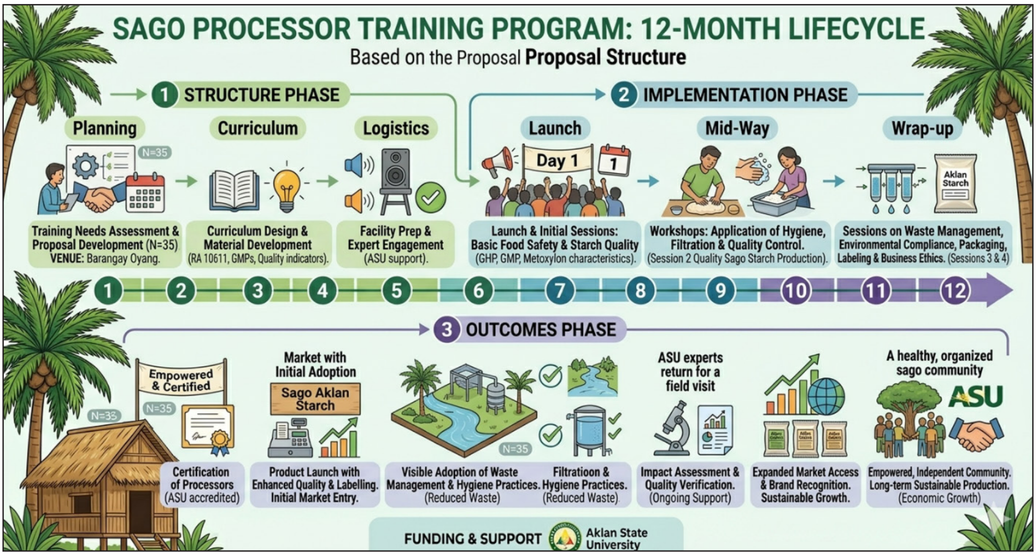

Figure 16. Sustainability, Adaptability, Guidance and Optimisation (SAGO) Training Proposal

struggling endeavour into a more robust economic resource, support must extend beyond individual resilience and involve institutional backing. Providing modern machinery and technical training would not only save time and enhance efficiency but also help rebrand the industry as a modern and sustainable livelihood for future generations. Figure 16 shows the outline of the SAGO training proposal.

CONCLUSION

This paper highlights the cultural and economic importance of sago processing in Aklan, Philippines. It recognises the various efforts and experiences of local sago processors. The proposed SAGO Training Program aims to enhance the sustainability of the industry, convert waste into valuable products, and protect local ecosystems.

Based on the discussions, key recommendations include improving infrastructure with support from local government, enforcing waste management regulations for sago mills, establishing a dedicated "SAGO Desk" to assist processors, and promoting modern technology and product diversification to raise industry standards. The S.A.G.O. model could potentially be applied in other regions as well, but additional research on biotechnology and the involvement of youth is necessary to ensure long-term growth and revitalisation of the sector.

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CONFLICTS OF INTEREST

The authors declare no competing interests.

DISCLAIMER

During the preparation of this work, the authors used ChatGPT (OpenAI), Google Gemini and Microsoft Copilot in order to assist with drafting and language editing, structural revision of the manuscript in response to peer-review feedback, preparation of supporting figures and verification of references against publicly available regulatory and bibliographic sources. After using these tools, the authors reviewed and edited the content as needed, independently verified all factual claims, data values, and citations against primary sources and take full responsibility for the content of the published article.

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