FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Improving efficiency in the Nigerian aquaculture sector by employing Lean Production Systems

Fish Innovation Lab

Final Technical Report: June 1, 2020 – August 15, 2023

Cooperative Agreement 7200AA18CA0030

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MISSISSIPPI STATE UNIVERSITY
GLOBAL CENTER FOR AQUATIC HEALTH AND FOOD SECURITY

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Prepared by:
Rohana Subasinghe, Project Lead, and Host Country PI
Sunil Siriwardena, Host Country Co-PI
Joseph T. Steensma, U.S. Co-PI
Julius A. Nukpezah, U.S. PI
Terri Lawrence, Lead Consultant
Oyediran Olusegun Oyebola, Consultant
Elizabeth Akuwa, M&E Specialist
Cletus Bijalam Mbalida, Research Assistant

This report is made possible by the generous support of the American people provided by the Feed the Future Innovation Lab for Fish through the United States Agency for International Development (USAID). The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government. The Feed the Future Innovation Lab for Fish is managed by Mississippi State University through an award from USAID (Award No. 7200AA18CA00030; M. Lawrence, PI) and provides support to Grant No. [00003821]; [R. Subasinghe], PI

Partners/Institutions

WORLDFISH
Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang Malaysia
IITA Campus, Ibadan, Nigeria

MISSISSIPPI STATE UNIVERSITY (MSU):
Mississippi State University, P.O. Box 6100, Mississippi State, MS. 39762-6100

WASHINGTON UNIVERSITY IN ST. LOUIS
One Brooking Drive, St. Louis, MO 63130, USA

COLLABORATIVE IMPACT

Seattle, WA, USA.

UNIVERSITY OF IBADAN (UI)

Ibadan, Oyo State, Nigeria

TREASURE FISH FARMERS MULTI-PURPOSE COOPERATIVE SOCIETY

34, Ekiugbo-Warri Rd, Ekiugbo, Ughelli, Delta State

IJEBU DEVELOPMENT INITIATIVE ON POVERTY REDUCTION (IDIPR)

Ijebu-Ode, town, Ogun state, Nigeria

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE (IITA)

PMB 5320, Oyo Road, Ibadan 200001, Oyo State, Nigeria.

Abbreviations and Acronyms

IITA – International Institute of Tropical Agriculture
MSU – Mississippi State University
WUSTL – Washington University at St. Louis
IDIPR - Ijebu Development Initiative on Poverty Reduction
TPS - Toyota Production System
UI- University of Ibadan
UN – United Nations
FAO – Food and Agriculture Organization of the UN
USD – United States Dollar
LSME - Lean Subject Matter Expert

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Abstract

The aquaculture sector has been growing at a rate faster than any other food production sector in the world. Aquaculture now contributes nearly 50% of total fish consumption worldwide. Although aquaculture is growing and is poised to contribute more to global food demand, the sector faces significant challenges and bottlenecks. Many critical issues continue to stifle aquaculture growth in Africa. Nigeria, Africa's second-largest aquaculture producer, continues to struggle to bridge the gap between production output and domestic fish consumption demand.

Lean management technology

Toyota Motor Corporation revolutionized the automobile industry with its Toyota Production System, which has evolved into a wellspring of competitive advantages. The primary goal of this system, also called Lean management, is to minimize costs or maximize efficiency by eliminating waste and converting waste into value. Waste reduction and process optimization are key components to improve quality and delivery while conserving resources like time and money.

Despite the overwhelming evidence that several agricultural businesses are adopting Lean practices and benefiting from them, others in the sector are less prepared to implement the tools used in Lean management. Further, the integration and application of Lean principles to aquaculture is largely still in its infancy, yet the sector represents a huge opportunity for efficiency gains.

Project objectives

Considering the importance of better understanding the production and processing inefficiencies in Nigerian aquaculture and finding solutions for improvement, a Feed the Future Innovation Lab for Fish project examined the suitability and practicality of using the Lean management concept and training fish farmers on effective practices. The specific objectives are to use Lean management to:

- improve operational efficiency.
- reduce post-harvest losses.
- improve waste management.
- decrease the cost of production.

Summary results

The results show significant improvements in the aquaculture value chain efficiency in Nigeria after the intervention, which suggests that the Lean approach has successfully minimized inefficiencies in fish farms in Ogun and Delta States. With rare exceptions, farmers reaped benefits from Lean training, regardless of age, gender, geographical location, company status, farm type, farm size, and annual income. Findings demonstrate the ability of Lean management practices to continue helping the Nigerian aquaculture sector and individual farmers to drastically reduce waste and become more profitable. Building a more resilient aquaculture industry in Nigeria requires equipping farmers with the tools to address different types of on-farm waste, and this study demonstrates that Lean management tools are simple to incorporate and effective.

Key findings

The 14 domains of waste that benefited from the application of Lean management include reduction in time, mortality, and labor cost. Lean management tools also contributed to efficiency in energy use, inventory space, labor, feed cost, and feed quantity. The other

domains that improved are reduction in medication cost, water treatment cost, transportation cost, maintenance cost, and fish losses.

Key Beneficiaries

- The project trained 40 Nigerian aquaculture value chain actors and certified them as Lean Subject Matter Experts (LSMEs) in aquaculture. These trainees have been equipped with the necessary tools to train others to adopt and disseminate the Lean management tools.
- In all, more than 340 aquaculture value chain actors benefited directly from Lean management training, with about 20 percent being females. The statistical analyses attest that females are good adopters of Lean innovation, as are their male counterparts, and that they could be used in scaling up the technology.
- Although aquaculture in Nigeria is considered a pastime of retirees and it is dominated by older people, efforts were made to include the youth. Ten percent of the beneficiaries were below 31 years. Only 10 percent were above 57 years.
- The project included actors with small, medium, and large-scale aquaculture activities. Although most farmers identify as smallholders, the project targeted beneficiaries with corporate recognition and demonstrated that Lean tools can benefit all these groups, too.
- Although Pond is the popular system of choice in Nigeria and accounted for 75 percent of the systems used by the beneficiaries, users of tank systems (18.5%) and other systems (6%) benefited from how Lean can contribute to improving the efficiency of their aquaculture production business.
- Although the beneficiaries come from two states, outreach programs using Webinars suggest the beneficiaries of the innovation extend beyond the borders of these states.

Recommendations

- Given the reported benefits of Lean in the two Nigerian states, the scope of Lean management should be expanded to other states, the West African sub-region, and elsewhere in the world by extensively disseminating the study findings through publications, conferences, webinars, etc.
- Since Community-based Lean Subject Matter Experts (LSME) can be effective resources for disseminating the tools, these should be certified as trainers and paid for their services, to ensure the continuity of the project beyond the lifespan of the project.
- Acknowledging that financial resources are needed to expand the scope of the project, the project team, along with the Management Entity and other stakeholders, should consider exploring other funding opportunities to spread the Lean innovation.

Introduction

Toyota Production Systems and Lean Management

Toyota Motor Corporation revolutionized the automobile industry with its Toyota Production System (TPS), which, introduced in the late 1940s and early 1950s, has evolved into a wellspring of competitive advantage. Following Toyota's unparalleled successes in improved efficiency and profitability, TPS's evolution, principles, designs, and applications have been the subject of significant research. The primary goal of the TPS is to minimize costs or maximize efficiency by eliminating wastes like excess inventory workforce (Monden, 2012). The TPS is one of the key precursors of lean production and its thinking, defined in (Womack et al., 2007) as the process of continuously converting waste into value from the perspective of the customer, increasing production line efficiency and flow, and maximizing benefits with the fewest resources through continuous improvement. Thus, waste reduction and process optimization are key components of lean manufacturing. These techniques help to improve quality and delivery while conserving resources like time and money.

Lean Management in Food Production Systems

The agricultural industry is among those with the highest annual losses and waste. Based on its analysis of total waste from farm to fork, the UN Food and Agricultural Organization estimated that approximately one-third of all food products intended for human consumption is lost annually, contributing to food insecurity. These losses are estimated to total over a billion tons of food and $940 billion in lost economic output each year (Huho et al., 2020). According to the most recent report on global food waste, 15.3% of all food produced is still wasted annually at farm stage, or 1.2 billion tons (WWF-UK, 2021). Consequently, many researchers have been evaluating the viability of lean production principles in the agricultural sector and assisting food suppliers and farmers in putting these principles into practice to reduce losses and increase profits.

Despite the overwhelming evidence that many agricultural businesses are adopting lean practices and benefiting from them, others in the sector are still less prepared to implement lean. (Castro & Posada, 2019) reported, for example, that only a few businesses in the baking industry have high standards for using lean manufacturing methods. (Raja Sreedharan & Raju, 2016) concluded that there are fewer studies on lean management in the food industry than in other areas after a careful, systematic literature review of various sectors that have adopted lean as an operating paradigm.

Waste and Inefficiency in the Aquaculture Sector

The integration and application of lean principles to aquaculture is largely still in its infancy, yet the sector represents a huge opportunity for efficiency gains. Aquatic products (i.e., fish, crustaceans, molluscs, and other aquatic animals, but excluding aquatic mammals, reptiles, seaweeds, and other aquatic plants) derived from aquaculture are an important, nutritious, and chosen food commodity with a high consumer demand, requiring continuously increasing volumes of supplies. According to FAO fisheries and aquaculture statistics, aquaculture accounted for 56.2 percent of combined global fisheries and aquaculture production in 2020 (122.58 million tons produced with a value of USD 281.5 billion; FAO FishStatJ, 2022).

Aquaculture production accounted for 47.8 percent of fish for human consumption over the same year. With marine fish catches relatively static since the late 1980s, aquaculture has been responsible for the continuing impressive growth in the supply of fish for human consumption. If fish production and trade take place as "business as usual" (supply based on continued recent growth trends), there will be a significant demand-supply gap by 2030. Recent trends confirm that global aquaculture will continue to expand, diversify, and intensify over the coming decades, to bridge the demand-supply gap. What is important is that we bring our past experiences in tackling the hurdles and bottlenecks of sector growth, to ensure that this predicted expansion and intensification will result in sustainable aquaculture development and production (Subasinghe et al., 2023).

Despite this growth and tailwind for the sector at large, the aquaculture industry faces several challenges, including significant annual waste and economic losses, with contributors ranging from improper farming techniques, fish deaths during live marketing, lack of cold chains, disease, and poor handling that results in contamination and physical deterioration to name a few. An analysis by (Akande & Diei-Ouadi, 2010) found small-scale fisheries losses in five countries in sub-Saharan Africa to be 5% of their total fish yield; The average loss reached about 30% of the fish that were caught, processed, and traded when quality losses, which accounted for 70% of this loss, were considered. In short, there is ample evidence of losses and inefficiency across the aquaculture value chain.

Lean: An Opportunity for African Aquaculture?

Over the years, African aquaculture production has gradually increased, but progress remains far from fast (Hinrichsen et al., 2022). In terms of production volumes and worth, Egypt leads African aquaculture, and Nigeria follows (Hinrichsen et al., 2022). However, Africa's contribution to global aquaculture production as of 2020 stands at approximately 2.7%, which is a consequential improvement from just a decade earlier

but is a fraction of the amount needed to satisfy demand (Halwart, 2020)

Many critical issues continue to stifle a more robust aquaculture growth in Africa. Study conducted by (Affognon et al., 2015) in Sub-Saharan Africa, found approximately 25% of the fish harvested is lost, and underdeveloped cold chains are recognized as a salient area for intervention to boost value chain actors' profits and resource efficiency (Chan et al., 2019). Nigeria now ranks as Africa's second-largest aquaculture producer with an annual production output of approximately 300,000 tons, dominated mainly by cultured tilapias, catfish, and carp (Adeleke et al., 2021; Emmanuel, 2014) However, the current demand for fish in Nigeria has been about four times the local production level, and Nigeria continues the struggle to bridge the gap between production output and domestic consumption (Emmanuel, 2014). While Nigeria spends significant foreign exchange to import fish, lack of organized cold chain structures, efficient processing and value adding, and overall poor inputs and waste management in aquaculture continue to make roadblocks in the national aquaculture development process.

Considering the importance of better understanding the production and processing inefficiencies in Nigerian aquaculture towards finding field solutions to improve value chain efficiency, this project was designed to examine the suitability and practicality of using Lean Production Systems concept in Nigeria’s aquaculture system.

Research Methods

The research utilized a train-the-trainer model, in which experienced aquaculture professionals from Delta and Ogun States applied to become experts in lean production. Those selected to become Lean Subject Matter Experts (LSMEs) applied to the program after attending a "Lean Sensitization" workshop, wherein participants were exposed to lean principles and examples of how it could be applied to aquaculture. Forty LSME-trainees were selected based upon their demonstrated interest, social standing in their community, and capacity to help others carry out lean projects. Participants were initially trained in lean techniques, starting with online training and then a week-long in-person training that included classroom and field experiences. Once they demonstrated their proficiency in lean principles, these local experts were asked to return to their cooperatives, communities, and corporations to share their knowledge. Their task was to help others identify areas of waste and develop projects to address those issues.

Photo 1: Professionals from Delta and Ogun States in training to become lean experts

LSMEs and the 212 farmers they assisted carried out a total of 265 projects, addressing 410 targeted areas of waste. Demographic and project-specific data were collected using the RedCap repository and imported into IBM SPSS Version 29 and R-studio for additional examinations. Pre- and post-intervention evaluations were conducted using either of two techniques based on the attributes of the data. The data collected included project intent, targeted waste, pre-intervention measurements, and post-intervention measurements. The project aimed to evaluate whether the interventions implemented by the farmers led to waste reduction and/or improved efficiency and whether different groups experienced varying benefits (e.g., female versus male, Delta State versus Ogun State, young farmers versus older farmers). Data were analyzed using SPSS, and pre-and post-intervention effectiveness was assessed using two methods. Paired sample T-tests were utilized unless the assumptions for the assessment were violated. In such scenarios, the non-parametric Wilcoxon Sign-rank Test was used to identify variances in distributions across pre- and post-intervention measurements.

Picture 2: Trained LSME sensitizing fish farmers on Lean technology

Project intentions (reducing labor time, cutting labor costs, lowering energy consumption, and decreasing feed quantity, etc.) varied widely, indicating the numerous challenges fish farmers continue to face in the Nigerian fish supply chain. The places of intervention in the value chain were also very different and included the hatchery, feed production and processing, nursery, and logistics. Almost twenty intentions were the focus of the projects. However, only fourteen (14) were included in the analysis because the number of projects associated with the rest was too few to constitute a sufficient sample.

A percentage reduction between the pre-and post-intervention measurements was computed for each project intent and assessed to determine the effectiveness of the interventions. Additional analyses compared the improvement observed across the various groups to explore differences in benefits.

Research Results

Introduction and Demographics.

Forty Nigerian Lean Subject Matter Experts, or LSMEs assisted two hundred and twelve fish farmers in implementing interventions to tackle inefficiencies in their operations. In total, there were 265 Lean interventions that sought to address 410 processes that were identified for improvement. The Lean interventions addressed fourteen domains of inefficiency, or waste, in the fish supply chain. These waste domains ranged from reducing time wastage (in transportation, movement, or waiting times) to lowering the costs of water treatment. However, only eleven domains of waste were considered for statistical analysis to measure the impact of the Lean intervention. The remaining three areas had less than twelve projects; they lacked the sample size to conduct meaningful comparisons and were therefore omitted. **Importantly, the intervention proved to be effective in reducing waste across all the areas evaluated** (Appendix-Table 2). It was equally beneficial to almost all farmers, regardless of their sociodemographic characteristics such as age, gender, and location, as evidenced by the percentage improvements observed after the intervention.

The ratio of farmers to projects was 4:5, indicating many farmers took on more than one Lean intervention. On average, the farmers were 43 years old and had approximately nine years of experience in aquaculture. The sample was skewed towards male farmers (80.2%). Two hundred farmers revealed their location, and those farmers were nearly evenly split between Ogun and Delta states. Three-quarters of the farmers (75.9%) used ponds for fish rearing, 18.4% used tanks, and the remaining 5.7% used other systems for fish farming. More than four out of five farmers (81.6%) identified themselves as smallholders, compared to 18.4% as corporate farmers. One hundred ninety-seven armers reported their operation scales in tons, with 53.8% indicating an operation size above 4 tons. 22.3% and 23.9% reported operation scales between zero and two tons and between 2.01 and 4 tons, respectively. Of the 198 farmers who disclosed their annual revenues, 40.4% earned over 5 million Naira, while 23.2% earned between 2.6 million and 5 million. The remaining 36.4% earned not more than 2.5 million.

Waste Domains

Time wasted

Central to reducing or eliminating waste using Lean management techniques is to eliminate waste caused by transportation and unnecessary movement of workers, materials, and equipment. Farmers carried out 103 interventions to tackle processes that led to time or motion wastage. The overall average percentage reduction in time wasted for all groups was 68.8%. Large farms (earning more than 5 million Naira annually) and corporate operations recorded an average improvement of 73.5% and 70.2%, respectively, while smaller operations saw a gain of 68.3%. The intervention had a statistically significant impact ($p<0.05$) in reducing time spend in motion or movement. Further analysis showed no significant difference in the percentage improvement across various subgroups. For instance, male and female farmers experienced similar benefits. These results indicate that the intervention substantially improved this domain of waste for all farmers, regardless of gender, location, farm size, or system type (tank or pond). Refer to Tables 2 and 3 in Appendix A for detailed results.

Photo 2 and 3: Before and after picture of time waste due to transportation and unnecessary movement

Fish Mortality

Sixty-five interventions focused on decreasing fish fatalities. Before implementing the Lean intervention, the fish mortality rate was at an average of 33%. However, after the intervention, the rate dropped by almost 85%. The study demonstrated that the intervention substantially improved this domain of waste ($p<0.05$; see Table 2 in Appendix A). The average decrease in fish mortality rates for small-scale farmers and corporate farmers was 84% and 88%, respectively. At the same time, corporations earning more than 5 million Naira annually experienced an 86% decline in mortality rates. Similar trends were observed across sex, farm system, operation, and age groups. Comparative analysis revealed no statistically significant differences in average percentage fish mortality rate reduction across operation size, annual income, location, corporate status, age, and farmer sex. However, the average reductions were significantly higher in pond and tank projects than in projects where farmers reported using other systems for fish rearing ($p<0.05$). Overall, however, the intervention equally contributed to mortality reductions across the various groups (Appendix A-Table 4).

Photo 4: Fish mortality attributed to defect in water management.

Energy Consumption

Fifty-nine interventions were executed to lower energy consumption. The total decline in the quantity of fuel in liters was 48% and had statistical significance ($p<0.05$; Table 2 –Appendix A). The mean drop for corporate farms was 58% compared to 45% for small-scale farmers, but the variation was statistically insignificant. Although there were no significant variations observed among the remaining demographics (age, gender, operation size, state), the reduction percentage in energy consumption distinctly favored corporate farms over smallholder farms (Appendix A-Table 5).

Feeding Costs

Thirty-six interventions were implemented to decrease the expenses related to frequent feed purchases. Farmers observed a statistically significant 27% reduction in feeding costs despite the rising inflation. The decline was 22% in larger farms as opposed to 29% in small-scale farms, but the disparity was statistically insignificant. Farms that earned over 5 million annually witnessed a 19% decrease in feeding costs, which was considerably lower compared to the rates in the other income groups ($p<0.05$). Corporate farms with an operation size exceeding four tons also experienced a lower reduction (19%) than others ($p<0.05$). This is not unexpected, given that larger operations would tend to have less variation in feeding practices. Apart from that, all farmers across other demographic characteristics equally benefited from the intervention Appendix A-Table 6).

Hired Labor Costs

Twenty-four interventions were carried out to reduce these daily expenditures on labor. Hired labor expenses varied greatly across the various sizes of operations, which is to be expected. Importantly, the percent reduction of labor costs before and after the Lean interventions across all groups was both practically (56% reduction) and statistically significant (Appendix A-Table 2). In terms of percent reduction, the interventions were equally effective across all demographics, with no statistically significant differences observed across farm systems, location, operation size, annual income, and age (Appendix A-Table 7)

Water Treatment Costs

The mean decrease in expenses for water treatment was 60.3% and was statistically significant (Appendix A-Table 2). The reductions for small-scale farmers and corporates were 57% and 70%, respectively, and 65% and 55% for Delta and Ogun States farmers, respectively. Farmers with a higher annual income (over 5 million Naira) experienced a 51% decrease compared to 75% for those earning between 2.6 million and 5 million. No marked variances were detected across farm systems and operation size, but the reduction rate for younger farmers (18-30 years) was significantly less than that in the other age groups ($p<0.05$). However, overall, the interventions had an equally positive impact on all farmers (Appendix A-Table 8).

Medication Costs

Farmers also executed twenty-one interventions to combat the escalating expenses of antibiotics to reduce fish mortality. By prioritizing approaches that pursued economical alternatives and tackled the underlying causes of fish morbidity and mortality, farmers experienced an overall decline of 71% in medication expenditures ($p<0.05$). Females experienced a reduction of 74%, while small-scale farms witnessed an average decrease of 75%. Delta and Ogun States' rates were 72% and 70%, respectively. In contrast, larger corporations with an operational size of over 4 tons and an annual revenue of over 5 million Naira witnessed cutbacks in antibiotic costs of 74% and 69%, respectively, post the intervention. The highest average reduction (78%) was observed in farmers aged 57 and above. No statistically significant differences in reduction rates were observed across any of the

demographics (age, sex, location, etc.) (Appendix A- Tables 2 and 8).

Other Domains

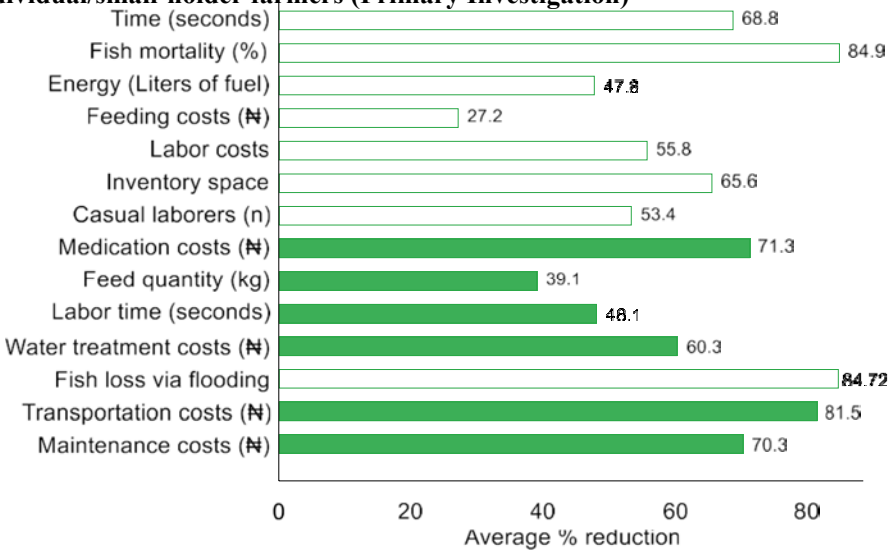
Regarding the remaining waste domains, farmers observed a 66% enhancement in storage capacity, a 53% decrease in temporary workers, a 39% reduction in daily feed quantity, and a 48% decrease in work hours. These improvements were statistically significant ($p<0.05$; Appendix A-Table 2). Nevertheless, no significant variations were observed regarding sex, farm category or corporate status, farm systems (except labor hours), location, operational size (except feed quantity), yearly income (excluding feed quantity), and age (Appendix A-Tables 9, 10, and 11).

Concluding Remarks: Comparison of two studies reported in Appendix A and Appendix B

This project consisted of investigations. The initial (and larger) objective of the investigation, which was conducted over two years, involved individual farmers and LSMEs implementing solutions to reduce waste and small-aquaculture operations. A small pilot project was undertaken after the initial study demonstrated success to assess the feasibility of implementing similar training and technologies in larger commercial operations. In this follow-up study two large-scale, commercial aquaculture operations were chosen to participate. Their employees received the same training as the LSMEs in the initial investigation. The difference in the two studies, in effect, was the environment; in the initial investigation, individual farms and small-scale operations were the target for the intervention, in the follow-up, large-scale operations were the target. In the initial investigation (reported in Appendix A), farmers enjoyed an overall 47.8% reduction in energy consumption. Fish mortality was reduced by 84.9% (this improvement was observed in a very short time frame during a process wherein fish mortality is elevated), and time wasted declined by nearly 70%. There was a 27.2% reduction in feed costs, and feed wastage saw a reduction of 39.1. Figure 1 shows the average post-intervention reductions (in percentages) across the 14 domains of waste among individual/small-holder farmers for the primary investigation, which is reported in Appendix A.

In the follow-up study (i.e., large-scale producers; reported in Appendix B), there was ample evidence pointing toward consequential improvement in both episodic and long-term fish mortality. Energy consumption was reduced by an average rate of 54.3% (individual team rates were 46%, 43%, 70%, and 58.3%), which was higher than the 47.8% in the original report. An overall average reduction of 10.7% (range: 10% to 11.3%) was observed, which was lower than the 39.1% previously reported. In the current study, one team reported a 42% increase in available space. In the original study, an increase of 34.4% in available space was achieved by reducing the amount of inventory. The results of the initial investigation, which had a much larger sample size than the follow-up study in large-scale commercial operations and was conducted over a longer time period, demonstrate that lean production and management practices indeed have the potential to reduce waste across domains for individual and small-scale commercial operations. The results of the follow-up study, which was conducted are large-scale commercial operations, are equally encouraging, though the smaller sample size and shorter duration are noted as limitations.

Figure 1: Average post-intervention reductions (in percent) across the 14 domains of waste among individual/small-holder farmers (Primary Investigation)



Outputs and Conclusions

The main project outputs and achievements are as follows:

1. Forty Nigerian aquaculture value chain actors have been trained as Lean Subject Matter Experts (LSMEs) and have been certified as effective resources for disseminating the tools.
2. Over 265 smallholder farmers and value chain actors have applied Lean principles in their respective workplaces and benefited from improving workplace efficiency.
3. The lean management system, as it applies to aquaculture production, has been disseminated to several people using seminars, conferences, workshops, Webinars, among others.
4. Lean systems management training manual and curriculum have been developed and applied.
5. RedCap database for continued Lean application data management has been developed and applied.
6. A general interest in applying Lean principles in workplaces by selected aquaculture communities has been created.

The project conclusions are that:

I. The significant improvements observed after the Lean management intervention suggest that the Lean approach has successfully minimized inefficiencies in fish farms in Ogun and Delta states and that it can be applied to aquaculture production.

II. With rare exceptions, all farmers reaped benefits from Lean interventions, regardless of age, sex, geographical location, company status, farm type, farm size, and annual income.

III. Findings demonstrate the ability of Lean management practices to help the Nigerian aquaculture sector and individual farmers to drastically reduce waste and become more profitable. This is because Lean management is made of self-applicable tools that depend little on others, are affordable, quickly learned, and easily applied.

IV. Building a more resilient aquaculture industry in Nigeria requires equipping farmers with the tools to address the myriads of waste within their operations and the supply chain at large. Lean production system has proven to be one such tool.

Technologies/Innovations developed, and what phase was achieved.

The three-year project is organized into four phases under which specific technologies and innovations were developed:

Phase I

- *Developed the Lean curriculum and training materials.* These were developed based on interventions identified for improving efficiency within Nigerian aquaculture systems. The Lean curriculum and tool development were informed by fact-finding, researching, interviewing, coordinating, identifying intervention participants, determining intervention measurements, and building relationships with aquaculture cooperatives, aquaculture corporations, and other stakeholders.

- *Developed the RedCap Infrastructure:* The IT/database expert developed the Lean Database for recording all Lean initiatives at all participating sites. The database offered additional insights with respect to Lean tool application monitoring, Lean evaluation, and final reporting.

Phase II

- *Trained Forty Lean Subject Matter Experts (LSMEs).* These trainees included smallholders, SMEs, cooperatives, and corporations, who were trained in appropriate Lean technology and Lean production systems, using the curriculum and training material developed under Phase I.

Phase III

- *The LSMEs trained 265 value chain actors.* These included farmers, processors, and relevant staff of two corporate aquaculture production and processing companies on the application of Lean technology and tools to increase the efficiency of their systems and practices. The trained LSMEs created interventions with their respective sub-cooperatives, corporate entities, societies, and smallholder independent farmers on a prescribed timeline with specific programming and tailored consultations.

- *RedCap was used to document all Lean interventions*. The entries included the effort, costs, efficacy, and return on investment of Lean activities.

Phase IV

- Technical report on the findings of the application of Lean tools in aquaculture. The team conducted a quantitative analysis of operational metrics (same as pre-intervention) and a qualitative study of participants.

Key Beneficiaries

The key beneficiaries are as follows:

1. Value chain actors seeking to become professionals: 40 Nigeria aquaculture value chain actors received Lean management training and were certified as Lean Subject Matter Experts (LSMEs) in aquaculture. These trainees have been equipped with the necessary tools to train others to adopt and disseminate the Lean management tools.
2. Male and female actors: Of the 265 actors in the project, 52 were females, representing about 20 percent of the total. The aquaculture sector in Nigeria is male dominated, and the 20 percent represents efforts to ensure females are among the innovators who can disseminate the Lean technology. Prioritizing females also ensured that the project demonstrate that females can be adopters of novel innovations. The statistical analyses attest that females are good adopters of Lean innovation as are their male counterparts, and that they could be used in scaling up the technology.
3. The youths: Although aquaculture in Nigeria is considered a pastime of retirees and it is dominated by older people, the project sought to make it a business that could be a source of income and attractive to the youth. Hence, efforts were made to focus on younger individuals to ensure the professional orientation of the endeavor. The age group, 31-43 years, constituted the majority, making up 44 percent. Ten percent of the beneficiaries were below the age group 31 years. Only 10 percent of the 265 actors were above 57 years.
4. Actors with various farm types: Actors with small, medium, and large-scale production benefited from the Lean management project. Although most farmers identify as smallholders, the project targeted beneficiaries with corporate recognition and demonstrated that Lean tools can benefit all these groups, too.
5. Users of various production systems: Although Pond is the popular system of choice in Nigeria and accounted for 75 percent of the system used by the beneficiaries, users of tank system (18.5%) and other systems (6%) benefited from how Lean can contribute to improving the efficiency of their aquaculture production business.
6. Farmers from Ogun and Delta States: Although the beneficiaries come from two states, outreach programs using Webinars suggest the beneficiaries of the innovation extend beyond the borders of these states.

How the scientific results were disseminated.

Scientific results have been disseminated at:

I. Conferences: Team members presented key findings at conferences, such as the 3rd All Africa Post Harvest Congress in September, 2021.

II. PI meetings: Quarterly and annual meetings of the Feed The Future Innovation L ab for fish was a platform to share the findings of the project among the scholarly community and the many scholars attending.

III. Webinars: The project organized a Webinar in collaboration with Aquaculture Africa Magazine to disseminate major findings of the project beyond the borders of Nigeria.

IV. Workshops: Multiple workshops on the merits of using aquaculture in Nigeria were organized in two states in Nigeria to acquaint participants with the innovation.

V. Publications:
   a. Success stories of users of Lean management were shared to document the impact Lean could have on farmers.
   b. Technical reports on the findings of the project were produced to disseminate findings of the project.
   c. Peer-reviewed articles are planned in aquaculture and related journals.
   d. Lean curriculum has been developed and is being shared with trainees as tool for engaging other value chain actors seeking to learn about the innovation.
   e. Lean training manual will be published and disseminated for use by other professionals.

Recommendations

1. Given the reported benefits of Lean in the two Nigerian states, the scope of Lean management should be expanded to other states, the West African subregion, and elsewhere in the world by extensively disseminating the study findings through publications, conferences, webinars etc.
2. Since Community-based Lean Subject Matter Experts (LSME) can be effective resources for disseminating the tools, these should be certified as trainers and paid for their services, to ensure the continuity of the project beyond the lifespan of the project.
3. Acknowledging that financial resources are needed to expand the scope of the project, the project team along with management entity and other stakeholders should consider exploring other funding opportunities to spread the Lean innovation.

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Appendices

Appendix A— Detailed analysis of Lean results— primary study.
Appendix B —Detailed analysis of Lean results— follow-up study.
Appendix C— Lean training manual.
Appendix D—Directory.

Appendix A:

Table 1: Demographic characteristics	
	Overall (N=212)
Age (years)	
Mean (SD)	42.9 (10.7)
Median [Min, Max]	42.0 [18.0, 76.0]
Years of experience	
Mean (SD)	8.56 (6.07)
Median [Min, Max]	7.00 [0, 35.0]
Farmer sex	
Female	42 (19.8%)
Male	170 (80.2%)
Nigerian State	
Delta State	98 (46.2%)
Ogun State	102 (48.1%)
Unreported	12 (5.7%)
Farm system	
Pond	161 (75.9%)
Tank	39 (18.4%)
Other	12 (5.7%)
Farm type	
Smallholder	173 (81.6%)
Corporate	39 (18.4%)
Operation size	
Unreported	15 (7.1%)
0-2 tons	47 (22.2%)
2.01-4 tons	44 (20.8%)
Over 4 tons	106 (50.0%)
Age group	
18-30	20 (9.4%)
31-43	93 (43.9%)
44-56	57 (26.9%)
57 and above	24 (11.3%)
Annual revenue (naira)	
Unreported	14 (6.6%)

Table 1: Demographic characteristics	
	Overall (N=212)
0-2.5 million	72 (34.0%)
2.6 million-5 million	46 (21.7%)
Over 5 million	80 (37.7%)

Table 2: Baseline data on the 14 waste domains and their post-intervention percentage reductions

	Projects	Pre-intervention Mean [min, max]	Post-intervention Mean [min, max]	Mean % reduction (SD)	p-value	Median [min, max]
Time wasted (sec)	103	56838 [20, 3630000]	30619.89 [0, 2419200]	68.8 (21.6)	***	69.4 [4.44, 100]
Mortality rate (%)	65	32.9 [.10, 100]	6.71 [0, 50.00]	84.9 (14.8)	***	88.9 [36.7, 100]
Energy usage (liters)	59	218.7 [4.5, 3840]	106.72 [0, 1920]	47.8 (23.9)	***	50.0 [6.00, 100]
Feeding costs (Naira)	36	844802 [2227.5, 12 million]	519072 [1485, 4.2 million]	27.2 (18.3)	***	25.0 [0.667, 68.8]
Labor costs (Naira)	24	51418 [2000, 500000]	29495 [0, 400000]	55.8 (25.9)	***	50.0 [15.7, 100]
Inventory space (%)	24	41.1 [0.10, 100]	12.9 [0.001, 97.55]	65.6 (29.2)	***	66.7 [2.45, 100]
Casual laborers (n)	21	5 [1, 52]	3 [0, 41]	53.4 (21.1)	***	50.0 [21.2, 100]
Medication costs (Naira)	21	24100 [4000, 213840]	12277 [0, 200640]	71.3 (24.7)	***	75.9 [6.17, 100]
Feed quantity (kg)	14	2231 [7.5, 10500]	1425 [5, 7000]	39.1 (11.3)	***	38.8 [25.0, 70.0]
Labor time (seconds)	13	13233 [1200, 42300]	6933 [600, 19800]	48.1 (24.7)	***	46.4 [3.08, 81.9]
Water treatment costs	12	18571 [2300, 90251]	8883 [0, 75200.00]	60.3 (25.9)	***	64.9 [16.7, 100]
Fish lost via flooding (n)	8	5133 [60, 16000.0]	921 [0, 3750]	84.72 (25.1)	.012	100 [30, 100]
Transportation costs (Naira)	5	3830 [2400, 6000]	600 [0, 1500]	81.5 (27.8)	.043	100 [37.5, 100]
Maintenance costs (Naira)	5	75800 [6000, 340000]	35200 [0, 165000]	70.3 (17.9)	.039	66.7 [51.5, 100]

***** Significant at the .001 level**

Table 3: Comparisons of improvement in % reduction in time wasted

	Projects (N=103)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	15 (14.6%)	68.7 (17.9)	.971	66.7 [22.2, 94.4]
Male	88 (85.4%)	68.9 (22.2)		69.8 [4.44, 100]
Nigerian State				
Delta State	46 (44.7%)	70.7 (19.4)	.122	75.0 [22.2, 100]
Ogun State	50 (48.5%)	65.3 (23.1)		66.7 [4.44, 100]
Unreported	7 (6.8%)	81.8 (19.6)		91.5 [49.8, 100]
Farm system				
Pond	78 (75.7%)	68.6 (22.0)	.421	71.0 [4.44, 100]
Tank	19 (18.4%)	73.1 (21.9)		77.5 [25.0, 100]
Other	6 (5.8%)	59.8 (12.1)		62.5 [42.3, 75.0]
Farm type				
Smallholder	74 (71.8%)	68.3 (21.7)	.692	69.0 [4.44, 100]
Corporate	29 (28.2%)	70.2 (21.5)		72.2 [33.3, 100]
Operation size				
Unreported	9 (8.7%)	74.2 (23.8)	.779	80.7 [33.3, 100]
0-2 tons	20 (19.4%)	66.6 (22.4)		75.0 [25.0, 98.0]
2.01-4 tons	23 (22.3%)	71.0 (21.0)		66.7 [22.2, 100]
Over 4 tons	51 (49.5%)	67.8 (21.6)		67.6 [4.44, 100]
Age group				
18-30	9 (8.7%)	54.0 (16.1)	.0853	59.3 [25.0, 76.7]
31-43	42 (40.8%)	72.1 (18.4)		75.0 [25.0, 100]
44-56	32 (31.1%)	64.6 (24.2)		66.7 [4.44, 100]
57 and above	8 (7.8%)	73.1 (25.9)		77.5 [33.3, 100]
Annual revenue	3 (2.9%)			
Unreported	9 (8.7%)	74.2 (23.8)	.204	80.7 [33.3, 100]
0-2.5 million	30 (29.1%)	63.9 (22.9)		66.7 [4.44, 98.0]
2.6 million-5 million	24 (23.3%)	65.4 (22.9)		67.4 [22.2, 100]
Over 5 million	40 (38.8%)	73.5 (18.6)		75.0 [33.3, 100]

Table 4: Comparisons of improvement % reduction in fish mortality

	Projects (N=65)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	13 (20.0%)	85.1 (14.5)	.962	87.5 [57.9, 100]
Male	52 (80.0%)	84.8 (15.0)		88.9 [36.7, 100]
Nigerian State				
Delta State	40 (61.5%)	82.0 (17.1)	.135	86.4 [36.7, 100]
Ogun State	24 (36.9%)	89.5 (8.70)		89.4 [74.0, 100]
Unreported	1 (1.5%)	89.5 (NA)		89.5 [89.5, 89.5]
Farm system				
Pond	42 (64.6%)	86.9 (11.6)	.0171*	89.1 [57.1, 100]
Tank	20 (30.8%)	84.1 (17.2)		87.9 [44.4, 100]
Other	3 (4.6%)	62.2 (23.6)		66.7 [36.7, 83.3]
Farm type				
Smallholder	52 (80.0%)	84.1 (16.0)	.204	89.1 [36.7, 100]
Corporate	13 (20.0%)	88.1 (7.97)		85.0 [77.2, 100]
Operation size				
Unreported	1 (1.5%)	89.5 (NA)	.598	89.5 [89.5, 89.5]
0-2 tons	20 (30.8%)	81.3 (18.7)		88.6 [36.7, 99.8]
2.01-4 tons	12 (18.5%)	84.7 (13.6)		85.4 [64.8, 100]
Over 4 tons	32 (49.2%)	87.0 (12.6)		89.1 [44.4, 100]
Age group				
18-30	11 (16.9%)	86.5 (14.2)	.696	89.5 [57.1, 100]
31-43	31 (47.7%)	83.7 (16.4)		87.5 [36.7, 100]
44-56	14 (21.5%)	83.0 (15.0)		86.6 [44.4, 100]
57 and above	8 (12.3%)	90.0 (9.49)		89.6 [75.0, 100]
Annual revenue				
Unreported	1 (1.5%)	89.5 (NA)	.960	89.5 [89.5, 89.5]
0-2.5 million	24 (36.9%)	83.8 (17.2)		89.5 [36.7, 100]
2.6 million-5 million	17 (26.2%)	84.8 (13.2)		84.0 [57.9, 100]
Over 5 million	23 (35.4%)	85.8 (14.1)		88.0 [44.4, 100]

Table 5: Comparisons of improvement % reduction in energy consumption

	Projects (N=59)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	8 (13.6%)	47.4 (22.6)	.959	50.0 [7.69, 71.4]
Male	51 (86.4%)	47.9 (24.4)		50.0 [6.00, 100]
Nigerian State				
Delta State	10 (16.9%)	35.8 (27.8)	.563	33.3 [6.00, 90.0]
Ogun State	46 (78.0%)	50.0 (23.7)		50.0 [7.69, 100]
Unreported	3 (5.1%)	43.1 (12.5)		38.9 [33.3, 57.1]
Farm system				
Pond	47 (79.7%)	49.8 (23.1)	.730	50.0 [7.69, 100]
Tank	7 (11.9%)	43.4 (27.1)		36.1 [15.0, 90.0]
Other	5 (8.5%)	14.5 (12.1)		14.5 [6.00, 23.1]
Farm type				
Smallholder	43 (72.9%)	44.5 (25.5)	.025*	50.0 [6.00, 100]
Corporate	16 (27.1%)	57.7 (15.2)		53.6 [33.3, 90.0]
Operation size				
Unreported	3 (5.1%)	43.1 (12.5)	.477	38.9 [33.3, 57.1]
0-2 tons	13 (22.0%)	33.9 (25.6)		25.0 [6.00, 90.0]
2.01-4 tons	9 (15.3%)	44.5 (23.2)		58.4 [10.9, 66.7]
Over 4 tons	34 (57.6%)	53.4 (23.2)		50.0 [7.69, 100]
Age group				
18-30	5 (8.5%)	41.2 (21.0)	.622	37.5 [23.1, 66.7]
31-43	21 (35.6%)	44.6 (24.9)		50.0 [6.00, 90.0]
44-56	21 (35.6%)	50.7 (24.7)		50.0 [8.31, 100]
57 and above	6 (10.2%)	57.5 (25.9)		57.5 [30.0, 100]
Annual revenue				
Unreported	3 (5.1%)	43.1 (12.5)	.734	38.9 [33.3, 57.1]
0-2.5 million	23 (39.0%)	41.6 (25.8)		41.7 [6.00, 100]
2.6 million-5 million	6 (10.2%)	49.4 (30.9)		42.9 [10.9, 100]
Over 5 million	27 (45.8%)	52.8 (21.6)		50.0 [8.31, 100]

Table 6: Comparisons of improvement % reduction in feeding costs

	Projects (N=36)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	7 (19.4%)	33.1 (19.1)	.382	30.0 [5.00, 68.8]
Male	29 (80.6%)	25.8 (18.1)		23.1 [0.667, 67.5]
Nigerian State				
Delta State	14 (38.9%)	35.8 (14.8)	.0589	36.9 [15.9, 68.8]
Ogun State	21 (58.3%)	21.1 (18.7)		20.8 [0.667, 67.5]
Unreported	1 (2.8%)	33.3 (NA)		33.3 [33.3, 33.3]
Farm system				
Pond	30 (83.3%)	24.6 (17.0)	.106	24.5 [0.667, 67.5]
Tank	4 (11.1%)	44.9 (22.1)		47.4 [15.9, 68.8]
Other	2 (5.6%)	30.8 (19.3)		30.8 [17.1, 44.4]
Farm type				
Smallholder	28 (77.8%)	28.5 (17.1)	.491	25.0 [5.00, 67.5]
Corporate	8 (22.2%)	22.4 (22.7)		19.5 [0.667, 68.8]
Operation size				
Unreported	1 (2.8%)	33.3 (NA)	.0302*	33.3 [33.3, 33.3]
0-2 tons	8 (22.2%)	40.0 (16.4)		41.3 [15.9, 68.8]
2.01-4 tons	9 (25.0%)	31.8 (21.6)		23.1 [6.25, 67.5]
Over 4 tons	18 (50.0%)	18.8 (13.8)		18.0 [0.667, 43.3]
Age group				
18-30	2 (5.6%)	23.9 (9.59)	.213	23.9 [17.1, 30.7]
31-43	9 (25.0%)	33.0 (18.0)		31.5 [8.77, 65.0]
44-56	15 (41.7%)	27.2 (19.2)		28.0 [0.667, 68.8]
57 and above	8 (22.2%)	15.5 (10.3)		15.0 [5.00, 28.0]
Annual revenue				
Unreported	1 (2.8%)	33.3 (NA)	.0146*	33.3 [33.3, 33.3]
0-2.5 million	11 (30.6%)	39.3 (19.6)		40.0 [6.25, 68.8]
2.6 million-5 million	4 (11.1%)	34.2 (21.3)		27.5 [16.7, 65.0]
Over 5 million	20 (55.6%)	18.8 (13.1)		19.0 [0.667, 43.3]

Table 7: Comparisons of improvement % reduction in labor costs

	Projects (N=24)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	2 (8.3%)	50.0 (0)	.307	50.0 [50.0, 50.0]
Male	22 (91.7%)	56.4 (27.2)		50.0 [15.7, 100]
Nigerian State				
Delta State	4 (16.7%)	65.2 (44.1)	.511	80.0 [15.7, 100]
Ogun State	20 (83.3%)	54.3 (23.4)		50.0 [20.0, 100]
Farm system				
Pond	23 (95.8%)	57.5 (25.2)	.162	50.0 [15.7, 100]
Other	1 (4.2%)	20.0 (NA)		20.0 [20.0, 20.0]
Farm type				
Smallholder	11 (45.8%)	51.6 (23.5)	.500	50.0 [15.7, 100]
Corporate	13 (54.2%)	59.2 (28.3)		50.0 [20.0, 100]
Operation size				
0-2 tons	1 (4.2%)	33.3 (NA)	.388	33.3 [33.3, 33.3]
Over 4 tons	23 (95.8%)	56.9 (26.0)		50.0 [15.7, 100]
Age group				
18-30	3 (12.5%)	61.1 (34.7)	.686	50.0 [33.3, 100]
31-43	12 (50.0%)	49.5 (18.5)		50.0 [20.0, 80.0]
44-56	4 (16.7%)	53.9 (34.7)		50.0 [15.7, 100]
57 and above	5 (20.8%)	66.7 (31.2)		50.0 [33.3, 100]
Annual revenue				
0-2.5 million	2 (8.3%)	66.7 (47.1)	.777	66.7 [33.3, 100]
2.6 million-5 million	2 (8.3%)	47.7 (3.21)		47.7 [45.5, 50.0]
Over 5 million	20 (83.3%)	55.5 (26.0)		50.0 [15.7, 100]

Table 8: Comparisons of improvement % reduction in inventory space

	Projects (N=24)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	5 (20.8%)	62.9 (25.3)	.805	62.6 [33.3, 100]
Male	19 (79.2%)	66.3 (30.7)		66.7 [2.45, 100]

Table 8: Comparisons of improvement % reduction in inventory space

	Projects (N=24)	Mean % reduction. (SD)	p-value	Median [min, max]
Nigerian State				
Delta State	12 (50.0%)	70.0 (28.2)	.422	69.0 [2.45, 100]
Ogun State	9 (37.5%)	55.8 (28.1)		50.0 [24.9, 100]
Unreported	3 (12.5%)	77.8 (38.5)		100 [33.3, 100]
Farm system				
Pond	20 (83.3%)	63.3 (31.2)	.646	63.0 [2.45, 100]
Tank	3 (12.5%)	80.8 (12.4)		85.7 [66.7, 90.0]
Other	1 (4.2%)	66.7 (NA)		66.7 [66.7, 66.7]
Farm type				
Smallholder	17 (70.8%)	63.3 (31.0)	.531	66.7 [2.45, 100]
Corporate	7 (29.2%)	71.2 (25.5)		66.7 [33.0, 100]
Operation size				
Unreported	3 (12.5%)	77.8 (38.5)	.154	100 [33.3, 100]
0-2 tons	6 (25.0%)	85.2 (13.6)		87.9 [66.7, 100]
2.01-4 tons	5 (20.8%)	59.6 (42.2)		70.8 [2.45, 100]
Over 4 tons	10 (41.7%)	53.3 (21.4)		49.5 [24.9, 100]
Age group				
18-30	2 (8.3%)	80.7 (19.8)	.237	80.7 [66.7, 94.7]
31-43	10 (41.7%)	72.5 (25.3)		71.4 [24.9, 100]
44-56	5 (20.8%)	46.6 (35.3)		47.4 [2.45, 100]
57 and above	4 (16.7%)	49.9 (20.4)		49.0 [30.0, 70.8]
Annual revenue				
Unreported	3 (12.5%)	77.8 (38.5)	.891	100 [33.3, 100]
0-2.5 million	7 (29.2%)	63.7 (26.6)		66.7 [30.0, 97.1]
2.6 million-5 million	7 (29.2%)	61.6 (38.0)		70.8 [2.45, 100]
Over 5 million	7 (29.2%)	66.4 (22.8)		63.5 [33.0, 100]

Table 9: Comparisons of improvement % reduction in number of casual laborers

	Projects (N=21)	Mean (SD)	p-value	Median [min, max]
Farmer sex				
Female	3 (14.3%)	50.0 (0)	.473	50.0 [50.0, 50.0]
Male	18 (85.7%)	54.0 (22.9)		50.0 [21.2, 100]
Nigerian State				
Delta State	1 (4.8%)	50.0 (NA)	.874	50.0 [50.0, 50.0]
Ogun State	20 (95.2%)	53.6 (21.7)		50.0 [21.2, 100]
Farm system				
Pond	20 (95.2%)	55.0 (20.3)	.120	50.0 [33.3, 100]
Other	1 (4.8%)	21.2 (NA)		21.2 [21.2, 21.2]
Farm type				
Smallholder	12 (57.1%)	52.8 (15.6)	.893	50.0 [33.3, 100]
Corporate	9 (42.9%)	54.2 (27.9)		50.0 [21.2, 100]
Operation size				
0-2 tons	2 (9.5%)	41.7 (11.8)	.423	41.7 [33.3, 50.0]
Over 4 tons	19 (90.5%)	54.6 (21.7)		50.0 [21.2, 100]
Age group				
18-30	2 (9.5%)	41.7 (11.8)	.265	41.7 [33.3, 50.0]
31-43	8 (38.1%)	44.3 (11.0)		50.0 [21.2, 50.0]
44-56	5 (23.8%)	60.0 (22.4)		50.0 [50.0, 100]
57 and above	6 (28.6%)	63.9 (28.7)		50.0 [33.3, 100]
Annual revenue				
0-2.5 million	2 (9.5%)	41.7 (11.8)	.697	41.7 [33.3, 50.0]
2.6 million-5 million	2 (9.5%)	50.0 (0)		50.0 [50.0, 50.0]
Over 5 million	17 (81.0%)	55.2 (23.0)		50.0 [21.2, 100]

Table 10: Comparisons of improvement % reduction in medication costs

	Projects (N=21)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	6 (28.6%)	73.9 (21.7)	.756	77.5 [37.5, 100]
Male	15 (71.4%)	70.3 (26.5)		75.9 [6.17, 100]
Nigerian State				
Delta State	12 (57.1%)	45.1 [36.4, 53.8]	.885	77.9 [36.4, 98.5]
Ogun State	9 (42.9%)	70.4 (31.1)		75.0 [6.17, 100]
Farm system				
Pond	14 (66.7%)	73.6 (18.3)	.298	75.4 [33.3, 100]
Tank	5 (23.8%)	75.6 (39.3)		86.7 [6.17, 100]
Other	2 (9.5%)	45.1 (12.3)		45.1 [36.4, 53.8]
Farm type				
Smallholder	19 (90.5%)	74.6 (20.8)	.502	80.0 [33.3, 100]
Corporate	2 (9.5%)	40.6 (48.7)		40.6 [6.17, 75.0]
Operation size				
0-2 tons	2 (9.5%)	64.4 (15.0)	.851	64.4 [53.8, 75.0]
2.01-4 tons	8 (38.1%)	69.2 (21.5)		77.9 [36.4, 87.8]
Over 4 tons	11 (52.4%)	74.1 (29.2)		80.0 [6.17, 100]
Age group				
18-30	4 (19.0%)	49.4 (34.8)	.127	55.7 [6.17, 80.0]
31-43	9 (42.9%)	81.9 (15.4)		86.7 [53.8, 100]
44-56	4 (19.0%)	62.7 (32.6)		58.8 [33.3, 100]
57 and above	4 (19.0%)	78.1 (5.70)		75.4 [75.0, 86.7]
Annual revenue				
0-2.5 million	9 (42.9%)	74.1 (19.8)	.917	75.0 [33.3, 100]
2.6 million-5 million	5 (23.8%)	69.3 (20.0)		75.9 [37.5, 86.7]
Over 5 million	7 (33.3%)	69.3 (35.1)		80.0 [6.17, 100]

Table 11: Comparisons of improvement % reduction in feed quantity (kg)				
	Projects (N=14)	**Mean % reduction. (SD)**	**p-value**	**Median [min, max]**
Farmer sex				
Female	2 (14.3%)	36.7 (4.71)	.598	36.7 [33.3, 40.0]
Male	12 (85.7%)	39.6 (12.3)		38.8 [25.0, 70.0]
Nigerian State				
Ogun State	13 (92.9%)	39.6 (11.7)		40.0 [25.0, 70.0]
Unreported	1 (7.1%)	33.3 (NA)		33.3 [33.3, 33.3]
Farm system				
Pond	14 (100%)	39.1 (11.3)	NA	39.1 [39.1, 39.1]
Farm type				
Smallholder	11 (78.6%)	40.7 (12.1)	.322	40.0 [30.0, 70.0]
Corporate	3 (21.4%)	34.2 (8.04)		37.5 [25.0, 40.0]
Operation size				
Unreported	1 (7.1%)	33.3 (NA)	.0018**	33.3 [33.3, 33.3]
0-2 tons	1 (7.1%)	NA (NA)		NA [NA, NA]
2.01-4 tons	1 (7.1%)	70.0 (NA)		70.0 [70.0, 70.0]
Over 4 tons	11 (78.6%)	36.6 (6.17)		38.8 [25.0, 46.4]
Age group				
18-30	1 (7.1%)	40.0 (NA)	.523	40.0 [40.0, 40.0]
31-43	2 (14.3%)	30.0 (NA)		30.0 [30.0, 30.0]
44-56	5 (35.7%)	39.3 (5.48)		38.8 [33.3, 46.4]
57 and above	4 (28.6%)	34.6 (7.12)		36.7 [25.0, 40.0]
Annual revenue				
Unreported	1 (7.1%)	33.3 (NA)	.0045**	33.3 [33.3, 33.3]
0-2.5 million	2 (14.3%)	70.0 (NA)		70.0 [70.0, 70.0]
2.6 million-5 million	1 (7.1%)	30.0 (NA)		30.0 [30.0, 30.0]
Over 5 million	10 (71.4%)	37.3 (6.08)		40.0 [25.0, 46.4]

Table 12: Comparisons of improvement % reduction in labor time

	Projects (N=13)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	5 (38.5%)	55.4 (14.9)	.357	50.0 [38.9, 75.0]
Male	8 (61.5%)	43.5 (29.2)		36.7 [3.08, 81.9]
Nigerian State				
Delta State	4 (30.8%)	49.2 (25.6)	.938	50.0 [22.0, 75.0]
Ogun State	8 (61.5%)	48.7 (27.4)		48.2 [3.08, 81.9]
Unreported	1 (7.7%)	38.9 (NA)		38.9 [38.9, 38.9]
Farm system				
Pond	9 (69.2%)	58.7 (20.3)	.0487*	66.0 [22.1, 81.9]
Tank	2 (15.4%)	21.0 (25.3)		21.0 [3.08, 38.9]
Other	2 (15.4%)	27.6 (8.05)		27.6 [22.0, 33.3]
Farm type				
Smallholder	10 (76.9%)	53.7 (23.3)	.202	58.0 [22.0, 81.9]
Corporate	3 (23.1%)	29.5 (23.2)		38.9 [3.08, 46.4]
Operation size				
Unreported	1 (7.7%)	38.9 (NA)	.935	38.9 [38.9, 38.9]
0-2 tons	2 (15.4%)	50.0 (23.6)		50.0 [33.3, 66.7]
2.01-4 tons	5 (38.5%)	53.4 (29.2)		66.0 [22.0, 81.9]
Over 4 tons	5 (38.5%)	43.9 (27.5)		46.4 [3.08, 80.0]
Age group				
18-30	3 (23.1%)	30.3 (32.3)	.383	22.0 [3.08, 66.0]
31-43	7 (53.8%)	51.9 (22.2)		46.4 [22.1, 80.0]
44-56	1 (7.7%)	50.0 (NA)		50.0 [50.0, 50.0]
57 and above	1 (7.7%)	81.9 (NA)		81.9 [81.9, 81.9]
Annual revenue				
Unreported	1 (7.7%)	38.9 (NA)	.561	38.9 [38.9, 38.9]
0-2.5 million	5 (38.5%)	47.6 (19.7)		50.0 [22.1, 66.7]
2.6 million-5 million	3 (23.1%)	65.6 (22.5)		75.0 [40.0, 81.9]
Over 5 million	4 (30.8%)	37.9 (33.2)		34.2 [3.08, 80.0]

Table 13: Comparisons of improvement % reduction in water treatment costs

	Projects (N=12)	Mean % reduction. (SD)	p-value	Median [min, max]
Farmer sex				
Female	4 (33.3%)	78.7 (17.1)	.0546	75.4 [64.0, 100]
Male	8 (66.7%)	51.2 (25.4)		51.8 [16.7, 94.0]
Nigerian State				
Delta State	9 (75.0%)	65.3 (19.3)	.377	65.7 [35.8, 100]
Ogun State	2 (16.7%)	55.3 (54.7)		55.3 [16.7, 94.0]
Unreported	1 (8.3%)	26.1 (NA)		26.1 [26.1, 26.1]
Farm system				
Pond	7 (58.3%)	71.6 (24.8)	.210	66.7 [26.1, 100]
Tank	2 (16.7%)	41.7 (35.3)		41.7 [16.7, 66.7]
Other	3 (25.0%)	46.4 (12.4)		43.5 [35.8, 60.0]
Farm type				
Smallholder	9 (75.0%)	57.0 (18.3)	.675	64.0 [26.1, 85.0]
Corporate	3 (25.0%)	70.2 (46.5)		94.0 [16.7, 100]
Operation size				
Unreported	2 (16.7%)	63.0 (52.3)	.997	63.0 [26.1, 100]
0-2 tons	2 (16.7%)	63.3 (4.71)		63.3 [60.0, 66.7]
2.01-4 tons	5 (41.7%)	58.8 (19.5)		64.0 [35.8, 85.0]
Over 4 tons	3 (25.0%)	59.1 (39.2)		66.7 [16.7, 94.0]
Age group				
18-30	3 (25.0%)	32.0 (13.8)	.0071**	35.8 [16.7, 43.5]
31-43	4 (33.3%)	76.4 (15.8)		75.8 [60.0, 94.0]
44-56	3 (25.0%)	65.5 (1.35)		65.7 [64.0, 66.7]
Annual revenue				
Unreported	2 (16.7%)	63.0 (52.3)	.789	63.0 [26.1, 100]
0-2.5 million	3 (25.0%)	64.1 (3.61)		65.7 [60.0, 66.7]
2.6 million-5 million	2 (16.7%)	74.5 (14.8)		74.5 [64.0, 85.0]
Over 5 million	5 (41.7%)	51.3 (29.8)		43.5 [16.7, 94.0]

August 20, 2023

WorldFish Project - Technical Report

Field Staff/Consultant Name	Terri Lawrence/Collaborative Impact LLC
Contract Number	PLA13104, AG10507, BU11286, AECG004
Contract Duration	July 10 through August 25, 2023
Project Covered by this Report (if applicable)	Improving Efficiency in Nigerian Aquaculture Sector by Employing Lean Production Systems
Countries Covered by this Report (if applicable)	Nigeria
Period Covered by this Report	July 10 through August 25, 2023

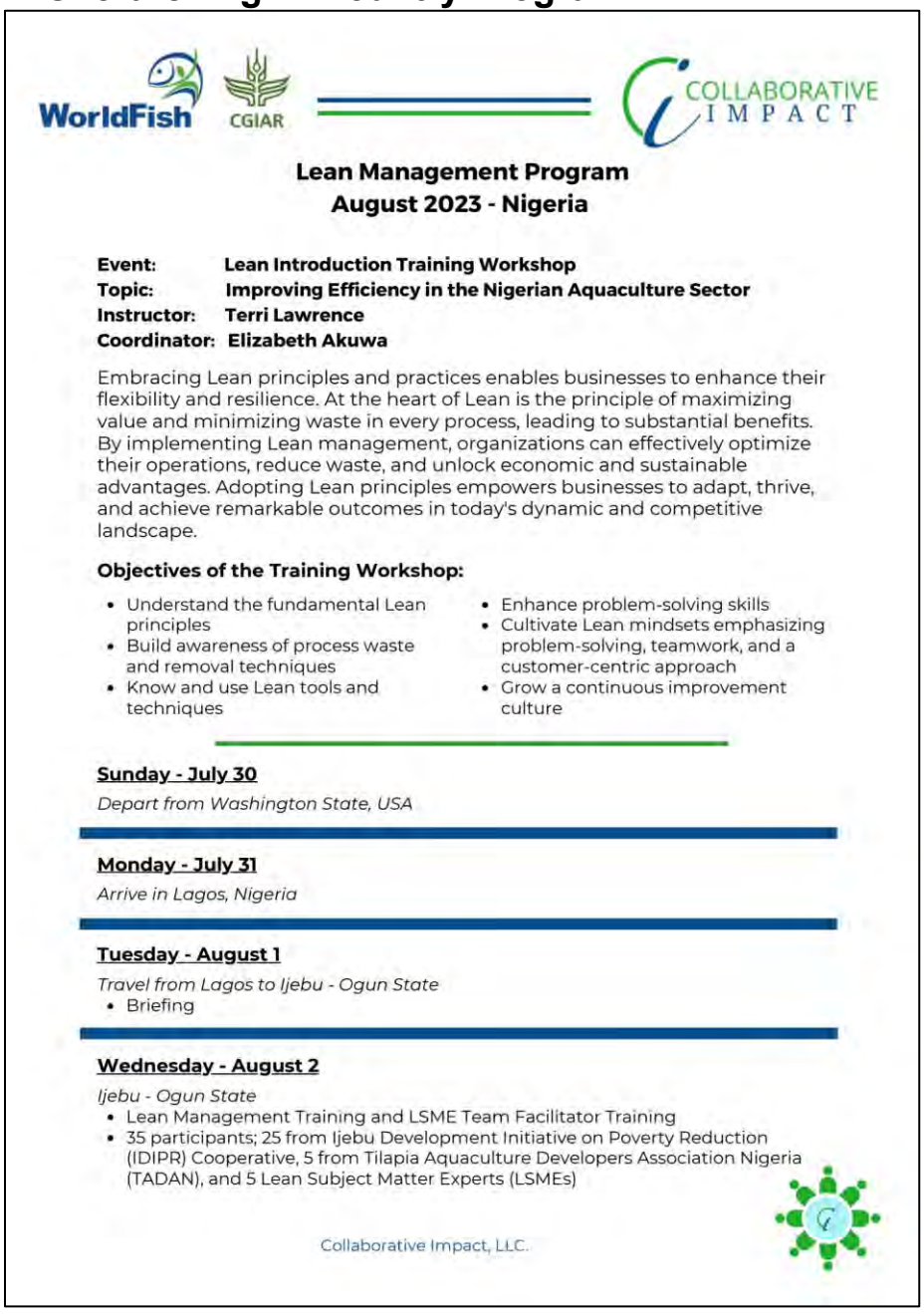
I. Purpose

In the original comprehensive report focused on enhancing efficiency within the Nigerian aquaculture value chain through lean production techniques, forty (40) aquaculture professionals underwent rigorous training in lean management. Once they demonstrated their competence, they were charged with returning to their respective communities to assist aquaculture farmers in implementing interventions to address identified inefficiencies. The report identified fourteen (14) areas of waste within the aquaculture system, including issues such as time wasted in farm-related activities, excessive processing and transportation, fish mortality, energy consumption, feeding costs, expenses related to antibiotics, and water quality improvement. Through statistical analysis, it was determined that the lean interventions significantly reduced waste across all fourteen areas. Furthermore, the report revealed that the benefits experienced by farmers were invariant across different sociodemographic characteristics, indicating that the positive outcomes were not significantly influenced by factors such as age, gender, or socioeconomic status. The results revealed that enumerable challenges confront the Nigerian aquaculture industry. However, regardless of their demographic characteristics or social class, farmers have equal chances of success in witnessing similar reductions.

In that report, the average post-intervention percentage reductions among corporate farms or large operations were not significantly different from those seen by smallholders across all domains. However, differences in project distribution were observed, as evidenced by the smallholder-to-corporate farmer project ratios across the fourteen areas, even though more than 80% of the farmers identified as smallholders. These variations in project distribution were observed in the other demographic groups, further reinforcing the need to adopt interventions sensitive to and mindful of the differences among farmers in their aquaculture struggles. Since corporate projects were less represented, two corporate farms and one feed mill in three locations (Abeokuta in Ogun State, Ijebu-Ode in Ogun State, and Ibadan in Oyo State) in Nigeria to see if the results could be replicated, and lean workshop surveys were used to learn

more about farmers' experiences and success stories. Twelve teams representing corporate farms were recruited, and 75% were based in Ogun State. Two in three of the teams in Ogun State were in Ijebu-Ode. Figure 1 shows a word cloud of some common themes from the projects.

II. Overarching In-Country Program



WorldFish CGIAR COLLABORATIVE IMPACT

Lean Management Program
August 2023 - Nigeria

Event: **Lean Introduction Training Workshop**
Topic: **Improving Efficiency in the Nigerian Aquaculture Sector**
Instructor: **Terri Lawrence**
Coordinator: **Elizabeth Akuwa**

Embracing Lean principles and practices enables businesses to enhance their flexibility and resilience. At the heart of Lean is the principle of maximizing value and minimizing waste in every process, leading to substantial benefits. By implementing Lean management, organizations can effectively optimize their operations, reduce waste, and unlock economic and sustainable advantages. Adopting Lean principles empowers businesses to adapt, thrive, and achieve remarkable outcomes in today's dynamic and competitive landscape.

Objectives of the Training Workshop:

- Understand the fundamental Lean principles
- Build awareness of process waste and removal techniques
- Know and use Lean tools and techniques
- Enhance problem-solving skills
- Cultivate Lean mindsets emphasizing problem-solving, teamwork, and a customer-centric approach
- Grow a continuous improvement culture

Sunday - July 30

Depart from Washington State, USA

Monday - July 31

Arrive in Lagos, Nigeria

Tuesday - August 1

Travel from Lagos to Ijebu - Ogun State

- Briefing

Wednesday - August 2

Ijebu - Ogun State

- Lean Management Training and LSME Team Facilitator Training
- 35 participants; 25 from Ijebu Development Initiative on Poverty Reduction (IDIPR) Cooperative, 5 from Tilapia Aquaculture Developers Association Nigeria (TADAN), and 5 Lean Subject Matter Experts (LSMEs)

Collaborative Impact, LLC.

Lean Management Program
August 2023 - Nigeria

Thursday-Friday - August 3-4

Ijebu - Ogun State
- In-field team workshops for Lean Management practical application with the same participants

Saturday - August 5

Travel from Ijebu to Abeokuta - Ogun State
Abeokuta - Ogun State
- Lean Management Training and LSME Team Facilitator Training
- 11 participants; 6 from Premium Aquaculture Ltd (corporate feed mill) and 4 LSMEs

Sunday - August 6

Abeokuta – Ogun State
- In-field team workshops for Lean Management practical application with the same participants

Monday - August 7

Travel from Abeokuta to Ibadan – Oyo State

Tuesday - August 8

Ibadan – Oyo State
- Lean Management Training and LSME Team Facilitator Training
- 10 participants; 6 from Premier Feed Mills Ltd (corporate feed mill) and 4 LSMEs

Wednesday - August 9

Ibadan – Oyo State
- In-field team workshops for Lean Management practical application with the same participants

Thursday - August 10

Ibadan – Oyo State
- Debriefing

Friday - August 11

Travel from Ibadan to Lagos – Depart to the USA

III. Summary of Highlights

1. Completed Lean training and knowledge transfer to attendees in three separate locations in Ogun and Oyo State, Nigeria
2. Engaged participants in applying the Lean tools, methods, and mindsets in practical applications on-site in structured team workshops
3. Captured team activities, their results, and benefits
4. Accumulated and summarized participant surveys from each location

IV. Program Details

- The curriculum involved lectures, exercises, competitive activities, and team challenges, all designed to inspire submersion into learning and playing with the Lean tools, methods, and mindsets
- In-field workshops enabled participants to apply their new skills in the workplace practically
- Agenda:

WorldFish CGIAR COLLABORATIVE IMPACT

Lean Management
Introduction Training Workshop
Nigeria
Program Schedule
August 2023

Time	Agenda	Description
Day 1		
09:00-9:30 am	Welcome	Introductions Goals and Agenda
09:30-10:15 am	Participant Activity	Icebreaker Activity
10:15-10:30 am	***Break***	
10:30-12:00 pm	Lean Training	Goal Setting and Lean History 5 Principles, 8 Wastes Customer Value
12:00-1:00 pm	***Lunch Break***	
1:00-2:15 pm	Lean Training	Root Cause Analysis Value Stream Mapping 5S and Layout Optimization
2:15-2:30 pm	***Break***	
2:30-3:45 pm	Lean Training	Standards and Quality TPM and Visual Workplace Rapid Improvement Events
3:45-4:45 pm	Team Competition In-Field Prep	Simulation game Create Teams and Plans Discuss Roles and Assignments
4:45-5:00 pm	Closing Remarks and Adjourn	

WorldFish CGIAR COLLABORATIVE IMPACT

Lean Management
Introduction Training Workshop

Nigeria

Program Schedule

August 2023

Time	Agenda	Description
Day 2		
9:00-9:15 am	Welcome	Opening Remarks Questions/Clarifications Field Planning Activities
9:15-10:15 am	Team Field Activities	Follow Field Guide Steps Assess Environment Review Processes & Equipment Begin Creating Presentation
10:15-10:30 am	***Break***	
10:30-12:00 pm	Team Field Activities	Create Team Plan Continue Following Field Guide
12:00-1:00 pm	***Lunch Break***	
1:00-2:15 pm	Team Field Activities	Continue Field Activities Determine Issues and Solutions Test Solutions & Implement
2:15-2:30 pm	***Break***	
2:30-4:30 pm	Team Field Activities Team Coordination	Continue Share Next Day Plan of Action
4:45-5:00 pm	Closing Remarks and Adjourn	

Lean Management
Introduction Training Workshop
Nigeria
Program Schedule
August 2023

Time	Agenda	Description
Day 3 or Final Day		
9:00-9:15 am	Welcome	Opening Remarks Questions/Clarifications Field Planning Activities
9:15-10:15 am	Team Field Activities	Follow Field Guide
10:15-10:30 am	***Break***	
10:30-12:00 pm	Team Field Activities	Finalize Improvements Calculate Measurements Complete Presentation Material
12:00-1:00 pm	***Lunch Break***	
1:00-2:15 pm	Team Wrap-Up Activities	Prepare for Team Presentation
2:15-2:30 pm	***Break***	
2:30-3:45 pm	Team Presentations	Team Report Outs
4:45-5:00 pm	Closing Activities Adjourn	Next Steps, Reflection, Survey

1. Lean Subject Matter Expert (LSME) Directory: an LSME introduction document that describes the training, skills, and experience they bring to assist the hosting location.
   - https://www.dropbox.com/sh/lhe313vciawefic/AAD1wfukTbOYpmEBD07llgHZa?dl=0
2. Training Materials: Lean Aquaculture and Teams-Leadership Presentations
   - https://www.dropbox.com/sh/2owp6kn2zl2f5l3/AAA4WS6kZKZ-gF-3iT5tigZFa?dl=0
3. LSME Training and In-Field Guide Materials
   Facilitation Presentation & Field Guide
   - https://www.dropbox.com/sh/4jn3jqt3tw6g2jq/AACxdH_aFXe7e64GSYWcN3XHa?dl=0
4. Pre-Event Meeting Document – A guide for discussions with hosting organizations in preparation for on-site team activities
   - https://www.dropbox.com/sh/tf0fsd5it0zowqc/AACsrKJAzLnVz0xpxEElcw2Wa?dl=0

V. Critical Activities

Those activities listed here should directly correspond with the SOW.

Task	Activities This Reporting Period
Lean Workshop Development	Conducted meetings and coordination to develop the Lean workshop and fieldwork plan, including curriculum re-design and content.
Travel Logistics	Coordinated, planned, and finalized in-country travel aligning activities with multiple stakeholders across multiple locations.
Lean Subject Matter Experts (LSME) directory	Created a Lean Subject Matter Experts (LSME) directory to outline the LSME experience and the value they bring to the participating organizations.
Program Development	Developed the overarching in-country program
Tailored Training Curriculum	Created and finalized the tailored curriculum, presentation materials, and activities.
In-Field Team Activities	Developed and facilitated in-field teams and on-site activities, including each team's purpose, scope, and metrics.
LSME Facilitation Training	Created LSME facilitation training and a detailed field guide for their use when guiding team activities.
Host Pre-Event Meeting Content	Prepared and provided hosting location leadership information and expectations prior to team on-site activities.
Finalize Agenda	Finalized the workshop agenda by incorporating previous learning and information from Phase I of the program.
Lean Training and Workshop	Conducted Lean training and workshops across three locations encompassing aquaculture farms and feed mill locations in Ogun and Oyo States. LSMEs developed under Phase I of this program assisted with team activities. • Evaluated and summarized the impacts and benefits of the team activities during the Lean workshops. • Submitted a final technical report covering the above scope of work.

VI. Outcomes/Outputs of this Trip

Lean Training-Workshop Results

1. **Location #1: Ijebu-Ode, Ogun State**
   Ijebu Development Initiative on Poverty Reduction (IDIPR) Farm Cluster
   Number of participants: 40
   Team groupings: 6

The lean intervention began at the IDIPR large farm cluster in Ijebu-Ode by implementing lean management practices. The Success Cluster Eriwe Farm Village Team achieved significant quantitative and qualitative benefits. The cleaning and reorganization of the store and the surrounding area resulted in a 42% increase in available space. Redesigning the feeding process reduced the time required by 45% and resulted in a cost reduction of N273,000 every five months. In addition, the company saw improved productivity, profitability, and reduced production costs. Employees enjoyed less stress, better communication, teamwork, increased morale, and streamlined workflows. Customers benefited from improved quality, standards, a friendly environment, and good customer service.

The Ifedayo & Rising Star Team at Trailer Park Eriwe Farm Village focused on improving farm efficiency and climate change resilience. The activities improved water quality monitoring, and early indications suggest a consequential improvement on fish mortality. Energy costs have been reduced by 43%, and movement on the farm has been reduced by 50% weekly. Protecting the ponds from flooding increased fish production by 71%. The company experienced higher productivity, higher return on investment, and profitability. Employees benefited from improved efficiency, reduced fatigue, faster turnaround times, and higher morale. Customers enjoyed a larger market, constant fish supply, and competitive prices.

The Able God Team in Ogun State focused on improving workplace organization and reducing energy consumption. They accomplished two primary outcomes. A reorganization of the feed storage shed resulted in a 53% improvement in functionality and cleanliness. The team converted the fuel source from traditional fuel to gas, leading to a substantial reduction of 70% in energy fuel consumption costs. These improvements brought several benefits to the company, including increased profitability, cost savings on fuel, reduced hazards, healthy fish production, less feed waste, and minimized feed spoilage due to rodents. Employees experienced easy access to tools, reduced stress, and a happier working environment. There was also a significant improvement in customer service and satisfaction.

The C.C.A Fish Farm Cluster successfully reduced water pump running time by implementing changes to water channels, resulting in a 57% reduction in gas costs and an increase of 57% in the water pump's lifespan. Other benefits included reduced environmental pollution with fewer emissions. Not only did fuel usage reduce by 73.3% and healthy fish production rose by 80% in the IWATA Cluster but also revenue generation increased by 80%. Employees experienced a safer working environment, improved work efficiency, saved time finding items, less fatigue, and avoided accidents in a hazardous workplace. Customers enjoyed increased fish availability, higher quality fish without diseases, and access to better services.

In the last Ijebu team (ADOKS), where the focus was on reducing energy costs, fish mortality, and optimizing the feeding process, they reduced the cost of energy by switching from petrol to gas, resulting in a 58.3% reduction in usage. Switching from sinking feed to floating feed, the team saw an 11.3% reduction in feeding costs. Time wasted in motion and transportation related to feed was also reduced by 80%.

2. **Location #2: Abeokuta, Ogun State**
   Premium Aquaculture Ltd
   Number of participants: 17
   Team groupings: 3

Premium Aquaculture Ltd in Abeokuta, also in Ogun State, was not left behind. The team activities improved operations substantially by implementing lean principles and methodologies to address inefficiencies and waste across the hatchery, nursery, and warehouse value chains, reducing waste and enhancing operational efficiency.

The Catfish Hatchery – Pre-Nursery Team focused on removing inefficiencies in the pre-nursery phase. The primary outcomes of the intervention program included organizing the weighing area with a checklist, implementing area labeling, and establishing a small feed store near the hatchery. The quantitative benefits of these changes were significant, including a 46% reduction in fuel waste and cost by relocating the feed store closer to the hatchery. Other benefits included reduced feed waste, increased production, higher profits, improved utilization of personnel, enhanced efficiency, increased morale, and the delivery of a high-quality fingerling product to customers.

Similarly, the Nursery Team also witnessed improvements, with a 69% reduction in feeding time, and early results suggest a profound positive impact on fish mortality. In addition, they have controlled feeding, leading to a 10% reduction in feed consumption and waste, resulting in significant cost savings. The farmers also reported improved water quality and increased efficiency.

The Warehouse Team was comprised of five people, with a warehouse size of 3000 square feet. The primary focus was to improve warehouse organization to maximize storage capacity, efficiently identify feed types and sizes, and ensure proper distribution weighed and re-bagging of leftover feed. There was a significant reduction in feed wastage and savings on feed expenditure. Other benefits included less employee stress, a less hazardous working environment, less excessive motion, and a cleaner workspace. The team also noticed fish quality improvement and consistent fish growth.

3. **Location #3: Ibadan, Oyo State**
   Premier Feed Mills Ltd
   Number of participants: 19
   Team groupings: 3

The Lean Intervention Program in Premier Feed Mills Ltd teams in Ibadan, Oyo State, achieved equally impressive results. In the Sales Support team, fish and feed weighing processes were reduced by 64% and 70%, respectively, while sorting frequency and draining time were cut by 50% and 45%, respectively. The Sales - Finish Goods Office Team achieved an 83% time savings through automation, increased order fulfillment to 100%, and raised production capacity to 800 mt. The Production Inventory team recovered lost time, improved bagging efficiency, and enhanced product quality. These outcomes were accompanied by benefits such as cost reduction, improved safety, and heightened customer satisfaction. Overall, the program successfully reduced waste, optimized processes, and boosted productivity in the Oyo State teams.

4. Concluding Remarks: Comparison to Original Report

In the original comprehensive report, farmers enjoyed an overall 47.8% reduction in energy consumption. Fish mortality was reduced by 84.9% (this improvement was observed in a very short time frame during a process wherein fish mortality is elevated), and time wasted declined by nearly 70%. There was a 27.2% reduction in feed costs, and feed wastage saw a cutdown of 39.1%. In the present study, there was ample evidence pointing towards consequential improvement in both episodic and long-term fish mortality. Energy consumption was reduced by an average rate of 54.3% (individual team rates were 46%, 43%, 70%, and 58.3%), which was higher than the 47.8% in the original report. An overall average reduction of 10.7% (range: 10% to 11.3%) was observed, which was lower than the 39.1% previously reported. In the current study, one team reported a 42% increase in available space. In the original study, an increase of 34.4% in available space was achieved by reducing the amount of inventory. These results demonstrate that lean production and management practices indeed have the potential to reduce waste across domains.

5. Supporting Documents and Photos for the Three Site Locations
   a) Participant Attendance Sheets
      - https://www.dropbox.com/sh/yorxxvl2vuivp1a/AACQivBbTsAZAo41I-oSYlnYa?dl=0
   b) Team Results-Benefits Summaries and Individual Team Reports

- https://www.dropbox.com/sh/6op83c6hzkqz0lg/AAA_j0KptaQAmExuX7gS4H8ja?dl=0

c) Photos

- https://www.dropbox.com/sh/7xf38iv943ifrl3/AAAC7BP9CZHDaLJRgRewplXxa?dl=0

Figure 1: Word cloud of themes generated from a combined file of the various summaries.

Participant Surveys

1. Participants completed anonymous surveys to reflect on their experience in the Lean Program, including an option for individual comments.
    - Survey Summaries and Raw Data for the Three Site Locations https://www.dropbox.com/sh/mta8rsxr7fxz7n4/AAA9MInpk67fOvKF6Ku1-JTKa?dl=0
2. Participant surveys were analyzed, and eleven common themes were repeated across all three locations. Overall, the comments reflect a strong enthusiasm for the Lean Production Systems workshop, a desire for continuous learning and improvement, and an eagerness to apply Lean principles to drive positive change within organizations and industries.

1. **Continuous Improvement and Innovation:** Many participants mention the principle of continuous improvement, aligning with the core concepts of Lean management.
2. **Expansion and Inclusion:** Numerous comments express a desire to expand the workshop's reach. Participants suggest reaching out to more audiences, involving junior staff, increasing the number of participants, and expanding the workshop's scope to include various levels of the organization.
3. **Frequency and Duration of Workshops:** Several participants highlight the frequency and duration of the workshops. They recommend conducting the workshops frequently, extending the training days to allow for more exploration of ideas with less stress, and offering multi-day training sessions to allow for deeper learning.
4. **Positive Impact and Transformation:** Many participants share how the Lean workshop has positively impacted them. They describe it as life-changing, transformative, impactful, and informative. The workshop seems to have shifted their perspectives and problem-solving approaches.
5. **Practical Application and Hands-On Learning:** A recurring theme is the value of practical and hands-on learning. Participants suggest more group exercises, fieldwork, and practical-oriented activities to enhance the learning experience.
6. **Engagement and Empowerment:** Participants express the importance of engaging more people and empowering them with Lean principles. They suggest involving more stakeholders, encouraging trainees to become trainers, and advocating for broader awareness.
7. **Feedback and Suggestions for Improvement:** Many participants offer specific feedback and suggestions for improving the workshop. These include incorporating more visual aids, extending training time, adding quizzes, and providing more instructional materials.
8. **Long-Term Vision and Sustainability:** Several comments reflect a desire for sustained impact. Participants hope for continued workshops, periodic training, and the spreading of knowledge across various states and regions.
9. **Global Perspective and Collaboration:** Some participants suggest international collaboration and conferences to enhance knowledge sharing on a global scale.
10. **Appreciation and Gratitude:** Many participants express gratitude and appreciation for the workshop and its organizers. They commend the facilitators for their efforts and effective delivery.
11. **Specific Industry Concerns:** A few comments touch on industry-specific concerns, such as advising on cost impacts, addressing wastage, and improving product and cost reduction in feed and energy.

VII. Activity KPIs (Key Performance Indicators)—KPI Reporting Table

Performance Measure	August 2023
Engaged workshop participants	76

VIII. Recommendations

The following recommendations align with direct feedback from participants and issues observed on-site at multiple locations.

1. Streamline Processes and Systems – Examine and Reduce Waste and Inefficiencies
    - Production
    - Quality
    - Transportation
    - Raw Materials
    - Warehouse
    - Finished Goods
    - Distribution
    - Customer Satisfaction
    - Records and Accountability
2. Lean Subject Matter Experts (LSME) Training Program – for company personnel
    - LSME In-Depth Program
        - Training on Lean, Facilitation, Metric collection, Outcomes, Impacts, and Benefits
        - LSMEs will be prepared to train others and expand Lean knowledge and culture across the organization
3. Reduce Equipment Downtime and Maintenance Costs
    - Total Productive Maintenance Program
        - Reduce/eliminate machine breakdowns
        - Increase lifespan and efficiency of machine/equipment
        - Improve output quality and reduce maintenance cost
4. Quick Changeover – Efficient Product Change on Equipment
    a. Dramatically reduce equipment change over times
    b. Reduce defects
    c. Increase product yield
    d. Increase production
5. Grow Employee Engagement and Motivation
    - Teamwork and Leadership
        - Company strategy and clarity
        - Company culture
        - Employee engagement and morale
6. Improve Sales and Marketing
    - Brand awareness
    - Grow sales
    - Increase customer satisfaction
7. Optimize Inventory Management
    - Organization and retrieval systems
    - Reconcile inventory materials
    - Determine optimum levels and minimum levels
    - Inventory systems and alignment; accounting, stores, production

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Lean management in aquaculture:
A practical guide for smallholder fish farmers

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Lean management in aquaculture: A practical guide for smallholder fish farmers

Authors

Terri K Lawrence,[1] Joseph T Steensma,[2] Oyediran O. Oyebola,[3] Elizabeth I Akuwa,[4] Carroll L Rhea,[1] Rohana P Subasinghe,[4] Julius Nukpezah[5] and Sunil N Siriwardena.[4]

Affiliations

[1] Collaborative Impact
[2] Washington University in St Louis
[3] University of Ibadan
[4] WorldFish
[5] Mississippi State University

Citation

This publication should be cited as: Lawrence TK, Steensma JT, Oyebola OO, Akuwa EI, Rhea CL, Subasinghe RP, Nukpezah Jand Siriwardena SN, 2023. Lean management in aquaculture: A practical guide for smallholder fish farmers. Penang, Malaysia: WorldFish. Manual: 2023-18.

Acknowledgments

This publication was made possible through support provided by the United States Agency for International Development (USAID) through the Feed The Future Innovation Lab for Fish. This work was developed with the support of WorldFish. The program is supported by contributors to the CGIAR Trust Fund.

About the Fish Innovation Lab

The Fish Innovation Lab supports the United States Agency for International Development's agricultural research and capacity building work under Feed the Future, the U.S. Government's global hunger and food security initiative. Mississippi State University is the program's management entity. The University of Rhode Island, Texas State University, Washington University in St. Louis, and RTI International serve as management partners.

Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: worldfishcenter@cgiar.org

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Front cover, Elizabeth Akuwa/WorldFish.

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Introduction

Welcome to this guide on lean management for fish farmers. Are you tired of high costs and inefficiencies that are stealing your profits? Do you feel overwhelmed by complex approaches to solving these issues? If so, you're in the right place. This guide is designed to provide a simple, step-by-step solution to help you address these major thieves in fish production quickly and effectively.

Meet Mary, a small-scale fish farmer just like you. She is frustrated with the high costs of feed and fuel and is overloaded with farm tasks. But with lean management, Mary is hoping to transform her farm from barely sustainable to profitable and thriving. And with the roadmap provided in this guide, you can do the same.

Are you tired of running a farm that's just barely scraping by? Well, lean management is the game-changer you've been looking for. This system is chock-full of powerful tools, methods, and structures that can make your farm more efficient and profitable. By implementing the principles in this guide, you can improve your operations by a staggering 80 percent or more. And that's not all—the overall increase in revenue could soar past 33 percent. So why wait? Take your farm to the next level with lean management today.

Throughout this guide, we'll take you on a journey with Mary, a fictional character representing a typical small-scale catfish farmer, as she implements lean management on her farm. You'll learn about the fundamental principles and tools of lean management and how to apply them to your own operation. By the end of this guide, you'll have the knowledge and skills you need to transform your small-scale fish farm into a lean, mean, profit-making machine.

1. Jump into lean

Are you tired of inefficient processes, wasteful practices, and low profitability in your aquaculture business? Look no further than lean management! This approach has revolutionized industries worldwide, and aquaculture is just getting started. So let's begin a new era of aquaculture management.

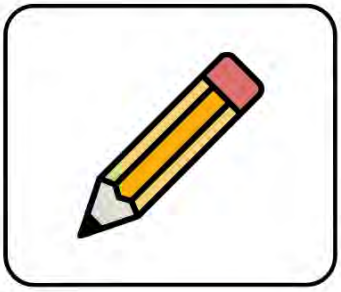
Lean management, also known simply as "lean," is all about minimizing waste and maximizing value for the customer, which translates into lower costs, improved product quality and higher profits for the producer. By examining your processes critically and implementing creative, low-cost solutions, you can maximize your production efficiency with minimal waste. And the best part? Implementing lean principles comes with little to no cost.

The core principles of lean management involve minimizing waste, maximizing value, and continuously improving processes. In aquaculture, this can mean using less water, minimizing feed waste, improving fish quality and optimizing energy consumption. By fostering a culture of bottom-up problem-solving, lean management also creates a positive work environment that is respectful, engaged, accountable and collaborative.

In light of this, focusing on the skillsets and growth potential of your farm's personnel is highly recommended. To achieve this, one practical approach is to fill out an employee skills reference form.

Take a moment to think about the people around you and your farm. Then fill out the form in Figure 1 to have a good reference sheet for you to quickly identify and tap into the skills and temperaments that can help you address farm issues as they arise.

Employee Skills Reference Form



Name	Job Title	Skills	Growth Opportunities	Personality Traits	Other Information

Figure 1. Employee skills reference form.

Employee Skills Reference Form Example

Name	Job Title	Skills	Growth Opportunities	Personality Traits	Other Information
John	Farm Manager	Fish husbandry, water quality management, feed formulation, record-keeping	Leadership training, project management, business development	Organized, analytical, responsible	Has 5 years of experience in fish farming, previously managed a small farm
Grace	Fish Health Specialist	Fish disease diagnosis and treatment, water quality management, data analysis	Veterinary training, aquaculture research, team management	Detail-oriented, independent, proactive	Holds a Bachelor's degree in Fisheries and Aquaculture, recently completed an internship at a research institution
Michael	Farm Technician	Fish feeding, pond maintenance, equipment operation, record-keeping	On-the-job training, machinery repair and maintenance	Physically fit, adaptable, team player	Has 2 years of experience in fish farming, previously worked on a poultry farm

Figure 2. Example of a completed employee skills reference form.

Knowing your employees is an important part of lean management, as it taps into skillsets and personality traits on your farm to drive changes through a bottom-up problem-solving and teamwork culture. For this, an employee skills reference form can be used to quickly reference an employee's abilities, potential for advancement, personality traits, and other pertinent details. This information can help you identify an employee's strengths and weaknesses, assign tasks and responsibilities, provide training and development opportunities, and make informed decisions about promotions or hiring. It can also help you identify gaps in skills or experience that you need to fill through either recruitment or training.

One of the most significant advantages of lean management is that it empowers employees and involves them in the improvement process. By providing training and resources and encouraging employees to identify and suggest improvements, farmers can build a culture of continuous improvement and increase employee engagement, motivation, and satisfaction.

Implementing lean management principles requires a strong desire to take action and move away from business as usual. Small-scale fish farmers must be willing to critically examine their processes and identify areas for improvement. By doing so, they can increase their competitiveness and achieve long-term success in the industry.

Mary is a prime example of a farmer who is ready to step up and do the work it takes to elevate her farm to the next level. Mary sees how implementing lean management principles can lead to significant improvements. By reducing waste and improving efficiency, Mary expects to improve the quality of her fish and increase her profits.

Lean management is a powerful approach that can significantly benefit the aquaculture industry. By minimizing waste and maximizing value, businesses can improve the quality of their products and increase their profits while reducing their environmental impact. In addition, by learning the principles of lean management and applying them to their operations, small-scale fish farmers, like both you and Mary, can make significant improvements at zero cost to them. So why wait? Jump into lean management and experience a new era of aquaculture management.

2. Setting your sights

Are you ready to get organized and take your aquaculture business to the next level? In this chapter, we will help you identify your top priorities and turn them into actionable goals. But we won't stop there. We'll also introduce you to Mary's farm, where Mary is struggling with low profits because of the high costs of feed and fuel. Finally, we'll show you how Mary turns her concerns into goals and prioritizes them to achieve success.

First, let's get clear on your top priorities.

2.1. Prioritizing and goal setting

A great way to start this activity is to ask yourself a critical question about your farm operations.

Typical answers include not enough money, dying fish, too much work to do, high cost of feed, running out of fuel, inventory theft, water quality, etc.

Let's take a moment to dive deep into this crucial question, because identifying and prioritizing your primary concerns is critical to achieving success. Once you've identified your top three to five problems, it's time to turn them into prioritized goals. This step is crucial to ensure that you focus on the issues that matter most to set yourself up for success. So, let's get started!

Now, take a moment and think deeply about this critical question.

1. First, write down the main problems on your farm that come immediately to mind.
2. Next, look at them and determine the ones that would make the most significant impact if they were solved; it is essential to identify and prioritize your main concerns.
3. Finally, turn your top three to five problems into goals to address.

Follow these three steps and write your top goals in the form in Figure 3.

Figure 3. Goals exercise.

We will also do this goal-setting activity for Mary's farm. But first, let's look at Figure 4 to get a little more familiar with the farm itself.

2.2. description of Mary's farm

Mary has a one-hectare farm with two catfish ponds, each with its own water pump. She also has a handy storage shed on-site that keeps all the supplies and feed she needs for her fish. Mary is always busy managing her farm. She does everything from preparing her ponds to managing the water supply and keeping a watchful eye on inventory control. Of course, there are the issues of harvesting and transportation as well as finding the perfect buyers for her fish. Mary has one employee on-site to help her feed the fish and make sure the ponds have a good water flow to keep everything clean and healthy

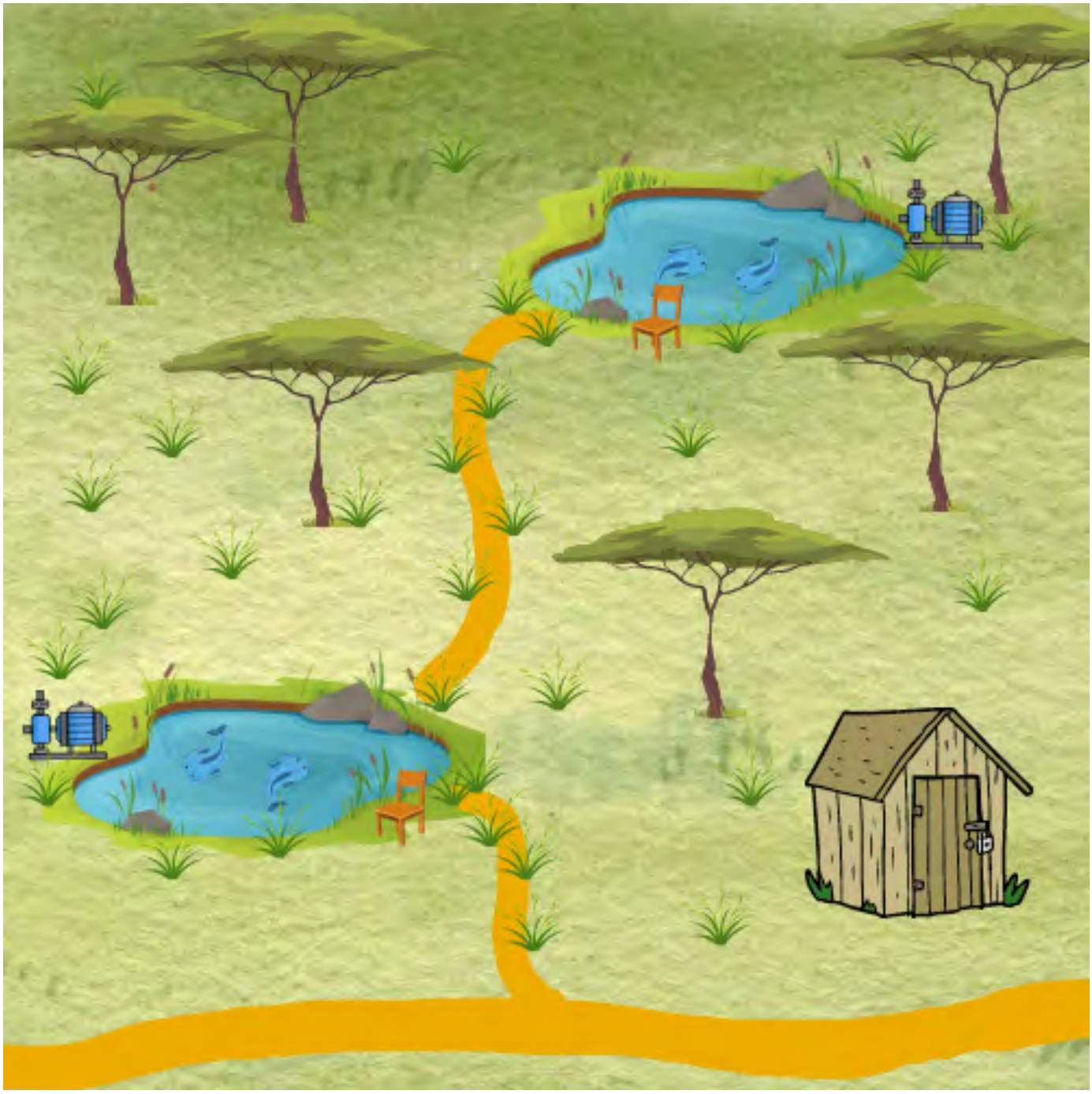


Figure 4. Mary's farm.

What's the biggest concern that keeps Mary up at night? She wants to know how to improve her low profits. With her experience, she knows the high costs of feed and fuel on her farm take a bite out of her profits. Being responsible for most of the farm's activities, Mary feels exhausted from being overworked.

In one of her first steps into lean management, she takes these issues, converts them into goals, and records them as her top priorities, as shown in Figure 5.

As a small-scale fish farmer like Mary, determining your top goals is crucial because it helps you identify and prioritize the most critical issues that you need to address in your operation. By focusing on the problems that matter most, you can set yourself up for success and make meaningful improvements that can lead to higher profits, improved efficiency and overall success in your aquaculture business. By converting your identified problems into prioritized goals, you can create a roadmap that guides your decision-making, making it easier to track progress, measure success and ultimately achieve your desired outcomes

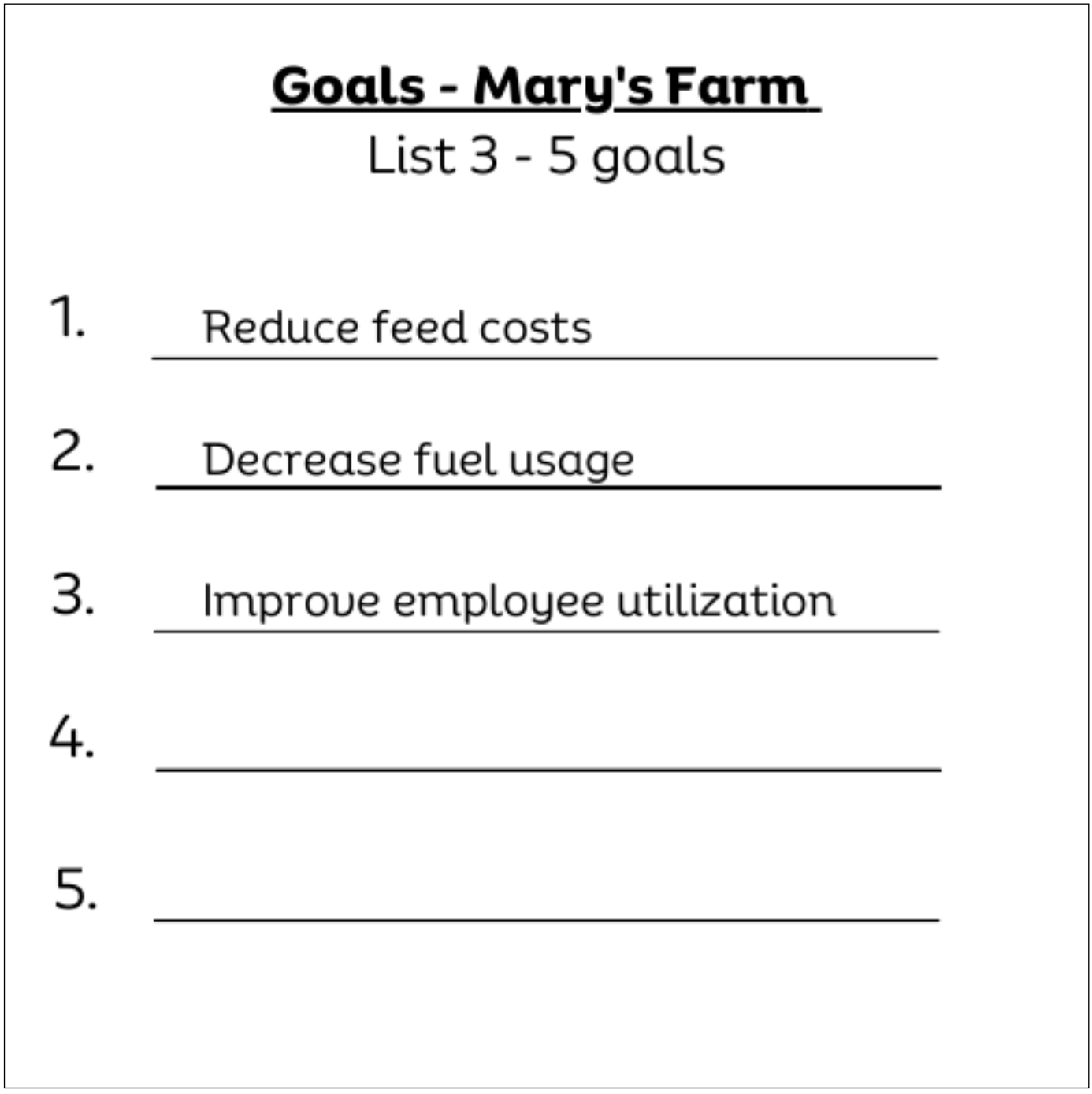


Figure 5. Mary's goals for her farm.

3. The power of mapping

Welcome to Chapter 3, where we dive into one of the most powerful lean management tools available: value stream mapping. Now that you have identified your top goals, it's time to focus on how to achieve them efficiently and effectively. This chapter will explore how to use the value stream mapping tool to streamline your processes and maximize your output. By mapping out the steps needed to achieve a specific goal and pinpointing areas of waste and inefficiency, you'll be well on your way to improving your operations and reducing costs. So get ready to take your farm to the next level as we guide you through the practical application of value stream mapping.

3.1. Value stream mapping: Definition and practical application

First, it's important to understand how lean management defines value. Value is any action or process that directly contributes to meeting the needs of the customer. Now, let's apply this thinking specifically to small-scale fish farmers. A fish farmer's value is providing their customers with a high-quality, nutritious and sustainable source of protein.

Value stream mapping is a lean management tool that helps document that value. A value stream map (VSM) clearly outlines the steps in the process and highlights opportunities for improvement to streamline your operations quickly. In addition, each step of the process shows related metrics like time, materials and resources, so you'll be able to pinpoint areas where you can cut waste and boost efficiency. With the value stream mapping tool in your arsenal, you'll be well on your way to optimizing your aquaculture processes and maximizing your output. So, get ready to take your operations to the next level!

To create a VSM, carry out the following steps:

1. Start by determining a specific process to focus on that will help you achieve your goals.
2. Write down the significant steps needed to achieve each goal in the order they are accomplished; there should be about 10 steps, but no fewer than five and no more than 15.
3. After you map the steps, make notes of critical measurements for each one, such as the amount of time to complete that step, the equipment needed, the amount of materials used and the number of people it takes to carry it out.

Once the VSM is complete, you have a fantastic one-page communication tool for evaluating and improving your targeted process.

Begin practicing this tool by following the three steps above to map one of your farm's processes using the template in Figure 6.

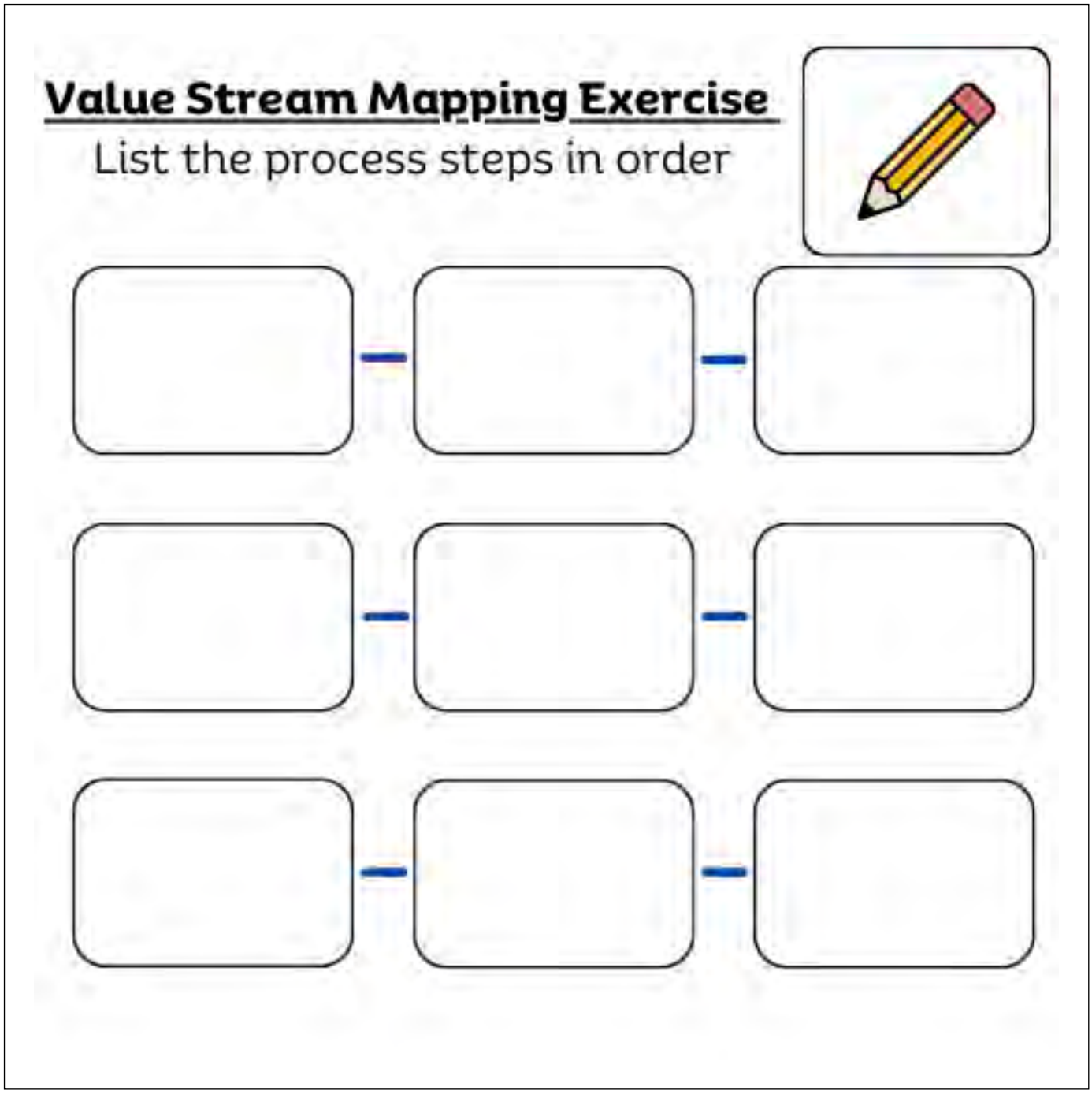


Figure 6. Value stream mapping exercise.

Excited to make a big impact on her farm, Mary hones in on her goal of reducing her feed costs and gets to work using the value stream mapping tool. She maps out the various steps involved in feeding her fish and notes how they are typically carried out.

Well done! You now know about the potent lean management technique called value stream mapping and how it can help you optimize the processes on your farm to achieve your goals. By following the steps outlined in this chapter, you can start mapping out your processes, pinpointing areas of waste, and increase efficiency to maximize your output. Remember, value stream mapping is not a one-time task but an ongoing process that can help you continuously improve your operations, so we will continue to use it as we progress throughout this guide. Don't hesitate to implement this tool and start impacting your farm today.

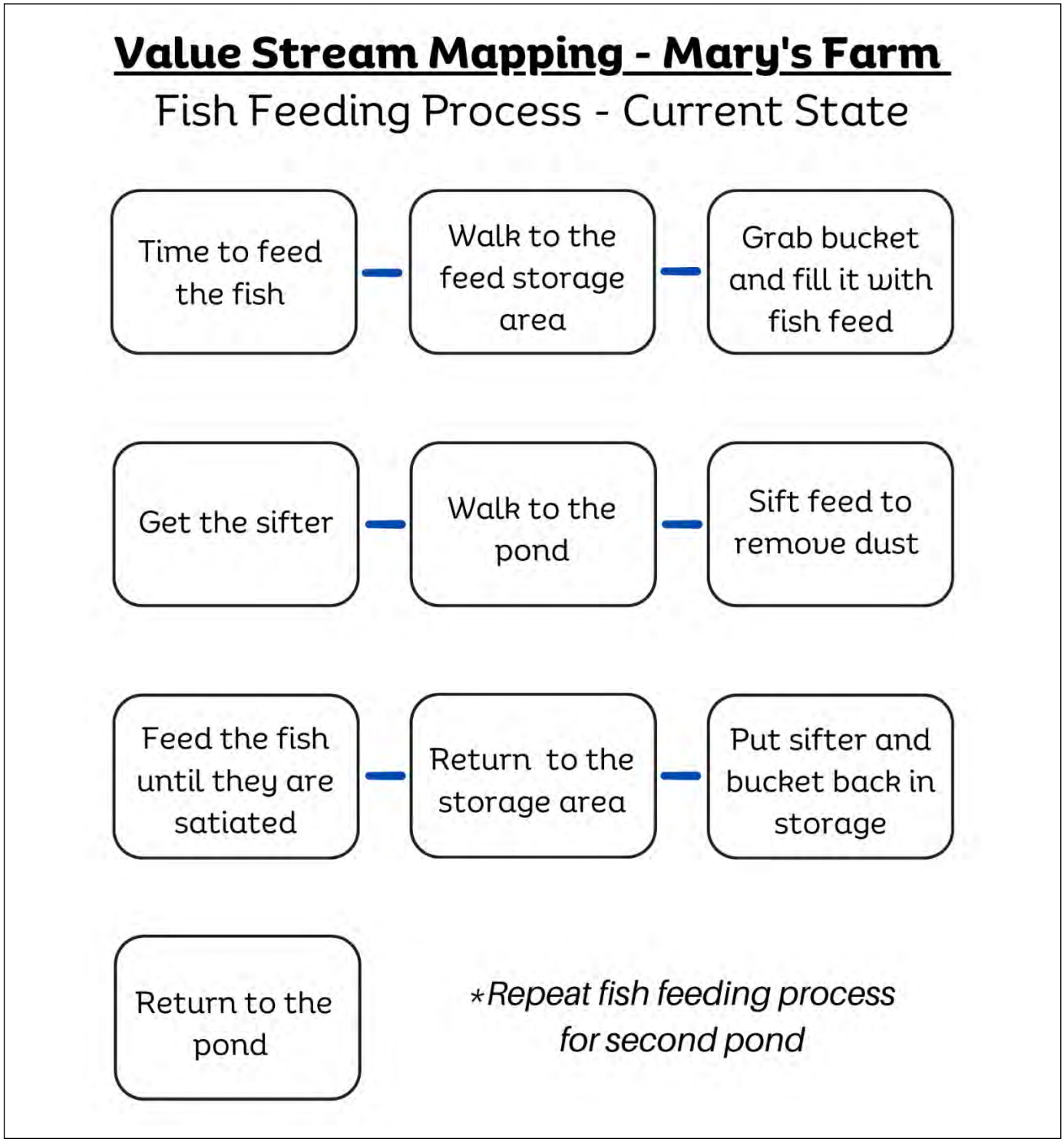


Figure 7. A VSM for Mary's farm.

4. Untangle inefficiencies

4.1. The spaghetti diagram tool

Welcome to the spaghetti diagram tool, a powerful visual representation of your farm's physical layout that can help you identify inefficiencies and improve your operations. With this tool, you can capture motion, equipment and materials to pinpoint areas of congestion, unnecessary movement or inefficient layout. By following the steps outlined in this chapter, you can create your own spaghetti diagram and use it to optimize your farm's layout. The resulting visual tool will quickly reveal inefficiencies in your process and provide opportunities for improvement. So, let's get started by learning how to create a spaghetti diagram and why it's such an effective tool for lean management in aquaculture.

To create a spaghetti diagram, carry out the following four steps:

1. Start by drawing a rough sketch of your farm's layout from a bird's-eye or top-down view.
2. Next, draw the location of essential parts of your farm, such as ponds, water sources, processing facilities, harvesting areas, administrative buildings, major equipment and storage areas.
3. Next, draw a line on the layout sketch to indicate the movement that the person doing the work takes.
4. Use different colors to create more complex diagrams that can separate and track the movements of materials, equipment and additional people.

Your resulting spaghetti diagram will reveal a visual tool that quickly identifies inefficiencies. It will show many drawn lines, illuminating excessive movement in both distance traveled and repetitive motion in your process.

Use the form in Figure 8 to practice using this tool by sketching the layout of your farm; it's just a rough sketch, so it does not need to be perfect.

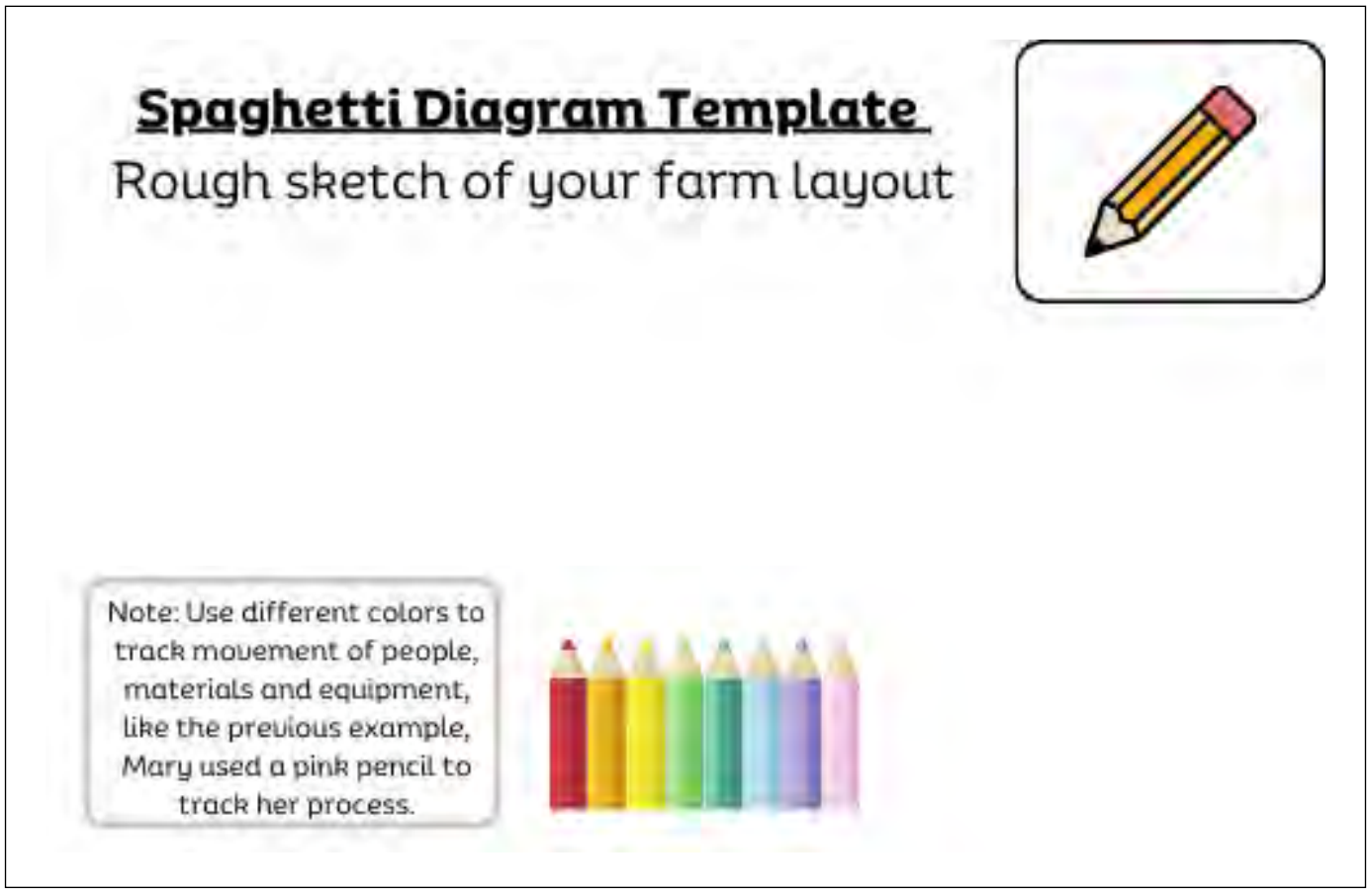


Figure 8. Spaghetti diagram template.

Let's see how Mary begins using this tool by sketching her farm's layout; it's simply a representation, so it doesn't have to look perfect.

The spaghetti diagram tool is a valuable visual representation of your farm's layout that can help you identify inefficiencies and improve your operations. By following the steps outlined in this chapter, you can create your own spaghetti diagram and start pinpointing areas of waste and inefficiency in your farm processes. Remember, this tool is not a one-time task but an ongoing process that can help you continuously improve your operations, so we will continue using it as we progress throughout the guide. By implementing the spaghetti diagram tool and other lean management principles, you can increase your profitability, improve your product quality and minimize your impact on the environment. So, take action to make your aquaculture business thrive!

Figure 9. A spaghetti diagram of Mary's farm.

5. Grow awareness

If you are like Mary, you want to get the most bang for your buck. The way to do this is by maximizing the value you create while minimizing any waste holding you back. Lean management focuses heavily on these two primary principles: creating value and eliminating waste.

5.1. Value

As mentioned in Chapter3, value is defined as any activity or process that directly contributes to delivering a product or service that meets the needs and requirements of your customers. Understanding what your customers truly value is critical to delivering it consistently. As such, value is determined by your customers and is always associated with a specific product or service. As a fish farmer, it is essential to understand what your customers truly value.

Generally, customers want fish that meet the following six criteria:

1. **Freshness**: Customers want fish that are freshly harvested and have not been stored for a long time.
2. **Quality**: Customers want fish that are healthy and free from diseases or parasites, with firm flesh and a pleasant smell and taste.
3. **Size and weight**: Customers may prefer buying fish of a certain size and weight, depending on their needs and how they intend to use the fish.
4. **Cleanliness**: Customers want fish that have been properly cleaned and gutted, with no scales or debris left on the fish.
5. **Price**: Customers want to buy fish at a fair price, which can vary depending on the conditions at local markets.
6. **Convenience**: Customers may prefer to buy fish in easy-to-use portions or fillets, or packaged in a way that makes them easy to transport and store.

When it comes to purchasing fish, customers typically look for freshness, high quality and affordability while also having preferences for size, cleanliness and convenience. In addition, the customer's interest could differ depending on location, customs and the socioeconomic structure. Because of these factors, you should familiarize yourself with the interests of your target customers in order to avoid waste. Fish farmers must understand the specific value their customers want and seek to deliver it consistently.

Identify and prioritize any unique customer demands that you have discovered, especially those that you need to give more attention to. Then, document them in the form in Figure 10.

Defining What Customers Value Exercise

Identify and prioritize any unique customer demands and give them the attention they deserve

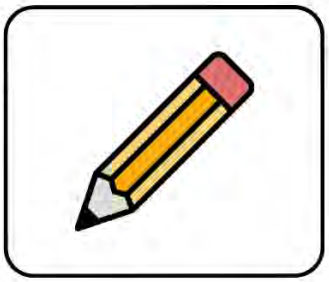


Figure 10. Customer value form.

5.2. Waste

Waste refers to any activity or process that does not add value to the product or service and should be eliminated or minimized. To do this, you need to develop "eyes for waste" in order to see the waste on your farm and within your current farm processes.

There are eight types of waste. They are easily remembered using the acronym DOWNTIME, which stands for Defects, Overproduction, Waiting, Not using people, Transportation, Inventory, Motion, and Extra processing.

- **Defects** refer to any errors or mistakes during the production process that results in products that do not meet the requirements of the customer. For example, in small-scale fish farming, defects could include fish that are of poor quality or fish that are damaged during transportation or handling.
- **Overproduction** occurs when more fish are produced than are needed or can be sold. This can lead to excess inventory and waste, as well as increased costs associated with storage and handling. In addition, excessive feeding in ponds can produce too much biomass, causing the water to turn heavily green and depleting the oxygen in the water.
- **Waiting** refers to periods of inactivity or delays during the production process, which can waste time and resources. For instance, in small-scale fish farming, waiting can happen if fish are not harvested or processed promptly, leading to spoilage or degradation of quality. Waiting can also occur when farmers wait for feed, feed ingredients or technical repairs for their pond facilities.
- **Not using people** applies to any situation where workers are not fully engaged or used in the production process, leading to wasted time and resources. In small-scale fish farming, this can occur if workers are not adequately trained or equipped to perform their jobs, resulting in inefficiencies and errors.
- **Transportation** waste is any unnecessary movement of products or materials that adds time and cost to the production process. In small-scale fish farming, transportation waste occurs if fish are moved between multiple locations unnecessarily or if inefficient transportation methods are used. For instance, carrying feed bags one by one is less efficient than using a trolley to transport many loads simultaneously.
- **Inventory** waste applies to any excess inventory that is not needed or cannot be sold. In small-scale fish farming, this occurs when too many fish are produced or when storage and handling methods are inefficient, leading to spoilage or loss of quality.
- **Motion** waste is any unnecessary movement or motion in the production process that adds time and cost. In fish farming, motion waste occurs when workers travel long distances to perform their jobs or use inefficient handling methods. For instance, locating feed in a store far away from the fishpond causes excessive motion in getting the feed and returning it to the pond.
- **Extra processing** refers to any unnecessary steps or processes in production that do not add value. For example, in small-scale fish farming, excess processing waste occurs when fish are processed or handled in unnecessary or inefficient ways.

These eight nearly invisible wastes steal time and money throughout your farm. But did you know that by being aware of DOWNTIME, you can easily spot areas of waste on your farm or within your processes? It's true! Armed with this knowledge, you can take proactive steps to reduce or even eliminate these wastes altogether, saving you money and adding time back into your day.

It's time to practice identifying your waste in the template in Figure 11. It might be helpful to take a walk around your farm, opening your eyes and searching for waste that is sometimes in plain sight but has been invisible previously. We call this having new "eyes for waste." Now, go spot waste with your new eyes!

By eliminating waste and focusing on creating value, lean management helps organizations increase efficiency, reduce costs, improve quality and enhance customer satisfaction. This approach emphasizes the importance of understanding customers' needs and requirements, designing processes to meet those needs, and continuously improving those processes to meet customers' changing demands.

Implementing lean management principles in fish farming can have significant benefits for a farm's efficiency, productivity and profitability. The key to success is understanding what customers value and eliminating any waste in the production process. Value is determined by customers' needs and requirements, such as freshness, quality, size, cleanliness, price and convenience. Waste, on the other hand, is any activity or process that does not add value to the product or service and should be minimized or eliminated. By being aware of the types of waste in DOWNTIME, you can take proactive steps to reduce or eliminate these wastes, saving both time and money. Overall, the lean management approach emphasizes continuous improvement and meeting customers' demands changing, leading to increased efficiency, reduced costs, improved quality and enhanced customer satisfaction.

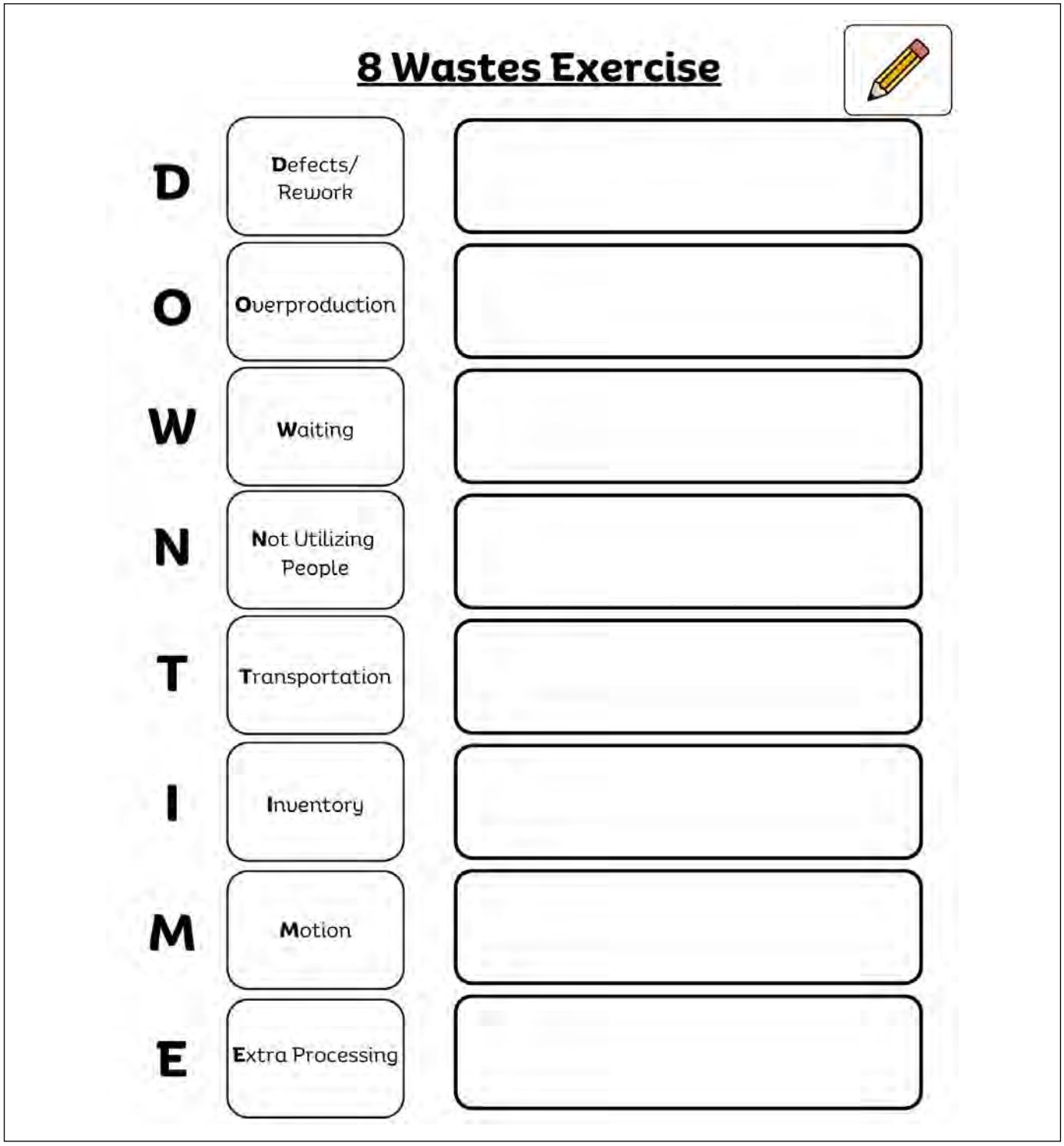


Figure 11. An 8 Wastes exercise.

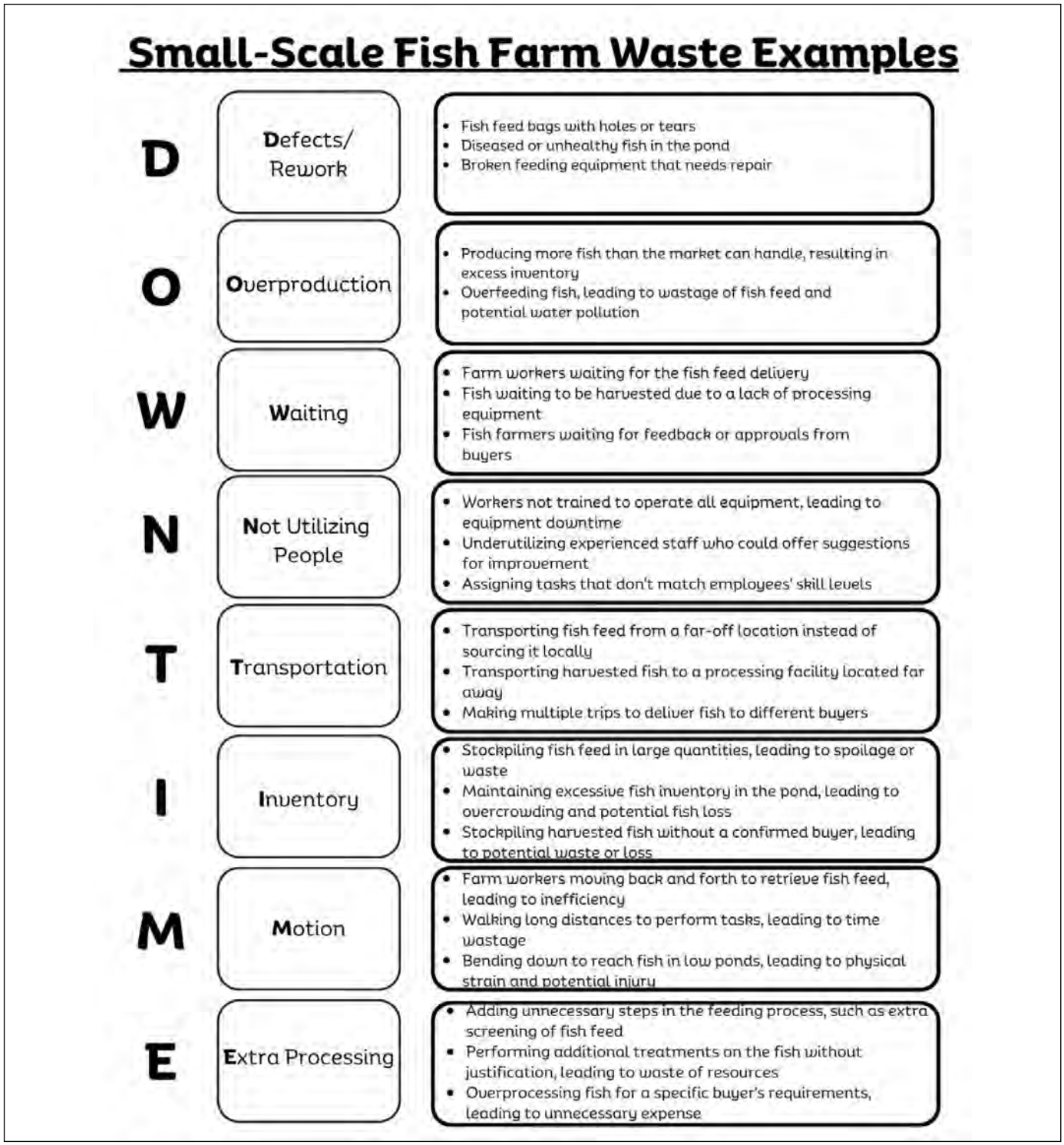


Figure 12. Examples of waste on small-scale fish farms.

6. Turbocharge farm efficiency

Now that you are ready to take action and remove the waste on your farm, it's time to introduce a lean management implementation methodology called a rapid improvement event (RIE).

6.1. Rapid improvement event

An RIE is a focused and intense team effort to solve a specific problem or improve a targeted process within a short period of time, typically lasting a few days or a week. The event brings together a cross-functional team to analyze the current state of the target process, identify areas of improvement and develop and implement solutions. The event involves identifying opportunities for improvement, engaging employees in the improvement process and using data to measure the effectiveness of changes.

There are seven steps in an RIE:

1. **Define the problem or opportunity for improvement**: Clearly define the issue or process that needs improvement and establish measurable goals for success.
2. **Assemble a team**: Build a cross-functional team of individuals with diverse skills and perspectives who can help identify the root cause of the problem and develop effective solutions.
3. **Analyze the current state of the target process**: Collect data and analyze the current process to identify areas of waste, inefficiencies, and opportunities for improvement.
4. **Develop and test potential solutions**: Brainstorm and evaluate potential solutions, and then test them to see if they address the root cause of the problem.
5. **Implement and standardize**: Once a solution has been identified and tested, implement it and create standard work procedures to ensure consistency and sustainability.
6. **Monitor and measure**: Monitor the new process continuously to measure its effectiveness and identify any areas needing further improvement.
7. **Celebrate success**: Celebrate and recognize the team's hard work and success in achieving the goals of the RIE. This helps build momentum and support for further continuous improvement efforts.

For Mary, she is a go-getter. She's motivated and takes the initiative to have conversations with her customers, ensuring she fully understands their needs and desires to provide them with the utmost value.

The problem Mary needs to address is the high cost of feed. She has 5000 fish in each of her ponds, for a total weight of 1000 kg. Mary uses Bob's Brand of sinking feed that she gets in town, and she feeds the fish in each pond 40 kg daily, which costs USD 1.25/kg for a total of USD 100 per day or USD 18,000 for a 6-month cycle per year. Mary also eagerly looks forward to implementing the RIE method on her farm to achieve her goals.

6.2. RIE Step 1

To begin the process of improvement, it is essential to define the problem or opportunity clearly. This involves identifying the issue or process that needs improvement and setting measurable goals for success.

Define the problem or opportunity for improvement: Clearly define the issue or process that needs improvement and establish measurable goals for success.

6.2.1. Mary's farm

In Mary's case, she and her team identify the problem as the need to optimize feed use and the feeding process to reduce feed costs by 20 percent. By defining this problem and setting a specific goal, Mary and her team can focus their efforts and develop a plan of action to achieve their desired outcome. With a clear understanding of the problem and a measurable goal in place, they can now move forward with confidence and purpose.

6.3. RIE Step 2

To effectively identify the root cause of a problem and develop practical solutions, it's essential to assemble a cross-functional team of individuals with diverse skills and perspectives.

Assemble a team: Create a cross-functional team of individuals with diverse skills and perspectives who can help identify the root cause of the problem and develop effective solutions.

6.3.1. Mary's farm

For this purpose, Mary carefully assembles an RIE team that consists of herself, one employee and three experienced farmers. Her team is well equipped to collaborate and work toward achieving the goals of the RIE. It's worth noting that the optimal team size is usually five to six people. Mary's team falls within this range, so it makes it easier for them to work together efficiently.

6.4. RIE Step 3

In the third step of the RIE process, the team must analyze the current state of the target process by collecting data and identifying areas for improvement.

Analyze the current state of the target process: Collect data and analyze the current process to identify areas of waste, inefficiencies, and opportunities for improvement.

6.4.1. Mary's farm

To prepare for this step, Mary gathers her tools, which include a VSM of the feeding fish process, a spaghetti diagram layout of her farm, and 8 Wastes DOWNTIME forms for each team member. The VSM helps visualize the current process, the spaghetti diagram provides a clear understanding of the physical layout of the farm, and the 8-Wastes DOWNTIME form is used to identify areas of waste and inefficiencies. With these tools in hand, Mary and her team can analyze the current state of the target process and determine where to make improvements.

The RIE team gathers together and observes Mary's employee perform the fish feeding process on her farm. As they watch, team members take photos, capture motion on the spaghetti diagram, time the process steps, measure the distance traveled, identify wastes and take notes. As shown in Figures 13 and 14, they update the VSM with process time information and draw the spaghetti diagram to show the movement of the worker who is performing the fish feeding process.

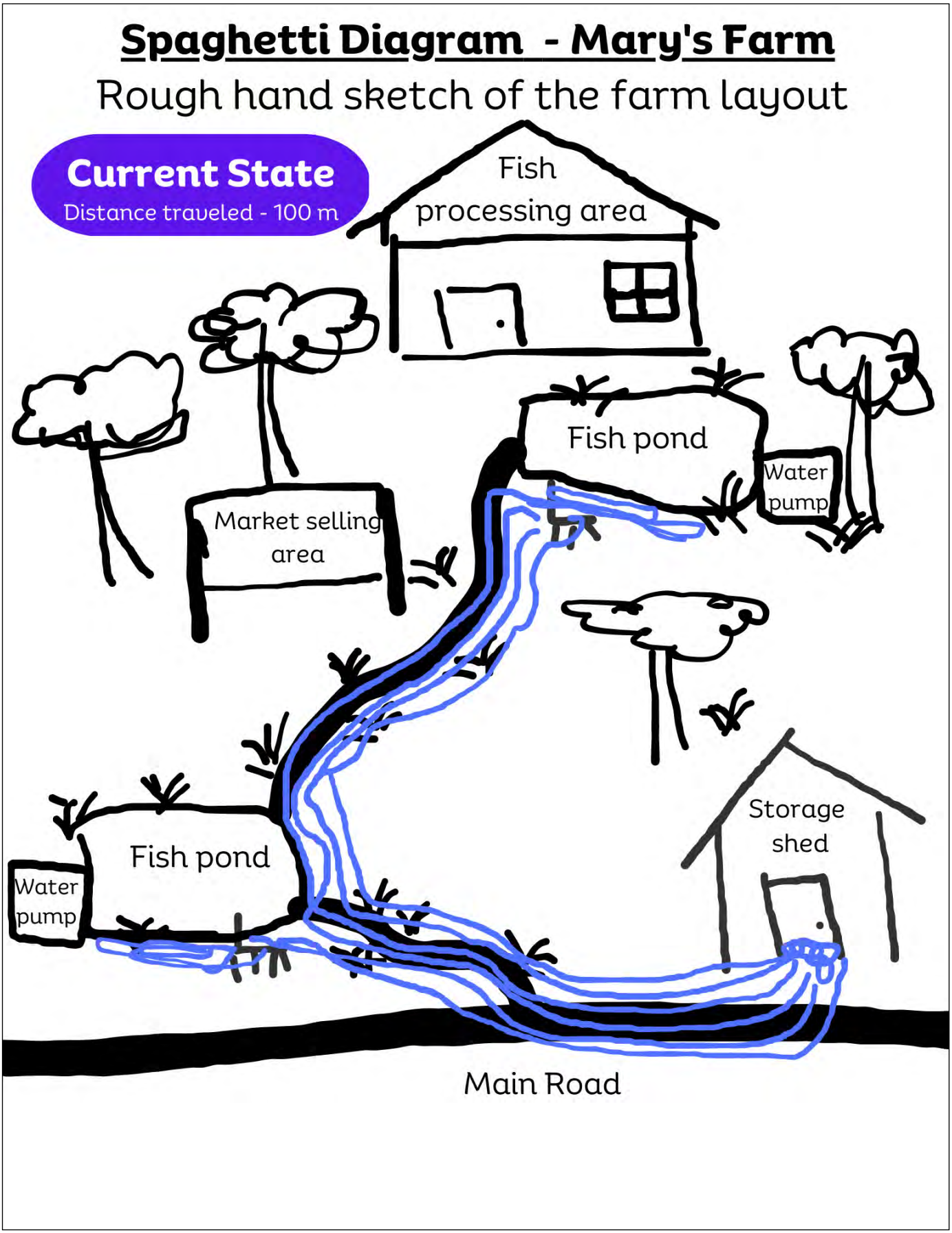


Figure 13. Updated spaghetti diagram for Mary's farm.

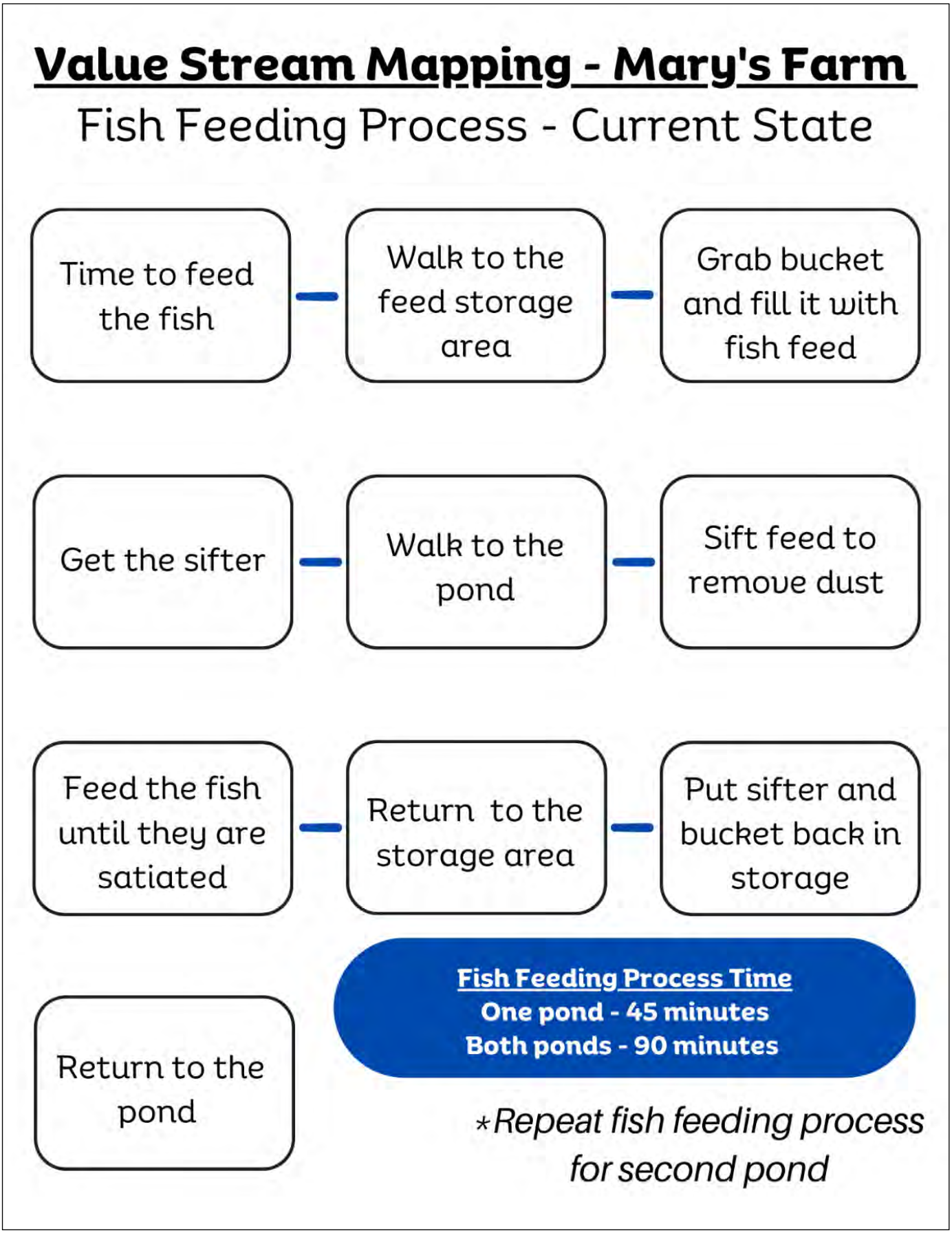


Figure 14. Updated VSM for Mary's farm.

After observing the feeding process, the team analyzes the data they've collected, asks the worker questions for clarification and discusses significant issues and opportunities. The group reviews all the information and identifies the crucial areas to address. Next, the team revisits their initial RIE objective, which is to optimize feed use and the feeding process and reduce feed costs by 20 percent. Finally, after reflecting on their lean management tools and having discussions, the team prioritizes the issues and opportunities based on their impact on their goal.

The team decides to concentrate on the following three areas:

1. **Farm layout using the spaghetti diagram tool**
- The feed bags are located in the storage shed, far away from the ponds.
- There is a lot of excess motion and travel in the feeding process.

2. **Feed process using the value stream map tool**
- Feeding takes longer than it should.
- The distance traveled to retrieve and distribute feed bags is excessive.
- The employee lacks proper knowledge of satiation from sinking feed.
- The fish are not interested in the feed, so they are not eating aggressively, leading to reduced feeding response.
- There are dead fish floating in the water.
- The water is green, cloudy and smells foul.
- Water pump is running constantly, using up too much fuel.

3. **The 8 Wastes DOWNTIME form**
- There are people who are not doing much, so their knowledge and experience are not being put to good use.
- There is too much movement during the fish feeding process.
- Transporting the feed during the fish feeding process takes too long.

Mary's team will continue the RIE steps in the upcoming chapters.

To sum up, RIE is a focused and intense team effort to solve a specific problem or improve a targeted process within a short period of time. It is a lean management implementation methodology that brings together a cross-functional team to analyze the current state of the target process, identify areas of improvement, and develop and implement solutions. The process is designed to quickly and efficiently improve productivity, reduce waste, increase profitability and create a culture of continuous improvement. Overall, by implementing lean management principles and using RIE, farmers can make quick and impactful improvements on their farms.

7. Get the roots out

Are you ready to take your farm to the next level? It's time to leave behind the monotony of the past and embrace a fresh approach that will yield amazing results. And the good news is, this guide will walk you through how to do it. So get ready to break free from the past and achieve the results you've been dreaming of!

Root cause analysis (RCA) is a crucial problem-solving tool for farmers looking to improve their farm's efficiency and productivity. By identifying the underlying cause of a problem, farmers can take the necessary steps to address the root cause and prevent the problem from reoccurring. So, if you want to improve your farm's performance, try getting to the root of your farm's problems.

Don't worry, you don't have to do it alone. This guide is your ultimate companion to achieving the success you've been yearning for. We'll start by diving into RCA. Then we'll take you on a journey through the implementation steps that will guide you through the changes you need to make on your farm.

7.1. Root cause analysis

Once you've thoroughly reviewed all the information and observed your farm's processes, it's time to get to the heart of the critical issues. Gaining a deeper understanding of these issues will enable you to find quick and effective solutions. Armed with this knowledge, you'll find that taking action and solving problems on your farm becomes a breeze.

When it comes to problem-solving on your farm, here's a valuable tip: take the time to uncover the root cause of the issue. It might take some extra effort, but it's well worth it. Dealing with the symptoms or surface-level problems might provide temporary relief, but it's unlikely to solve the issue over the long term. However, pinpointing and addressing the root cause will help prevent the problem from reoccurring and lead to more sustainable solutions. Plus, by focusing on the root cause, you'll save time and resources by avoiding ineffective or unnecessary interventions. So, dive into an RCA and identify those underlying issues that have been holding you back. Then, you can create a plan to overcome them and take your farm to a higher level of performance.

If you're struggling to identify the root cause of a problem on your farm, the 5 Why technique may be the answer you've been looking for. This methodology involves asking "why" questions repeatedly until you uncover the underlying cause of the issue. By digging deeper and going beyond the surface-level symptoms of the problem, you can identify the fundamental reason behind it and take the necessary steps to address it. With the 5 Why approach, you can unravel even the most complex issues and find effective solutions that stick.

The 5 Why Process works as follows:

1. **Define the problem**: Clearly define the problem that needs to be solved.
2. **Ask "why?" five times**: Ask "why" to determine the cause of the problem. Each answer leads to another "why" question until the root cause is identified. Generally, five "whys" are enough to identify the cause, though it might take more or less.
3. **Identify and implement solutions**: Once you identify the root cause, brainstorm potential solutions to address it. Then, implement the most effective solution(s) and monitor for improvement.

The best way to become familiar with this method is to see a couple of examples and get the rhythm of how it flows. Follow how to use the 5 Why method in Figure 15.

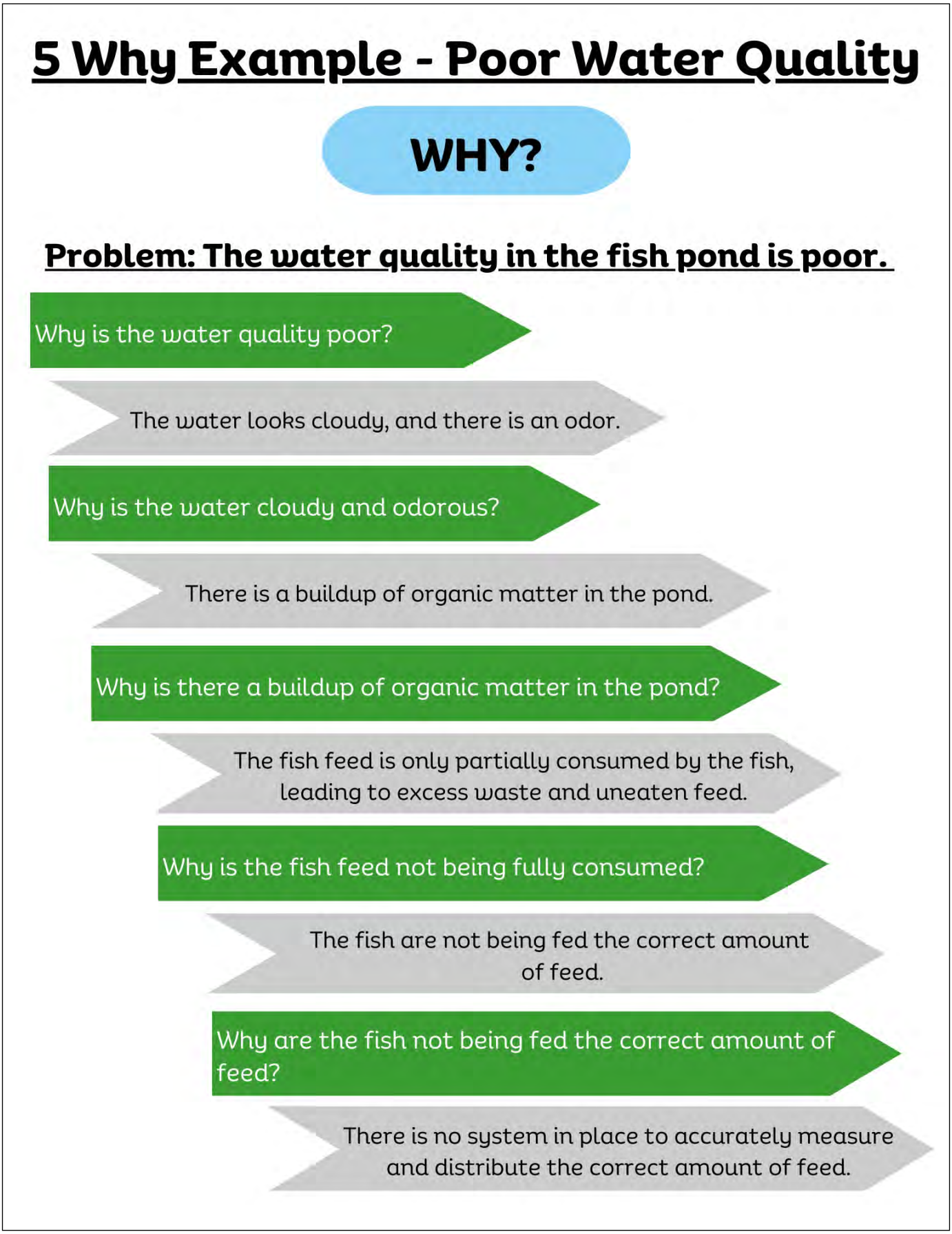


Figure 15. Example of the 5 Why method.

In this example, you can see that the root cause is the lack of a system to accurately measure and distribute the correct amount of feed. This leads to excess waste and uneaten feed, which in turn results in poor water quality from a buildup of organic matter.

Here is another 5 Why example related to slow fish growth:

Problem: The fish are growing slower than expected.

1. Why are the fish growing slower than expected?
   They seem to be eating less.
2. Why are the fish eating less?
   They do not like the feed.
3. Why do they not like the feed?
   We are using low-quality ingredients.
4. Why are we using low-quality ingredients?
   They are less expensive, and we are trying to keep our costs down.
5. Why are we trying to keep our costs down?
   We are not making enough profit from selling the fish, so we need to reduce our expenses.

In this example, you can see that the root cause of the problem is the need to lower expenses, which leads to using low-quality ingredients in the fish feed. However, to address the issue of slow fish growth, the farmer may need to consider using higher-quality ingredients in the feed, even if they are more expensive, to improve the fish's overall health and growth. In this case, one potential strategy to consider is investing in a short-term expense that could result in bigger and healthier fish, leading to higher revenues in the long run.

Now it's your turn. Select a problem, and go through the steps in 5 Why process in Figure 16 to practice getting to the root cause(s). This is another skillset you can learn to help you improve your farm.

The 5 Why method is a powerful, root cause technique that can reveal the underlying cause of a problem. By asking "why" questions repeatedly, you go beyond the symptoms and find the fundamental reason behind the issue. Once you identify the root cause(s) of a problem, you can use that information to determine the actions needed to resolve it.

The key to taking your farm to the next level lies in adopting a fresh approach that prioritizes problem-solving and efficiency. By using tools such as an RCA, you can identify and address the underlying causes of your farm's problems, paving the way for increased productivity and success. To that end, this guide is an essential resource for farmers who are ready to break free from the monotony of the past and achieve the results they've been dreaming of. Whether you're just starting out or looking to improve your farm's performance, the implementation steps outlined in this guide will guide you toward the changes you need to make to take your farm to new heights.

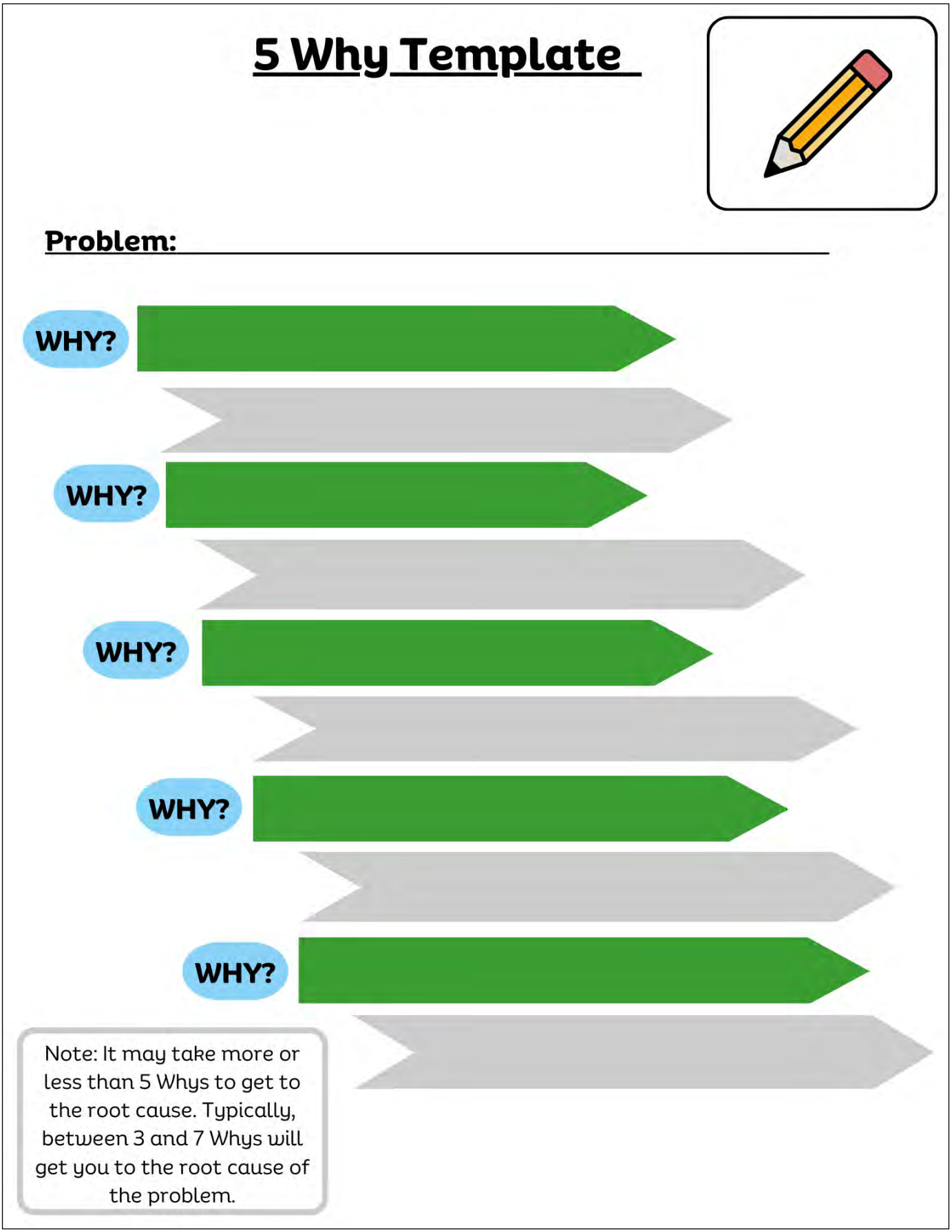


Figure 16. The 5 Why method.

8. Let's do it

The next step is where the real excitement begins. This is the point in an RIE where you get to brainstorm, analyze, try out and evaluate your chosen solutions focused on addressing the root causes of problems.

In this example, Mary and her team have already completed the first three steps of the RIE process. They are now ready for the fourth step: to develop and test potential solutions. They have grouped the issues on Mary's farm into five categories and have found that fish feed and the feeding operation caused most of the issues. The team has come up with creative solutions to address these problems, and they are eager to implement and test them to see if they work. In this chapter, we will learn about Mary's team's proposed solutions and how they plan to test them to achieve measurable goals for success. So let's dive in!

8.1. Making change

You probably have many exciting ideas you can't wait to try. This is the time to do just that. You want to continue using the RIE steps, as they will help you stay on the right path to creating impactful change that lasts.

Let's watch Mary and her team follow the next RIE step to make improvements.

Mary's team has already completed RIE steps 1–3 and is ready to take on step 4.

RIE Step 1 (Complete):
Define the problem or opportunity for improvement: Clearly define the issue or process that needs improvement and establish measurable goals for success.

- Mary has defined her issue and measurable success as follows: optimize feed use and the feeding process to reduce feed costs 20 percent.

RIE Step 2 (Complete):
Assemble a team: Create a cross-functional team of individuals with diverse skills and perspectives who can help identify the root cause of the problem and develop effective solutions. Pro tip: the optimal size for a team is five or six people.

- Mary has assembled an RIE team that consists of herself, one employee and three experienced farmers.

RIE Step 3 (Complete):
Analyze the current state of the target process: Collect data and analyze the current process to identify areas of waste, inefficiencies, and opportunities for improvement.

- To help with this step, Mary has collected her tools and made copies of the steps in the value stream mapping process, the layout of her farm, and the 8 Waste form for each team member. Her team has observed, analyzed and identified areas of opportunity for the feeding process.

8.2. RIE Step 4

Develop and test potential solutions: Brainstorm and evaluate potential solutions, and then test them to see if they address the root cause of the problem.

8.2.1. Mary's farm

Eager to start making changes, Mary's RIE team has categorized the problems on the farm into five categories: fish feed product, fish feed process, poor water quality, excessive water pump use, and fish mortality. It has become quickly apparent to the team that the fish feed and feeding operation have caused multiple issues on the farm. With the information they have gathered, along with their experience and a little research, Mary and her team have generated solutions to test and implement.

8.3. Problems and corrective actions

8.3.1. Fish feed

The team has focused on fish feed issues and identified two primary problems: overstocking and poor quality. The feed has been overstocked in the storage shed to avoid extra trips to purchase feed in town. This has led to several issues: the feed has rotted, it is infested with pests, and there are holes in feed bags, causing spillage and feed loss. Poor feed quality is also the root cause in multiple problems. The feed is traditional sinking

feed, so it is difficult to see how much feed the fish are consuming compared to how much sinks to the bottom of the pond. In addition, the binding agent in the feed is weak, causing the feed to break apart and creating significant amounts of dust in the feed. As a result, the dust has to be filtered and separated before feeding the fish. This wastes a considerable amount of feed, creating an extra step in the processing because the employee has to sieve the dust. It is also apparent that the fish do not like the feed, so they are eating less and thus growing slower.

After analyzing the problem and brainstorming solutions, the team generated several actions to address the issues of overstocked and poor quality feed and then tested them. The first solution is to buy feed from the retail shop across from the farm, which offers floating feed with nutrition labels. This approach provides quick and easy access to feed, eliminating overstocking and improving feed quality. Despite the slightly higher price, Mary believes the long-term benefits of using better feed will offset the increased cost.

8.3.2. Fish feeding process

The team members have now shifted their attention to the process of feeding the fish. Upon observation, they discovered excessive motion and transportation waste in moving feed from the storage shed to the ponds for each feeding. They have also noted additional processing waste in removing dust from the feed before feeding the fish. Overfeeding the fish until they are satiated results in wasted food sinking to the bottom of the pond.

To address these issues in the process, the team has devised low-cost and creative solutions. Their initial step is to place a feed tub next to each pond and directly stock it with fish feed bought from the local source. This will eliminate the need to store feed in the shed, which in turn will eliminate excessive motion and transportation and the expenses incurred in overstocking. Furthermore, the superior quality feed will bind efficiently, removing the additional process of having to remove dust before feeding. Lastly, the team's ingenious and simple solution to prevent overfeeding is to use a plastic bucket marked with a line to show the amount of feed needed to feed the fish.

8.3.3. Poor water quality

The team has identified poor water quality as an issue in both ponds because of cloudy water and an unpleasant odor. However, they believe several previously implemented improvements will address this problem. First, using the feed measurement system will ensure that the correct amount of feed is distributed in the water, reducing excess feed that can decompose on the pond bottom and feed the biomass. Second, the high-quality floating feed has an effective binding agent that will reduce feed waste in the water and allow the employee to monitor feed consumption easily. These two solutions will work together to keep the water cleaner.

8.3.4. Excessive water pump use

Excessive use of the water pump is another issue the team has identified. Both water pumps operate 8 hours a day to clean the water in the ponds. This is expensive and causes equipment wear, leading to maintenance issues. The team believes that improving the water quality in the ponds will reduce the use of the water pump significantly, from 8 hours down to 4 daily. Furthermore, they have discussed the possibility of connecting the two ponds with plastic piping to operate both with just one pump in the future to save equipment. They will also provide a backup water pump in case of breakdowns.

8.3.5. Fish mortality

During the feeding process, the team saw dead fish floating in the ponds. However, they remain optimistic that the changes they have already implemented will address this issue. For example, using high-quality floating feed and improving the water quality are expected to decrease the mortality rate dramatically. As a result, the fish will be healthier overall, and mortality will be reduced.

8.3.6. Underused employee

Not using people efficiently is a critical waste captured on the 8 Waste DOWNTIME form. Here are some examples to help you spot this elusive waste:

- Employees with relevant skills and expertise are not given tasks that use their full potential.
- Employees are not given sufficient training and resources to improve their skills and knowledge.

- Employees are not given enough opportunities for career development and growth within the organization.
- Employees are not given clear job responsibilities and expectations, leading to confusion and lack of productivity.
- Employees who are not motivated or engaged develop low morale and thus reduced productivity.

In Mary's case, she realizes she needs to train and delegate more responsibilities to her employee. As a result, the employee could be more engaged and motivated, and Mary is overloaded with farm tasks.

Here are six solutions to consider to improve the use of your employees:

1. **Cross-training**: Training employees to perform different tasks can improve their skillset and increase their value to your farm. For example, a fish farm worker trained in fish feeding and water quality management can easily switch between the two tasks, depending on the needs of your farm.
2. **Task rotation**: Rotating personnel among different tasks can help prevent monotony and boredom while improving overall productivity. For example, an employee in charge of feeding fish can be rotated to help with netting or harvesting.
3. **Specialization**: Some employees might have specific skills or interests that you can use to improve the efficiency of your farm. For example, an employee who is particularly skilled in fish health management can be given additional responsibilities in this area.
4. **Increased responsibility**: Giving employees more responsibility can increase their motivation and job satisfaction. For example, an employee responsible for cleaning and maintaining a fish tank can be given additional responsibilities, such as monitoring water quality or fish health.
5. **Automation**: Automating certain tasks, such as feeding the fish or monitoring water quality, can free employees to focus on other essential tasks, such as fish health management or farm maintenance. This can also improve the accuracy and consistency of these tasks.
6. **Strengths, interests and opportunities**: Overall, the key to using personnel on a fish farm better is to identify their strengths and interests and provide opportunities for growth and development within the farm.

For her part, Mary has immediately increased her employee's responsibilities and created a plan with the employee for cross-training.

8.3.7. Customer improvement

Mary and her team have found joy in solving problems and taking action to improve her farm, and they feel good about the progress they've made. As a result, Mary is inspired to address one more issue that her customers have brought up: the inconvenience of having to travel long distances on her farm to buy fish. Previously, her customers had to trek all the way from the road to the back of her farm to buy her fish and then carry the fish all the way back to their vehicles. Recognizing that this is a drain on the time and energy of her customers, Mary has relocated the marketing and sales area next to the road. This will make it more accessible and convenient for customers, providing them with even greater value.

Taking action to solve problems is what it's all about. With the RIE method, you have a powerful tool that can help you and your team identify problems, develop effective solutions and create dramatic results that last. For Mary and her team, using the RIE process focused their efforts on optimizing feed use and the feeding process and reducing feed costs by 20 percent. The team then proceeded to the fourth step: developing and testing potential solutions. First, the team grouped the problems on Mary's farm into five categories and identified fish feed and the feeding operation as the primary issues. Next, they generated several solutions to address these issues, such as buying better feed, eliminating feed storage in the shed, and using a plastic bucket marked with a line to prevent overfeeding. By implementing these solutions, the team was able to reduce motion and transportation waste, overstocking expenses, and feed waste, resulting in significant cost savings and improved water quality.

9. Leap to the next level

Fantastic work! It's great to see how much progress you've made in developing and testing solutions to improve your farm operations. Next, you will take the leap and officially implement the improvements and lock them down through standardization. So, let's get to it and take your farm operations to the next level.

9.1. RIE Step 5

Congratulations, it is time to officially implement improvements in the process as part of normal operations.

Implement and standardize: Once you have identified and tested a solution, implement it and create standard work procedures to ensure consistency and sustainability.

Once you have tested and refined the new process, the next step is to standardize it. Standardizing activities and creating procedures provide a clear framework for performing tasks such as feeding, water quality testing and disease prevention. Standards help minimize mistakes and reduce the risk of errors that can lead to poor fish health or low yields. This is done to ensure consistency and quality across the farm. Standards also help farms comply with regulations and standards for food safety and environmental sustainability.

Standard operating procedures (SOPs) are developed to document the new process and provide clear instructions for everyone involved. The team members are then trained on the new process and SOPs so that they fully understand the changes and can perform their roles effectively. Continuous improvement is also a vital aspect of the process. It involves ongoing monitoring and improvement of the new process to maintain effectiveness and efficiency over time. By continuously improving the process, a farm can remain competitive and meet the changing needs of its customers. By following SOPs, a farmer can optimize production, maintain the health of their fish and improve the operation's overall profitability.

To start standardizing, we need to go back to where we started. Remember how you initially captured your existing processes using the VSM and the spaghetti diagram tools? What you want to do next is take those tools and create new versions that reflect the improvements. The updated tools will give you a clear representation of the new processes and make it easy to compare "before" and "after" changes.

9.1.1. Mary's farm

Let's look at the VSM and spaghetti diagrams for Mary's farm before and after the fish feeding process, as shown in Figures 17–20.

9.2. Standards: Documenting procedures

You want to make sure that the new process is clear to employees, so it is necessary to create SOPs and other documents that reflect the expected activities and roles associated with the new processes.

The team on Mary's farm has created standards to support the new fish feeding processes.

9.2.1. Fish feeding process and responsibilities

1. Use proper management to supply high-quality feed.
2. Locate good quality feeds directly inside the feed tub beside each pond.
3. Feed the fish twice daily, in the morning between 08:30 and 09:30 and the evening between 17:00 and 18:00.
4. Avoid overfeeding the fish by feeding them the specified quantity daily and at the right time, as overfeeding can lead to poor water quality, disease outbreaks and increased costs.
5. Keep the remaining feed in tubs to prevent rodent infestation and spoilage.
6. Ensure the fish feed is high quality and store it properly in the feed tub to prevent spoilage.
7. Monitor the fish's growth rate and adjust the feeding schedule and amount as needed.
8. Feed the fish at the same time and in the exact location each day to help them establish a feeding pattern.

9. Keep a record of the feeding schedule, amount of feed given and rate of fish growth for future reference.

Tracking feeding is one of the requirements in the fish feeding process, so it is necessary to provide another standard for recording fish feeding.

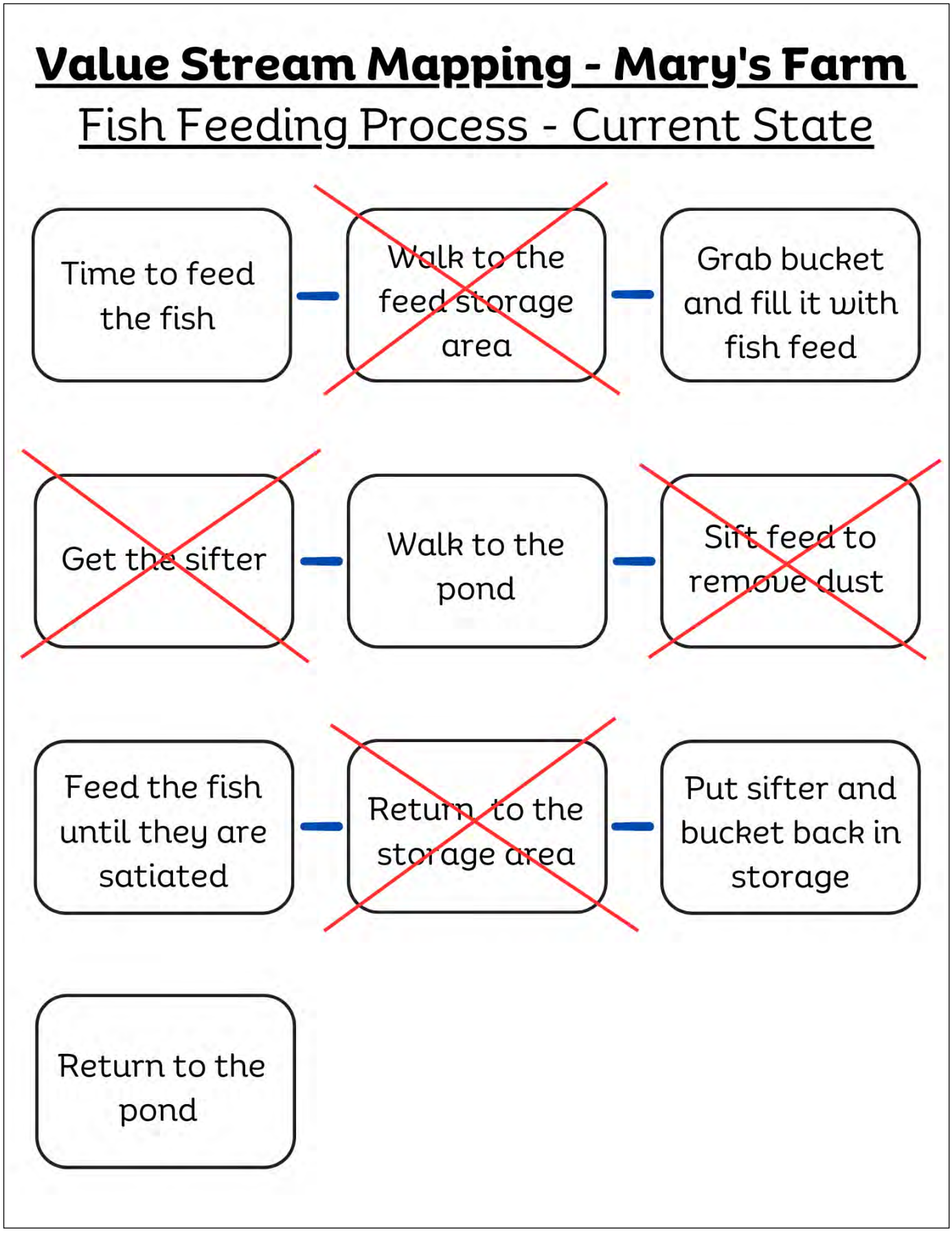


Figure 17. VSM for Mary's farm on the current state of the fish feeding process.

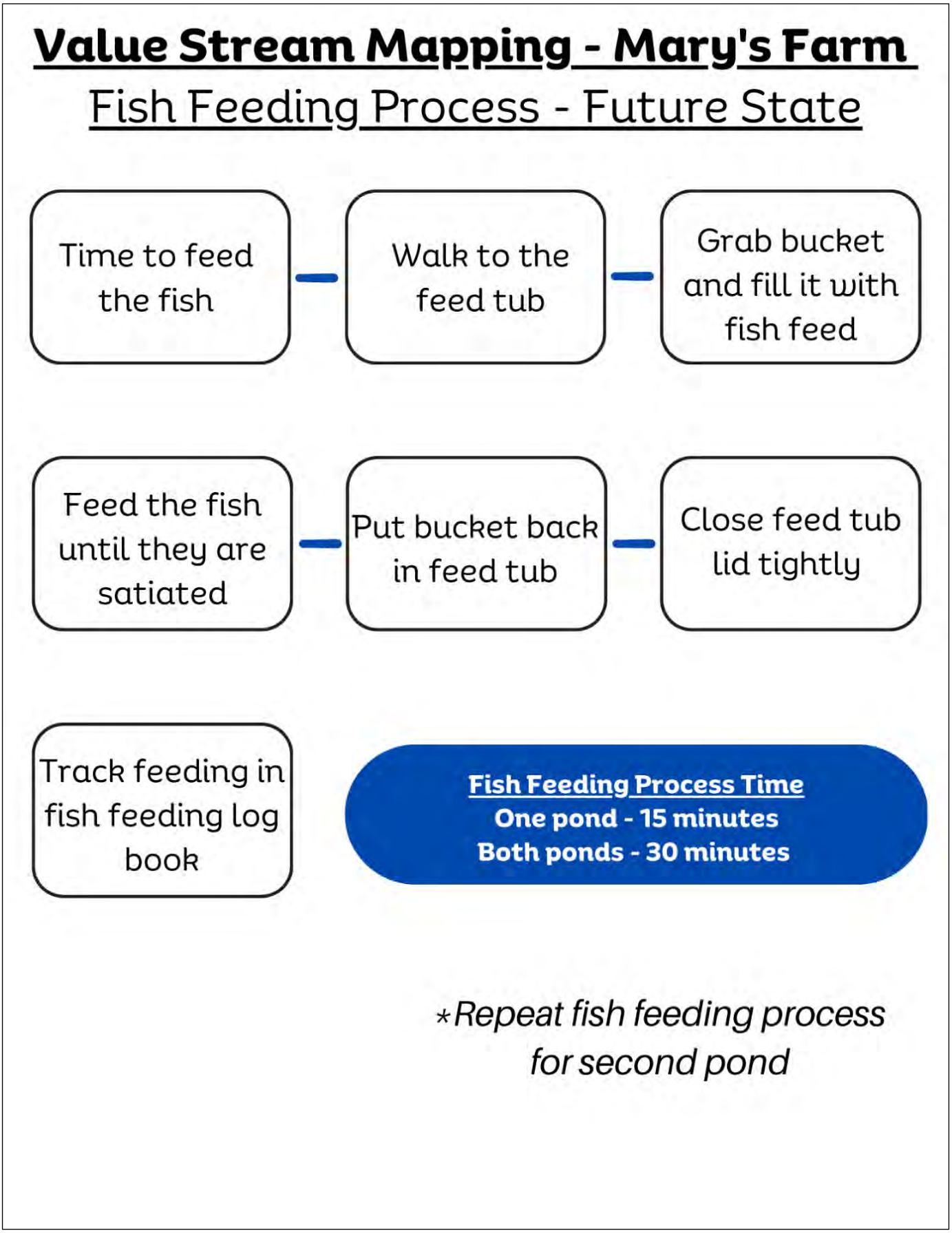


Figure 18. VSM for Mary's farm on the future state of the fish feeding process.

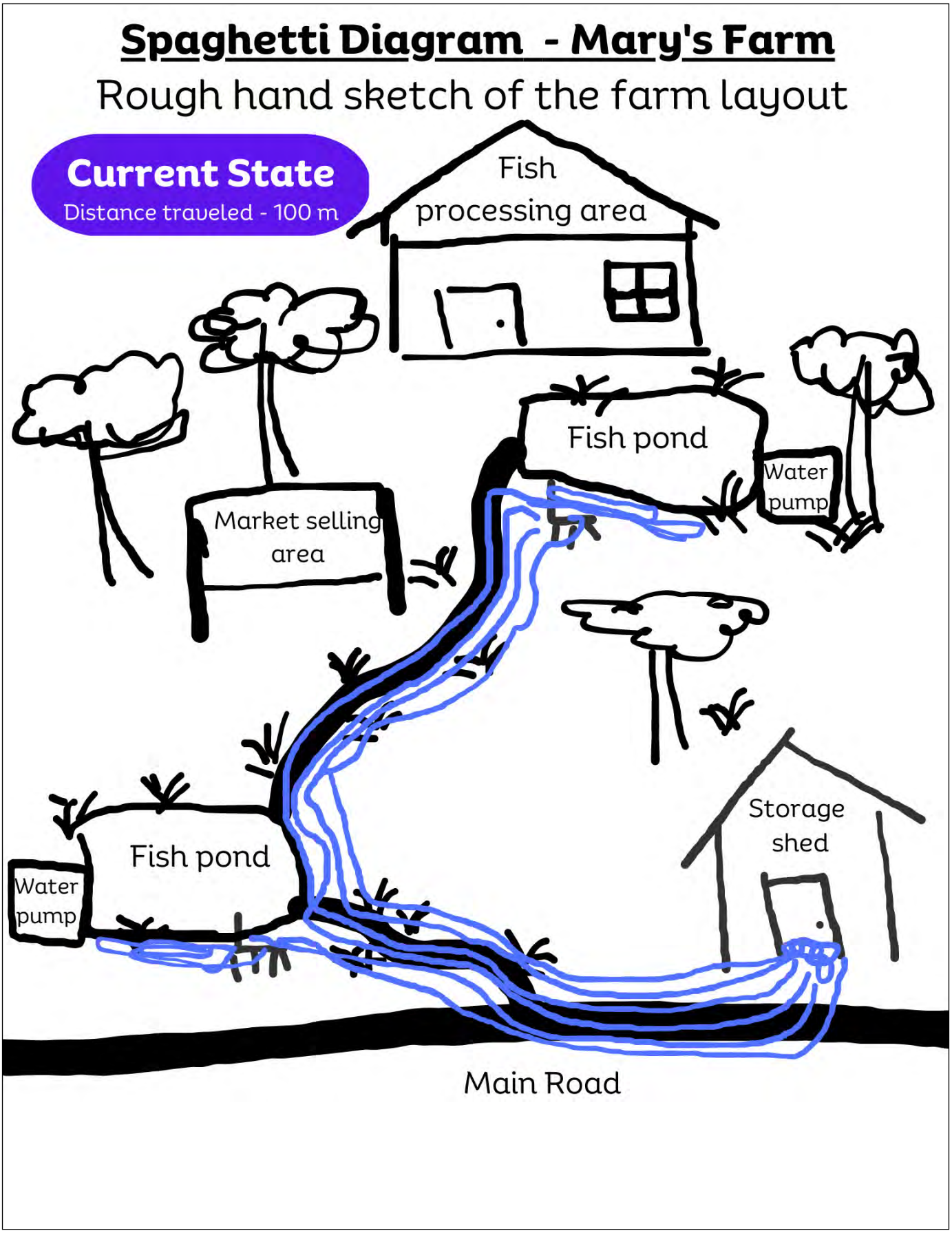


Figure 19. A spaghetti diagram of the current state or process movement of Mary's farm.

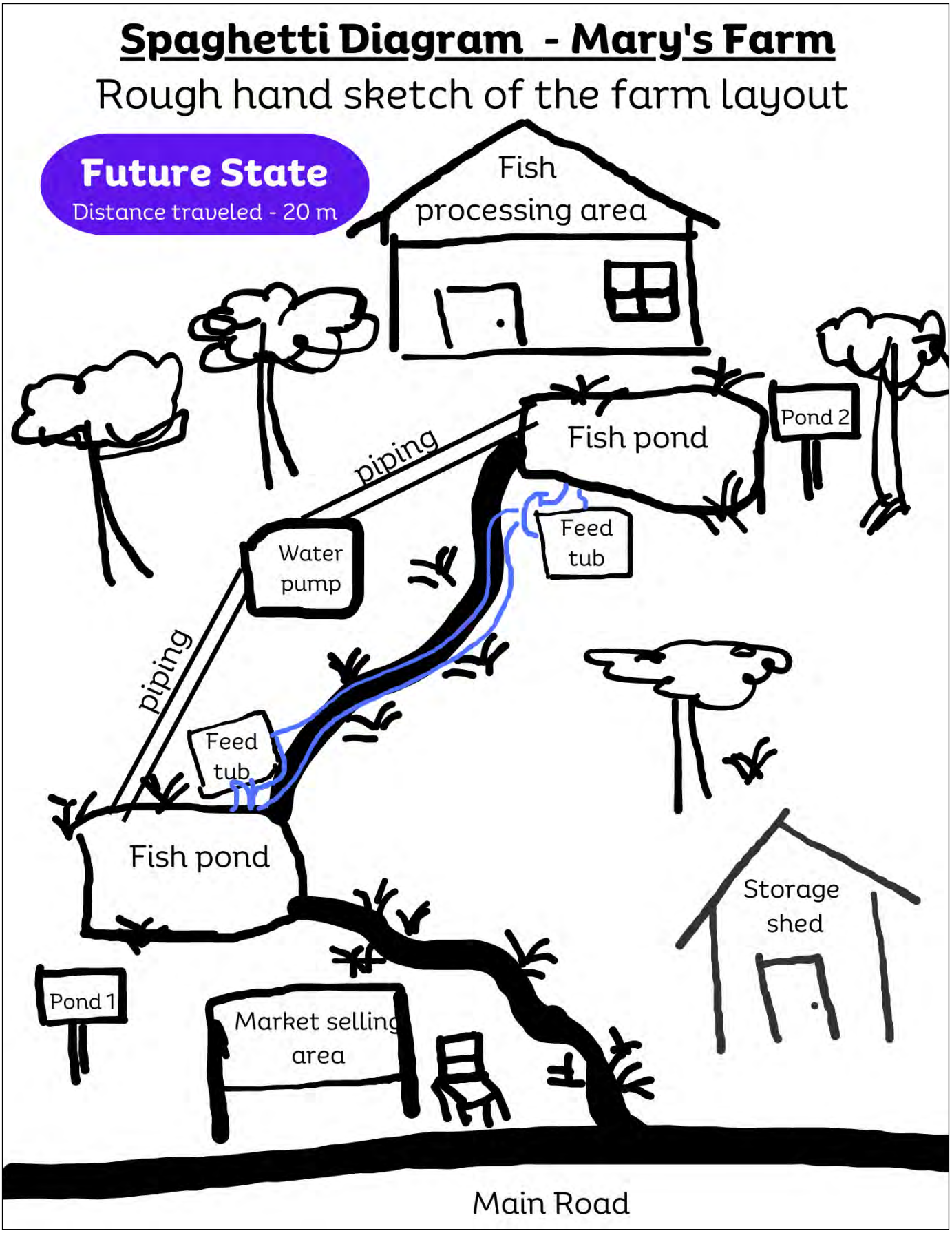
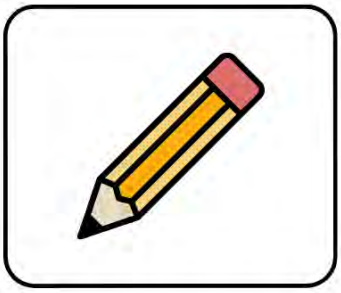


Figure 20. A spaghetti diagram of the future state or process movement of Mary's farm.

Fish Feeding Log Template



Date	Time	Water Temperature	Dissolved Oxygen	pH Level	Ammonia Level	Nitrite Level	Observations	Actions Taken

Figure 21. Fish feeding log.

Fish Feeding Log Example

Date	Time	Water Temperature	Dissolved Oxygen	pH Level	Ammonia Level	Nitrite Level	Observations	Actions Taken
12/4/2023	8:30 am	26°C	6.5 mg/L	7.2	0.2 mg/L	0.1 mg/L	Fish feeding well, clear water.	None.
12/4/2023	5:20 pm	24°C	6.2 mg/L	7.1	0.3 mg/L	0.2 mg/L	Some uneaten feed on the surface and fish seem active.	Reduced feed amount.
13/4/2023	8:45 am	25°C	6.3 mg/L	7.3	0.4 mg/L	0.3 mg/L	Water is slightly cloudy; fish are less active than usual.	Increased aeration.
13/4/2023	5:15 pm	23°C	5.8 mg/L	7.0	0.5 mg/L	0.4 mg/L	Water is heavily discolored, and fish not feeding.	Water exchange and added bacteria to reduce ammonia level.
14/4/2023	9:00 am	24°C	7.0 mg/L	7.2	0.2 mg/L	0.1 mg/L	Water clear, fish feeding well.	None.
14/4/2023	5:45 pm	25°C	6.4 mg/L	7.1	0.3 mg/L	0.2 mg/L	Water is slightly discolored; fish seem lethargic.	Increased water exchange and added oxygen.

Figure 22. Example of a fish feeding log.

It is essential to regularly monitor and record water quality parameters to identify any issues and take appropriate actions. Feeding records help farmers keep track of the feeding schedule and amount of feed given to the fish, as well as log any remarks or observations that could impact their growth and health. Farmers can use this information to make informed decisions about adjusting the feeding schedule or amount of feed, as well as to detect any irregularities or issues that arise.

Consistently maintaining water quality on the farm is crucial. To achieve this, it's vital to establish SOPs for checking the water quality.

9.2.2. Water quality monitoring process and responsibilities

1. Conduct a visual inspection of the water for any signs of discoloration, odor or debris.
2. Measure the water temperature using a thermometer. The optimal temperature range is typically between 24°C and 30°C.
3. Measure the dissolved oxygen (DO) levels using a DO meter or test kit. The DO should be at least 5 ppm.
4. Test the pH of the water using a pH meter or test kit. The optimal pH range for catfish is typically between 6.5 and 7.5.
5. Measure the ammonia and nitrite levels in the water using a test kit. The ammonia level should be less than 0.5 ppm, and the nitrite level should be less than 0.2 ppm.
6. Record the measurements and observations in a logbook or spreadsheet for future reference and to track changes over time.
7. Take corrective actions if water quality parameters are outside the optimal range, such as adjusting the feeding rate, increasing aeration or water exchange, or treating the water for diseases or parasites.

Note: Monitoring water quality parameters is essential to maintain optimal conditions for fish growth and health and to prevent disease outbreaks and mortality.

Performing the water quality monitoring process maintains the water quality in the fishpond at an appropriate level for the growth and health of the fish. Regular water quality monitoring allows farmers to identify issues early and take corrective action before they escalate into more significant problems that could negatively impact fish growth and health.

As mentioned in the water quality monitoring process steps above, recording the water quality measurements and observations is one of the requirements of the fish feeding process. As such, it is necessary to create this standard as well.

Date	Time	Water temperature (°C)	Dissolved oxygen (ppm)	pH level	Ammonia level (ppm)	Nitrite level (ppm)	Observations	Action taken
4/12/2023	10:00 am	27	6.0	7.2	0.2	0.1	Water is clear with no visible debris or odors. Fish are active and feeding well.	None
4/15/2023	2:00 pm	29	4.5	6.8	0.4	0.3	Water is slightly cloudy with a mild odor. Fish are less active and not feeding as well as before.	Increased aeration and reduced feeding rate. Added bacterial treatment to reduce ammonia and nitrite levels.

Table 1. Example of a water quality monitoring log.

Maintaining a record of water quality checks is essential, as it allows you to identify trends and patterns in the water quality data. You can then use this information to optimize your feeding schedule and make necessary adjustments to environmental factors such as water flow, aeration and temperature. These activities can help prevent disease outbreaks and improve fish growth rates and ultimately leads to a more profitable and sustainable farming operation.

Having a clearly defined water quality monitoring process, including recordkeeping, has left Mary feeling thrilled. Now, she can train her employee efficiently on the new standards and delegate some of her tasks, freeing up her time.

Having clear and concise SOPs for each task and process on the farm is one of the most crucial standards to implement. This ensures consistency and quality in the work performed. Additionally, it is important to establish clear performance metrics, such as fish growth rate, feed conversion ratio and water quality, to measure progress and identify opportunities for improvement. Finally, it is also essential to have a system for continuous improvement to make sure everyone is always looking for ways to improve processes and optimize performance.

Standards are a secret weapon. Creating and using standards on a fish farm is vital as this will

- promote consistency in work quality and output by ensuring that all tasks are performed the same way every time;
- help identify areas of inefficiency, allowing for improvements that can increase productivity and profitability;
- provide guidelines that ensure products or services meet specific quality standards, which can help build a strong reputation for the farm and its products.
- help establish safe working conditions and practices, reducing the risk of employee accidents or injuries.
- ensure that the farm complies with regulations and laws, reducing the risk of legal or regulatory issues.

Creating and implementing standards is vital for a fish farm's long-term prosperity and sustainability, which can help enhance profitability and success. So, consider the power of developing standards for your farm operations, as this is crucial to ensure consistency, efficiency, quality control, safety and compliance. So why not dive in and start creating as many standards as possible? Trust us, your farm will benefit from it in more ways than you can imagine.

10. Lock it down

Wow, you have made incredible progress and achieved so much, from identifying your goals to implementing and standardizing your lean management improvements. That is no small feat!

Transforming a small fish farm by implementing lean management principles is a brilliant move that can substantially improve productivity and efficiency. However, implementing changes is just the beginning, and it's not enough to sit back and hope for the best. It's paramount to measure and monitor these changes to guarantee three things:

1. The employees are adhering to the new protocols.
2. The lean management improvements are yielding the anticipated results.
3. Awareness is created for further improvements to optimize the production process for maximum efficiency and profitability.

By measuring and monitoring changes, you can translate your efforts into measurable success and pave the way for further growth and development. These activities are crucial to ensure your improvements are sustainable and effective in the long term. The effort is worth it!

Let's take the plunge into the next phase of tracking and evaluating your progress. Monitoring and measuring are vital to ensure that the newly implemented processes are executed effectively and produce the desired outcomes. With that said, let's forge ahead to step 6 of the RIE tool.

10.1. RIE Step 6

Monitor and measure: Monitor the new process continuously to measure its effectiveness and identify any areas that require further improvement.

First, let's begin by focusing on monitoring the improvements. You need to make sure those positive changes you've made on your farm last for the long haul. It's crucial to ensure the sustainability of the improvements you've implemented, and it is equally essential to ensure that all your team's work is not done in vain. We understand that change can be tough, but doing regular audits for processes can make adapting to new ways of doing things much easier. By developing an audit checklist that combines a standard with a visual tool, you can effectively monitor your farm's critical processes and ensure they are carried out correctly. These audits typically take the form of a checklist or questionnaire, and they help you assess whether your farm is adhering to the necessary procedures. The monitoring tool will make the audit process accurate, efficient and systematic, allowing you to sustain the recent changes and continue improving your farm's operations. It's a straightforward and effective approach that will help you achieve long-term success.

Mary's farm

Mary is determined to sustain her farm's lean management improvements and is keen to have her team create and implement monitoring audits. The team has used this approach quickly to develop farm checklists that ensure the employee adheres to the new standards designed for both the fish feeding and water quality monitoring processes. The objective here is to ensure that the fish feeding process is followed and that fish are fed regularly and appropriately.

By conducting an audit and monitoring the fish feeding process, you are ensuring the consistency of the process and its outcomes. For example, the audit verifies whether employees have followed the feeding schedule correctly, given the fish the appropriate amount of feed, modified feeding as needed, and documented the feeding records accurately. Audits should be done as frequently as weekly, biweekly or monthly based on the peculiarity of the farm. The objective here is to make sure that employees are following the water quality process and maintaining the fishpond at a level that is conducive to the growth and health of the fish.

On Mary's farm, the objective of the auditing checklist is to observe the water quality monitoring process closely and check that it is being followed correctly. This will enable a better understanding of whether employees are maintaining the water quality in the fishpond at a level conducive to the growth and health of the fish.

Auditing checklists are perfect for new lean management processes because they provide a structured and systematic approach to assess the implementation and effectiveness of the new process. By using an auditing checklist, the team can cover all the essential aspects of the process during their monitoring step. The checklist can also serve as a reminder of the critical points that need to be addressed during the audit. Additionally, auditing checklists can help identify gaps or areas that need improvement, which can be addressed through continuous improvement efforts. Are you convinced? Take some time to determine which processes are critical to monitor and create documents like the ones in Table 2 and Table 3. Auditing checklists are a valuable tool in ensuring that new lean management processes are implemented effectively and stand the test of time.

In summary, monitoring improvements is essential for ensuring the sustainability and effectiveness of the lean management changes made in a process. By creating an audit checklist, you can monitor critical processes and carry them out correctly, which helps sustain improvements and optimize operations for maximum efficiency and profitability.

Auditing criteria	Yes	No
Is the feeding schedule being followed?	X	
Is the amount of feed appropriate for the fish?	X	
Is feeding adjusted as necessary based on fish behavior and environmental factors?	X	
Are feeding records accurately and consistently documented?	X	
Are relevant remarks being consistently documented?	X	

Table 2. Audit form for the fish feeding process.

Audit Questions	Yes	No	N/A	Observations	Action taken
1. Water temperature consistently within range (24°C–30°C)					
2. DO level (at least 5 ppm)					
3. pH level (6.5–7.5)					
4. Ammonia level (less than 0.5 ppm)					
5. Nitrite level (less than 0.2 ppm)					
5. Water cleanliness (color, odor or debris)					
6. Observations and actions documented accurately					
Compliance questions					
7. Meeting process standards					
8. Improvements needed					

Table 3. Audit form for the water quality monitoring process.

11. Count the money

Congratulations, you are well on your way to success. Your new processes are implemented, and you are auditing to ensure the standards are followed. That's fantastic! Now, it is officially time to evaluate the fruits of your team's labor by measuring and analyzing the results.

11.1. RIE Step 6 (Continued)

Monitor and measure: Continuously monitor the new process to measure its effectiveness and identify any areas that require further improvement.

11.1.1. Measuring improvements

To measure activities on a fish farm well, you must collect and analyze data regularly. There are six steps to make sure you have a sound system for measuring:

1. **Define key performance indicators (KPIs)**: Identify and define the KPIs relevant to your fishpond operations, especially relating to the identified source of production waste, such as feed used, survival rate, growth rate and harvest size. These KPIs will help you measure the effectiveness of your improvements.
2. **Collect data**: Collect data regularly on the identified KPIs. Make sure the data is accurate and reliable.
3. **Analyze data**: Analyze the data to evaluate the performance of your fishpond operations. Compare the current data to the baseline data before implementing the improvements to assess the impact of the changes.
4. **Identify opportunities for improvement**: Based on the data analysis, identify areas for further improvements. This could involve adjusting the current processes or procedures to optimize efficiency or modifying the improvements that you have implemented.
5. **Implement further improvements**: Once you have identified additional opportunities for improvement, implement changes and monitor their effectiveness by collecting and analyzing both before and after data.
6. **Communicate results**: Inform all stakeholders of the results of the data analysis and improvement efforts to create awareness and encourage further improvements.

By regularly monitoring and measuring the KPIs, you can track the effectiveness of improvements and make data-driven decisions to optimize the production process. The farm can track progress and identify any issues or bottlenecks hindering the effectiveness of the changes. You can then use this information to make data-driven decisions to optimize the production process further to maximize efficiency and profitability. Additionally, measuring and monitoring the changes can help the farm identify wasted resources or opportunities to reduce costs. This can lead to significant savings in both time and money, further contributing to your farm's overall success.

On Mary's farm, the RIE team was overjoyed to learn about the impacts they achieved through the changes they implemented on her farm. Let's see how they did.

11.1.2. Feed improvements

In the world of small-scale fish farming, every dollar counts. That's why making changes to feed costs can have a massive impact on profitability.

Mary, a small-scale fish farmer, has realized that reducing the amount of feed given to her fish while ensuring they still receive the nutrients they need to grow can lead to huge savings on feed costs. After some research and discussion with her RIE team, Mary decides to reduce the amount of feed from 8 to 6 percent of fish weight. This change leads to a 25 percent reduction in total feed use, resulting in a significant cost-saving. Mary also opts for local, nutritious floating feed, which costs USD 1.52/kg compared to her previous feed cost of USD 1.25/kg. Although the initial cost is higher, the team believes that the extra cost is justified because the floating feed gives them the ability to see when the fish are satiated to avoid wasting feed.

The results are in! Over 6 months, the improved feed quality and reduced feeding protocol has resulted in faster fish growth and an 80 percent reduction in mortality rates, from 25 to 5 percent. In addition, Mary has seen a 33 percent increase in yield, from 3.6 to 4.8 t. This is a direct result of improved water quality and more nutritious feed.

The revenue impact of these changes over 6 months is remarkable. Mary's original revenue was USD 8604 from 3.6 t of fish at USD 2.39/kg. After the changes, she has produced 4.8 t of fish, generating USD 11,472 in revenue. Additionally, by analyzing her profits, Mary saw that she had a loss of USD 396 (-4.4 percent) on her feed investment before the changes. After the changes, Mary has turned that into a USD 3264 (39.77 percent) return on her feed investment.

In conclusion, Mary's decision to reduce her feed costs and improve feed quality has impacted her profitability as a fish farmer significantly. With these changes, she has increased her revenue and reduced losses, demonstrating the importance of optimizing feed costs in small-scale fish farming.

11.1.3. Fish feeding process improvements

Dramatically improving the feed process can impact fish farming operations significantly, and Mary's farm nailed it! With no more time spent sifting through the feed to remove dust and no excessive movement to get the feed to the ponds, Mary drastically has reduced the time spent on feeding. She has shortened the distance traveled 80 percent, from 100 down to just 20 meters, which has decreased the amount of time feeding per pond 66.7 percent, from a whopping 45 minutes to just 15. For two ponds with two feeding times, the time savings is 1 hour per day or 180 hours every 6 months. This is a huge improvement in efficiency, allowing Mary and her employee to focus on other value-added tasks, leading to a more productive and profitable operation. With such innovative changes in the feed process, it's clear that Mary is committed to finding ways to improve their farm's overall performance.

11.1.4. Water quality and water pump improvements

Mary's water quality improvements have led to a significant reduction in pump use, from 8 hours to only 4 per pond for two ponds, resulting in 4 hours of pumping compared to the initial 16 hours. This amounts to a remarkable 75 percent decrease in pump use. Mary has also been able to reduce the cost of fuel significantly, from 20 L per day at a rate of USD 0.56/L, which amounts to USD 11.20 per day or USD 2016 over 6 months, to just 5 L per day at the same rate, which now amounts to USD 2.80 per day or USD 504 over 6 months. As a result, the total savings realized from the reduced pump use and fuel costs amount to USD 1512 over 6 months.

Mary and her team have achieved these reductions by improving the water quality in her fishponds, which has reduced the amount of time needed for pumping. With just one pump running both ponds for 4 hours, the water quality is maintained at the appropriate level, and the fish are thriving. In addition, reducing pump use and fuel costs have helped lower greenhouse gas emissions, which is beneficial to the environment. The farm also benefits economically, as the savings increase profits. These improvements show that small changes can have a big impact, and it's worth investing in maintaining good water quality in fishponds.

11.1.5. Fish mortality improvements

Improving fish survival is essential to the success of any fish farming operation. Through a combination of water quality improvements and providing a higher level of nutrition, Mary has significantly reduced the mortality rate of her fish. Previously, 25 percent of her fish died, dramatically reducing revenue. However, by introducing a new, nutritious feed and improving the water quality, the mortality rate has dropped to just 5 percent. This 80 percent improvement in fish survival has tremendously impacted Mary's bottom line, with revenue increasing from USD 8604 to 11,472, representing a 33.33 percent rise in income.

By focusing on these critical areas, all fish farmers can see significant improvements in their business and, ultimately, achieve greater success in their operations.

The numbers reflected on Mary's farm represent some of the improvements achieved by implementing lean management in more than 200 small-scale fish farms.

11.2. Beyond the numbers

The lean management activities on Mary's farm have reaped big rewards: improved feeding efficiency, lower fish mortality, reduced time wasted in both motion and transportation, smaller environmental footprint, lower stress on labor, improved profit, shortened harvest cycle and increased farm expansion opportunities. Mary's decision to reduce her feed costs and improve feed quality have increased her revenue and profit, boosted efficiency, benefitted the environment, improved fish survival and resulted in innovative changes that led to positive outcomes. Mary and her team's commitment to finding ways to improve her farm's overall performance demonstrate their willingness to innovate and make changes that lead to tremendous results, which is essential for the long-term success of any farming operation.

Defining KPIs, collecting data, analyzing data, identifying opportunities for improvement, implementing further improvements and communicating results are the steps involved in measuring improvements and results. Regularly monitoring and measuring KPIs can help track the effectiveness of improvements, optimize production processes and identify wasted resources or opportunities to reduce costs. Overall, this phase is crucial for long-term success and continuous improvement.

Measuring and monitoring a fish farm can significantly improve production efficiency, profitability and cost savings. By defining measurements, collecting and analyzing data, implementing further improvements and communicating results, farmers can track progress, optimize production processes and make data-driven decisions.

Mary's farm is an excellent example of how reducing feed costs and improving feed quality, water quality and the fish feeding process optimizes a farm's efficiency and significantly impacts profitability in small-scale fish farming. With innovative changes in the feed process and water quality, Mary's farm has increased yield, reduced losses and improved overall performance. By implementing these improvements, fish farmers can not only maximize their profitability but also make a positive impact on the environment.

Step 6 is complete! There is just one more step to go in the RIE. And it's fun! Here's a quick reminder of all the work you have done so far:

RIE Step 1: (Complete)
Define the problem or opportunity for improvement: Clearly define the issue or process that needs improvement and establish measurable goals for success.

RIE Step 2: (Complete)
Assemble a team: Create a cross-functional team of individuals with diverse skills and perspectives who can help identify the root cause of the problem and develop effective solutions.

RIE Step 3: (Complete)
Analyze the current state of the target process: Collect data and analyze the current process to identify areas of waste, inefficiencies, and opportunities for improvement.

RIE Step 4: (Complete)
Develop and test potential solutions: Brainstorm and evaluate potential solutions, and then test them to see if they address the root cause of the problem.

RIE Step 5: (Complete)
Implement and standardize: Once you have identified and tested a solution, implement it and create standard work procedures to ensure consistency and sustainability.

RIE Step 6: (Complete)
Monitor and measure: Monitor the new process continuously to measure its effectiveness and identify any areas that require further improvement.

12. Time to celebrate

Yes, indeed! All the hard work has paid off, and it is time to do something that lets everyone know how much you appreciate their involvement in making improvements and taking your farm to the next level.

12.1. RIE Step 7

Celebrate success: Celebrate and recognize your team's hard work and success in achieving the goals of the RIE. This helps build momentum and support for further efforts at improvement.

12.1.1. Mary's farm

Mary and her RIE team are celebrating with a celebratory potluck meal. They are enjoying taking a moment to honor their work and the results they achieved. The atmosphere is filled with pride, and they have suggested many additional ideas for future team events.

Here are some ideas for you to celebrate your success (you can also come up with your own):

- **Throw a party**: Celebrate the team's success with a party or gathering. This could be a potluck lunch, a barbecue or even a dinner at a restaurant.
- **Recognition awards**: Present the team with awards or certificates to recognize their hard work and success. This could be done at a team meeting or in front of a group.
- **Bonuses**: If possible, provide bonuses or other incentives for the team's success. This could be in the form of monetary rewards or extra time off.
- **Publicize your success**: Share the team's success with others in the organization or with stakeholders. This could be done through an email, a newsletter or a press release.
- **Team outing**: Take the team on a fun outing or activity to celebrate their success. This could be a team-building exercise, a trip to a local attraction or a day off to relax and recharge.

The possibilities are endless. So, please make an effort to celebrate your team's success and inspire them to achieve even greater heights.

In summary, measuring improvements on a fish farm is crucial to optimize production processes, reduce costs and increase profitability. By following the steps of defining KPIs, collecting and analyzing data, identifying opportunities for improvement, implementing changes and communicating results, farmers can track progress and make data-driven decisions. The case of Mary's farm shows the significant impacts of making changes to feed costs, improving feed quality and the feeding process, as well as improvements to water quality and water pump. These changes resulted in a remarkable increase in revenue and profitability, demonstrating the importance of constantly seeking ways to improve and optimize farm operations.

Celebrating success is also an essential step toward achieving continuous improvement. It not only recognizes the team's hard work but also helps build momentum and support for further efforts at improvement. There are many ways to celebrate success; the key is to choose a celebration that suits your team and organization and inspires them to achieve even greater success in the future. Remember, a little celebration can go a long way in boosting team morale and encouraging them to strive for excellence.

13. Conclusion

This guide on lean management has offered you a simple and effective solution to address high costs and inefficiencies on a small-scale fish farm. Mary's story proves that implementing lean management principles can dramatically impact your farm's efficiency and bottom line.

Mary started by defining her farm's high-level goals to help improve profits and then delved into learning the philosophy and tools behind lean management. With a team in place, she followed the steps of the RIE and made significant improvements.

The results after 6 months of implementation were staggering. Mary lowered her feed costs 9 percent, thanks to a 25 percent reduction in feed use and a switch to higher-quality floating feed. She also decreased her fuel use a whopping 75 percent, resulting in a USD 1512 cost-reduction. She also used her employees more efficiently through cross-training and problem-solving, freeing time for her to do other value-added work.

In fish feeding alone, Mary managed to free up 180 hours. She also dropped mortality rates from 25 to just 5 percent, while increasing both fish yield and revenue. Perhaps most impressively, Mary's revenue grew from USD 8604 to USD 11,472.

With these kinds of results, it's easy to see why lean management is the key to transforming your small-scale fish farm into a lean, mean, profit-making machine.

By following the roadmap provided in this guide and learning about the fundamental principles and tools of lean management, you too can take your small-scale fish farm to the next level.

All right, now it's time for you to take the plunge and level up your small-scale fish farm. You've got the roadmap and the tools in your arsenal. It's time to make a splash and start putting lean management into action. Don't be a fish out of water—dive right in and see the improvements in your operations and revenue. There's no better time than the present to take action. You've got what it takes to make it happen!

For additional resources, please check out our website at www.collaborative-impact.com

About WorldFish

WorldFish is an international, not-for-profit research organization that works to reduce hunger and poverty by improving aquatic food systems, including fisheries and aquaculture. It collaborates with numerous international, regional and national partners to deliver transformational impacts to millions of people who depend on fish for food, nutrition and income in the developing world.

The WorldFish headquarters is in Penang, Malaysia, with regional offices across Africa, Asia and the Pacific. The organization is a member of CGIAR, the world's largest research partnership for a food secure future dedicated to reducing poverty, enhancing food and nutrition security and improving natural resources.

For more information, please visit www.worldfishcenter.org

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Meet our trained lean subject matter experts: A directory

Authors

Sunil N Siriwardena,[1] Terri Kay Lawrence,[1] Elizabeth Ihiechi Akuwa[1] and Rohana P Subasinghe.[1]

Affiliations

[1] WorldFish
[2] Collaborative Impact, USA

Citation

This publication should be cited as: Siriwardena SN, Lawrence TK, Akuwa EI, Subasinghe RP. 2023. Meet our trained lean subject matter experts: A directory. Penang, Malaysia: WorldFish. Manual: 2023-39.

Acknowledgments

This publication was made possible through support provided by the United States Agency for International Development (USAID) through the Feed the Future Innovation Lab for Fish. This work was developed with the support of WorldFish. The program is supported by contributors to the CGIAR Trust Fund.

About the Fish Innovation Lab

The Fish Innovation Lab supports the USAID's agricultural research and capacity building work under Feed the Future, the U.S. Government's global hunger and food security initiative. Mississippi State University is the program's management entity. The University of Rhode Island, Texas State University, Washington University in St. Louis, and RTI International serve as management partners.

Contact

WorldFish Communications and Marketing Department, Jalan Batu Maung, Batu Maung, 11960 Bayan Lepas, Penang, Malaysia. Email: worldfishcenter@cgiar.org

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What is lean management?

Embracing lean principles and practices enables businesses to enhance their flexibility and resilience. At the heart of lean is the principle of *maximizing value and minimizing waste in every process*, leading to substantial benefits. By implementing Lean management, organizations can effectively optimize their operations, reduce waste, and unlock economic and sustainable advantages. Adopting lean principles *empowers businesses to adapt, thrive, and achieve remarkable outcomes* in today's dynamic and competitive landscape.

Lean management principles and practices help make operations more efficient in the aquaculture industry.

- Reduce water treatment costs by 60 percent.
- Reduce energy consumption costs by 48 percent.
- Increase fish survivable by 85 percent.

Who is a lean subject matter expert (LSME)?

We trained 27 lean subject matter experts (LSMEs) under the Improving Efficiency in the Nigerian Aquaculture Sector by Employing the Lean Production Systems project, sponsored by the Feed the Future Innovation Lab for Fish and implemented by WorldFish. LSMEs were trained to apply lean management principles tools to identify and fix waste streams in aquaculture production and processing systems to improve efficiency.

Meet our trainer Terri Lawrence

Terri Lawrence is a highly experienced professional specializing in systems optimization. As the CEO of Collaborative Impact, Terri has provided invaluable operational guidance and expertise to a wide range of industries globally, including manufacturing, healthcare, and food production. Recently, Terri authored a practical guidebook on lean techniques specifically tailored for small-scale fish farmers, offering quick, simple, and impactful methods to enhance efficiency and cost savings. With extensive coaching experience and deep expertise in her field, Terri Lawrence is dedicated to assisting organizations in achieving profitability through resilient and sustainable operations.

Phone number: +1-206-698-2027
Email address: Terri.Lawrence@Collaborative-Impact.com

What our LSMEs can offer

Our team consists of accomplished LSMEs who bring their expertise, training and proven implementation experience to optimize your operations. Each team member possesses extensive experience and knowledge in aquaculture, coupled with the following qualifications:

- professional training and certification in lean management tools, processes and methodologies
- a proven track record of delivering training on lean management to others in the aquaculture industry
- successful implementation of efficiency improvements on aquaculture farms, resulting in cost reduction and more effective operations.

We take great pride in the demonstrated success of our LSME team for their expertise in disseminating and implementing lean management within the aquaculture sector. With an impressive track record of over 400 projects completed across 250 aquaculture farms, their efforts have consistently led to better fish survival, more efficient operations and lower costs.

Meet our trained LSMEs

Delta State

Abel Onavwie is an experienced fish farmer who specializes in encouraging farm managers to adopt best practice techniques by providing them with new knowledge and technology across the aquaculture industry. As the coordinator of Treasure Fish Farmer Multi-Purpose Cooperative Society, he has experience in coordinating and working with cluster members, cooperate members and partners as well as liaising with state and non-state actors. He studied agricultural economics in university.

Phone number: +234-915-610-5185
Email: ubel1980@gmail.com

Preye Ofunama will make you fall in love with fish farming. She is the founder of Farmers Meet and an ardent agriculturist who is inspiring a new generation of farmers across Africa. At the center of her work is a quest to help fish farmers succeed and to identify waste in the aquaculture sector.

Phone number: +234-906-382-7882
Email: preyeofu@gmail.com

Peter Akpokiniovo Diafe is an astute aquaculturist with several years of experience providing comprehensive high quality consultancy services in both static and running water culture of freshwater and saltwater species. He is an engineer, a team leader and the CEO of Pdexter farms. He also specializes in other aspects of aquaculture, such as fish health, water chemistry, pond construction, management and marketing.

Phone number: +234-806-362-6609
Email: cfinigeria@yahoo.com

Efejuku Precious Tajinere is the CEO of Tajin Farms. He has trained over 400 youths on entrepreneurship development under the Young Entrepreneurs Training Program organized by the Centre for Values in Leadership under professor Pat Utomi. He has taken several courses in business administration and management at the University of Bocconi in Italy and at the Africa Managers Initiative. He believes in the Ubuntu system, which says "without you, no me."

Phone number: +234-806-823-3092
Email: thefishpreneur@gmail.com

Mr. Ochuko Joshua Eriegha is an academic staff member in the Department of Fisheries and Aquaculture, Faculty of Environmental Management of the Nigeria Maritime University in Okerenkoko. He has over 15 years of experience across his work at the university, a research institute and on private fish farms as a fish farmer.

His main focus is answering questions on sustainable fish production, fish feed management, water quality management and environmental toxicology.

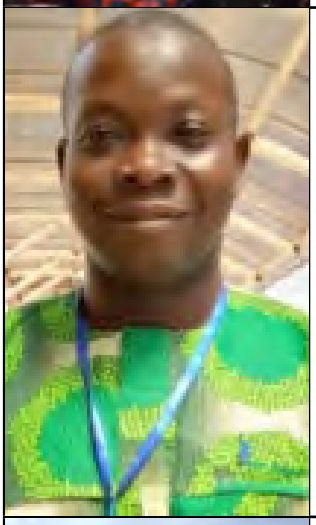
Phone number: +234-703-213-2859
Email: ochukodegreat@yahoo.com

Abdulrahman Yusuf is a professional farmer who specializes in aquaculture and poultry farming, as well as fish feed production. He is the coordinator for the fish farm clusters in Warri and is the president of the Liberty fish farm cluster. He has helped train and shared knowledge with smallholder fish farmers to help them improve farming culture. Many fish farmers have benefitted from the knowledge he has shared on the lean management operational system for aquaculture.

Phone number: +234-705-261-0715
Email: yusufyusufa@yahoo.com

Otomiewo Onorame is a highly motivated, proficient aquaculture specialist with years of experience in the aquaculture value chain. She has excellent managerial and leadership skills and has successfully trained and mentored fish farmers in contemporary methods, with a particular emphasis on maximizing profit. As the head of the IvoryBee fish farm cluster, she is an active contributor to aquaculture development at the community level, equipping women with the modern farming skills needed for self-empowerment.

Phone number: +234-803-723-6729
Email: clemonos78@gmail.com



Atuyota Donald Ekpekuro is the director of Donek Farms. His interests lie in improving and developing the fishery industry.

Phone number: +234-805-277-3438
Email: revddonald@gmail.com

Fredrick Mukoro is an experienced trainer in the aquaculture sector and is an executive member of the Treasure Fish Farm Multi-Purpose Cooperative Society. He was recently invited by the Ministry of Agriculture, in collaboration with the Delta State government, to give a lecture and sensitize fish farmers in the state.

Phone number: +234-808-106-7397
Email: mmkorofrederick254@gmail.com

Okotete E. Bravoh is a professional farmer specializing in aquaculture. He has helped smallholder fish farmers improve their farming methods by sharing knowledge learned from different practical training sessions by various international organizations.

Phone number: +234-805-415-5212
Email: erukayejenny@gmail.com

Akpoki Luke is the cluster head for the Pokas Fish Cluster in Ughelli. He trains his cluster members monthly to improve their productivity and to teach them about new technologies.

Phone number: +234-803-993-4365
Email: lukeapoki@gmail.com

Benson Ese Onoriode is an aquaculturist who specializes in the production and supply of quality fish seed.

He consults and trains fish farmers in aquaculture production and is the founder of Elevital Agricultural Enterprise in Ughelli.

Phone number: +234 706-173-7850
Email: elevital444@gmail.com

Stephen Awinimu is an experienced fish farmer who is a highly experienced professional in health, safety and the environment. He is certified by the Institute of Safety Professionals of Nigeria.

Phone number: +234-810-479-8059
Email: steveawins@gmail.com

Dr. Marcus Adegbenro Adeniyi is a robust and multidisciplinary professional who heads the management team of the Ijebu Development Initiative on Poverty Reduction (IDIPR) as general manager/CEO. The IDIPR established and administered the renowned UN/FAO acknowledged Eriwe Farm Village under his leadership in 2002, and the Aquaculture Cooperative Cluster Farm has over 1327 fish farmers in various cooperative societies. He is an alumnus of the Wageningen Center for Development Innovation at Wageningen University and Research in the Netherlands.

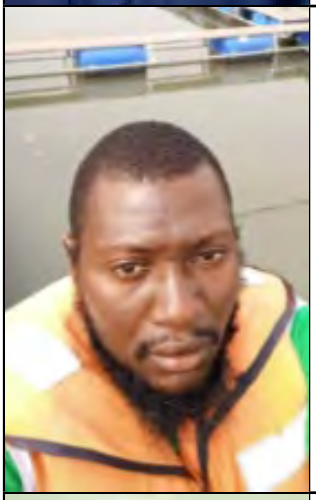
Phone number: +234-803-473-0236
Email: marcusidipr@gmail.com

Ogun State

Michael Musowo is an aquaculture specialist with a broad spectrum of experience across the agribusiness value chain ensuring the 4Ps (people, performance, productivity and profits).

He is currently the general manager of Philips Farms and Allied Industries Nigeria Limited in Agbor. He is keen on upholding the tenets of best practices, driven by an uncompromising commitment to excellence and professionalism with a deep understanding of diversity, equality and inclusion.

Phone number: +234-703-666-1719
Email: mgracker83@gmail.com



Salam Yusuf is a systems supervisor in cage and land-based aquaculture. He has seven years of demonstrated work experience in the fishery industry, and is skilled in such areas as water quality management, aquaculture and fisheries. He is a strong information technology professional with a bachelor's degree in aquaculture and fisheries management from the Federal University of Agriculture Abeokuta.

Phone number: +234-806-410-0794
Email: Salamyusuf64100@gmail.com

Atinuke Onaduja is an astute trainer and coach with over 10 years of experience in hands-on practice in aquaculture, hatchery to grow-out and fish feed formulation, as well as other parts of the aquaculture value chain.

She has been instrumental in the aquaculture sector, as she trains her fellow farmers in best management practices and lessons learned from the lean management system.

Phone number: +234-703-799-3060
Email: atinukeonaduja@gmail.com

Adebayo Solomon is the CEO of Dermav Farms and Farms Produce Ltd with wide-ranging experience in the aquaculture sector. He is a member of the Ogun State Fisheries and Aquaculture Farmers Association and an executive member of the Catfish and Allied Fish Farmers Association of Nigeria.

Phone number: +234-703-309-3708
Email: dermavfarmsltd@gmail.com

Timothy Uchendu is an experienced professional specializing in aquaculture. Currently, he is the assistant head of department and hatchery manager at CHI Farm Ltd. He has provided invaluable coaching, operational guidance and expertise to a wide range of corporate and individual farms in Nigeria, including hatcheries, grow-out farmers, feed mills and processing farms. He is dedicated to helping farmers to run successful and profitable ventures by using lean management in their operations.

Phone number: +234-703-469-7989
Email: uchendutimothy@gmail.com

Ayoola Daramola is an experienced aquaculturist who trains interns from different institutes in the southwestern part of Nigeria in fisheries and aquaculture, including lean management. He is the president of Youth in Agriculture at the IDIPR Eriwe Fish Farm Village in Ijebu-ode.

Phone number: +234-703-316-4196
Email: daramayoola@gmail.com

Temitope Bakare is a fish farmer at the Eriwe Fish Farm Village in Ijebu-Ode. Her specialty is training fish farmers in her local language for easy understanding.

Phone number: +234-803-614-9813
Email: temitopebakare1986@yahoo.com

Oluwafemi Babatunde Oduntan (PhD) is a lecturer and engineer who specializes in the construction of cost-effective, sustainable and easy-to-maintain facilities for aquaculture systems that ensure the security of the food supply.

As a way to strengthen ties between academic institutions, research facilities and businesses that manufacture fish feed, he worked on the creation of a bio-engineering interface for aquaculture. As a result of lean management, he has made a significant impact on a number of youths, farmers, students and women.

Phone number: +234-803-327-2525
Email: femkem03@yahoo.co.uk

Sunday Izomo has helped many smallholder fish farmers in the state and has been involved in various USAID projects aimed at enhancing farmers' productivity.

As a cluster head at the Eriwe Farm Village, he involves all of his cluster members in various projects.

Phone number: +234-803-111-0843
Email: izomosunday13@gmail.com

Oluyemi Oludayo Michael is an experienced aquaculturist who specializes in catfish production and marketing. He is a seasoned trainer who has trained both local and international organizations in the field of aquaculture. He is one of the founding members of the Ifeoluwa fish farmers Association in Ikangba.

Phone number: +234-802-240-1959
Email: mikeld1.ym@gmail.com

Isah Hussani is well versed in aquaculture as the president of the Mojalake Fish Farm in Ijebu-ife. His experience has helped him build the knowledge of his cluster members, and he always makes sure they are involved in different training sessions in the aquaculture value chain sector. He also does consultancy work for various farms in the state, which has helped build his confidence in providing training.

Phone number: +234-803-563-0610
Email: isahhussainimoshood@gmail.com

Flora Eyibio Olaifa is a professor of aquaculture and fisheries management at the University of Ibadan. She has participated in improving the efficiency of the Nigerian aquaculture sector by employing lean production systems in parts of Ogun and Oyo states.

Phone number: +234-803-550-9342
Email: floraolaifa@yahoo.com

Okole Lazarus is the president of the Asejere Fish and Allied Farmers Association Ikangba/Agoro in Ijebu-Ode with wide-ranging experience in the aquaculture sector. He has over 150 fish farmers under his leadership and has helped them by including them in different local and international training sessions on better management practices and how to maximize profit.

Phone number: +234-803-974-7470
Email: bluebest2017@gmail.com

About WorldFish

WorldFish is a leading international research organization working to transform aquatic food systems to reduce hunger, malnutrition, and poverty. It collaborates with international, regional, and national partners to co-develop and deliver scientific innovations, evidence for policy, and knowledge to enable equitable and inclusive impact for millions who depend on fish for their livelihoods. As a member of CGIAR, WorldFish contributes to building a food- and nutrition-secure future and restoring natural resources. Headquartered in Penang, Malaysia, with country offices across Africa, Asia, and the Pacific, WorldFish strives to create resilient and inclusive food systems for shared prosperity.

For more information, please visit www.worldfishcenter.org