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Integrating crop diversification and sericulture products and by-products: A pathway to increased farm production and income in Brgy. Imelda, Naguilian, La Union, Philippines

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Abstract

The Imelda Sericulture farm in Naguilian, La Union, Philippines demonstrated sustainable farming practices such as integrated nutrient management, waste recycling, silkworm rearing, crop diversification, and product and by-product development. These were implemented from May 2015 to December 2022 with the aim of increasing farm production and income. The practices were thoroughly documented, and their product and labor productivity as well as profitability were reviewed and studied in a descriptive manner. From 2015 to 2021, 293.82 kilogram of cocoons were produced. Other products included 13,422 mulberry saplings, 500 cutings, 800 grams of cut cocoons, 300 grams of dyed cocoons, and 222 novelty items. Also included were 80 bottles of wine, 55 bottles of vinegar, 10 bottles each of jams and jellies, and 10 sachets each of candy and tea. Various vegetables were also gathered, like snow cabbage (*Brassica rapa*), eggplants (*Solanum melongena*), tomatoes (*Solanum lycopersicum*), pepper (*Capsicum annuum*), beans (*Phaseolus vulgaris*), and horseradish tree (*Moringa oleifera*). Banana (*Musa* spp) was also collected. Mulberries and *Gliricidia sepium* (madre de cacao) trees provided food, energy, and fuel. Cocoon and other product sales generated PhP155,784.63 over seven years. The gross margin was PhP66,041.86, and the net income was PhP42,928.21. Return on investment was 67.27%, man-days generated 346.51, and value PhP65,707.18. The annual average is 49.50 man-days and PhP9,386.74. The demonstration project enhanced the efficiency and financial viability of the farm through sericulture and sericultural farming systems, which served as a source of food, income, and employment for the family.

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Introduction

Sericulture in the Philippines is a flourishing enterprise due to its high domestic and international demands. Based on the Philippine Fiber Industry Development Authority Philippine (PhilFIDA) records, export earnings and silk products reached $ 457,177 by end 2012, up from the 390,796 in 2011 (Benaning, 2013). Filipinos commonly rely on imports from other countries to sources of raw silk materials including those of natural costume – "barong" (Japan Information and Culture Center, JICC-Press Release No 02-2019) to meet local demands for the government silk uniforms in compliance with RA 9242 that requires the use of tropical fabrics for their office uniforms. In Region I, which is an administrative region in the Philippines located in the northwestern section, a total of 15,685 meters of silk fabric is required to provide clothing for the 6,272 government personnel and other agencies.

The enterprise that is compatible with existing farming systems is labor intensive producing high valued silk fabric could contribute to attaining sustainable development goals to end poverty, hunger, achieve food security, improve nutrition and promote sustainable agriculture. The proportion of poor Filipinos was recorded at 18.1% in 2021. This is about 19.99 million who live below the poverty threshold of about Php 12,030 pesos per month for a family of five (PSA, 2021). Region I has a total land area of 129.65 km^2 in 2013 with a population of 5,301,139 in 2020 and a growth rate of +1.13%. Potential members of the workforce or economically active population aged 15-64 are 63.21% or 3176.81 (Phil Atlas, 2022). The region has a poverty incidence of 20.2% of the population (1.07 million) in 1st semester 2021. The subsistence incidence among population was estimated at 7.1% or 375.9 thousand (PSA, 2022). Food security in Asia is being threatened by various factors. These include the increasing demand for food due to population growth, changes in food consumption patterns resulting from rapid urbanization, limitations in agricultural and fuel production, constraints in utilizing natural resources, the negative effects of global warming and climate change, and the instability of food and oil prices. (Teng and Escaler, 2012 as cited by Teng, 2013). These factors pose a significant risk and cause concern for the food and livelihood security of millions of impoverished farmers, fisherfolk, and marginalized communities, which are crucial for ensuring agricultural sustainability (Pulhin, 2016).

Sericulture in Region I remained at developmental stage. The farm productivity and profitability were low due to low adoption of good management practices for successful production (Caccam and Mendoza, 2010). A lot more could be done to address the problems in sericulture. The region is endowed with large tracts of marginal uplands, under-utilized plains and favorable climatic conditions for establishing mulberry plantations, silkworm rearing and easily manipulated/mitigated to suit its management requirements in case of environment crisis. This prompted the Sericulture Research and Development Institute (SRDI) to develop sustainable sericulture farming practices that could address the problems of low production and income at sericulture while sustaining the environment. A variety of alternative practices can potentially protect or enhance biodiversity through environmentally friendly approaches as multiple cropping, mixed farming, organic farming, conservation agriculture, integrated pest management, and indigenous knowledge systems (Wayne, 2018).

Several technologies had been developed at SRDI that yielded promising results as intercropping corn and legumes and cash crops in between rows of mulberries (Padilla *et al.*, 1999; Quinzon, 2001). In integrated nutrient management studies, mulberry plants applied with ½ recommended rates of nutrients (RRN) or 75 kg N +PK ha^{-1} + 5-ton silk wastes +10-ton *Sesbania grandiflora* (hummingbird tree) leaves during May - July 2014 produced heavier leaf and biomass yields (Caccam *et al.*, 2012). The fertilizer application of ½ recommended rate (RR) organic and ½ RR inorganic and RR inorganic N/ha^{-1} were the two systems that produced the highest yield of storage roots of sweet potato intercropped in

mulberry trees (Anislag, 2019). The use of Alfonso mulberry variety in pits applied with 10-ton` neem tree leaves or 10-ton madre de cacao (*G. sepium*) leaves in combination of ½ N recommendations per hectare are highly advocated as this has high quality mulberry leaf yields and income (Caccam *et al.*, 2011). The use of organic farming practices (intercropping corn-peanut) resulted to more products generated, higher income and return on investment (combined income). With more activities, more labor man-days were generated shared by men and women (Caccam *et al.*, 2019). While marginal benefit cost ratio was highest on other production systems, Low-External-Input and Sustainable Agriculture (LEISA), (pit planting + 100-50-50 kg NPK ha^{-1}+10-ton poultry manure +green leaf manure (*S. grandiflora* leaves) + mulch should be adopted as it reduces inorganic fertilizer use by 50% while producing green manure crops that provide additional income from food products and wood fuel. Green manure crops along with other organic fertilizer increase the fertility of the soil (Caccam and Mendoza, 2012). Studies have demonstrated that organic farming can achieve high yields that are comparable to conventional farming, provided that it is executed effectively.

In Imelda, Naguilian, La Union, Philippines, a project was conducted to back up the Don Mariano Marcos Memorial Ste University-Commission on Higher Education (DMMMSU-CHED) research project last January 2013. The project started with organic mulberry sapling production then mulberry establishment for the production of organic silk fabric and source of organic fruits for processing. The project both employed the organic farming practices like crop diversification (intercropping corn in between mulberries at establishment stage), organic fertilization strategies first using farm manures then composted silk waste and using Vesicular Arbuscular Micorrhizae (VAM) bio-fertilizer, mulching and natural pest management control. The project yielded promising results providing cocoons for processing into organic silk fabric for analysis and patenting. The project also supported the processing of fruits into jams, jellies and candies with and without tropical fruit blends like guyabano (*Annona muricatba*) and pine apple (*Ananas comosus*) so with processing shoots for teas with and without herb blends like pandan (*Pandanus pandan*) and lemon grass (*Cymbopogon citratus*), (Caccam *et al.*, 2019). The project was a resounding success giving the farmer cooperator incentives in the conduct of the project and to continue the project.

It is of this premise that the project was institutionalized and conducted as one of the extension projects of SRDI. Information drive on sericulture encouraged the farmers to venture on the project. The purpose of this study was to showcase the best sericulture technologies and its potential as a source of employment and livelihood of the farm family.

Specifically, the project sought to: a) demonstrate and document the package of technologies on sapling and mulberry leaf production, silkworm rearing, and production of food and non-food products; b) assess the productivity and profitability of the sericulture techno demo farm; c) assess the labor productivity (employment generated) to family and community people in the different sericulture production processes; and d) identify the strength, weakness, opportunities and threats of the sericulture enterprise in the area.

Materials and methods

Locale of the study

The project site was conducted in the Barangays (Brgy.) of Imelda and Bariquir, municipality of Naguilian, province of La Union, Philippines. The municipality is known as the home of original “basi” (sugarcane wine). Brgy. Imelda is an industrial and agricultural barangay with rice as major crop and legumes, corn and vegetable grown after rice while Brgy. Bariquir is an agricultural barangay with rice as major crop and corn, and vegetables grown after rice. Both barangays also raised poultry, small ruminants and livestock.

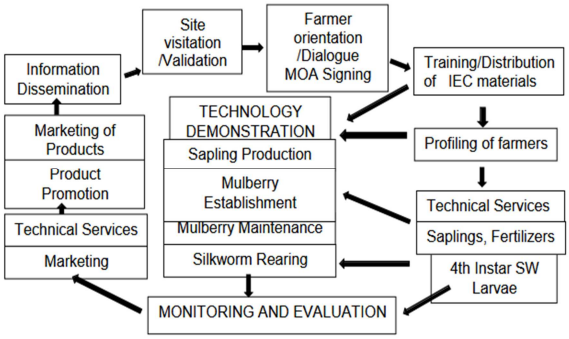

Fig. 1. Strategies of implementation

Strategies of implementation

Fig. 1 outlines the different management strategies that were implemented by SRDI and the farmer cooperator. These strategies were information dissemination, site visitation/validation, training and distribution of Instructional Education Communication (IEC) materials, profiling of farmers, provision of support services then technology demonstration that included technologies on crop diversification, farm waste recycling, sanitized silkworm rearing and product/by-product development applied to appropriate sericulture production systems as in sapling production, mulberry establishment and maintenance, silkworm rearing, product and by product development. Monitoring and evaluation was regularly done to check the progress of the project.

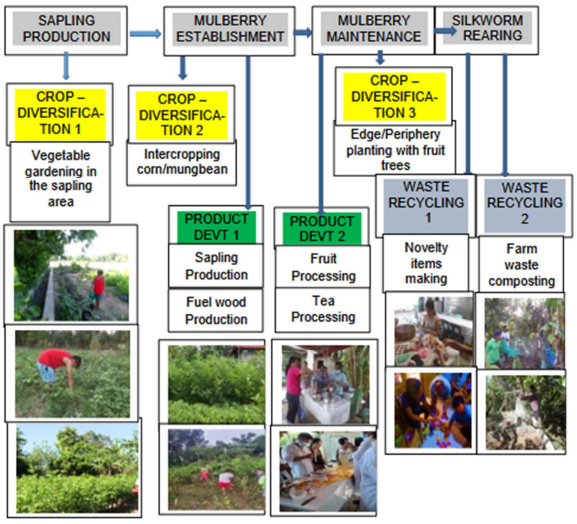

Fig. 2. Farming systems/practices integrated in sericulture farm

Technology demonstration on sustainable farming was applied in all aspects of producing cocoon, other product and by products employing technologies developed by SRDI as illustrated in Fig. 2.

Demonstration of the different production systems

Sapling production

Selected cuttings of mulberry Alfonso variety from Brgy. Imelda Lot 1 area were cut, dipped in low concentration of Alpha Naphthalene Acetic Acid (ANAA) and coconut water (25:75 Plant Growth Regulator, PGR: water) solution and incubated for 5-7 days before planting. A nursery bed with a dimension of 1 m × 9 m length was constructed in a prepared area. The beds were applied with organic silk wastes at the rate of 10t/ha^{-1}, incorporated into the soil and mulched with rice hay then watered. The incubated cuttings were planted at a distance of 10 × 10 cm by inserting the cuttings into the soil in slanting position then again sprinkled with water. The plants were weeded one month after planting, replanted the missing hill and fertilized with inorganic fertilizer, N at the rate of 150 kg N ha^{-1} then watered as needed until ready for transplanting after six months. These were pulled from beds then trimmed for ready planting.

Mulberry establishment

Mulberry saplings were planted in three parcels of lots in Brgy. Bariquir area. In one lot, an open area was thoroughly prepared using a tractor rotavator. Using an animal-drawn plow, furrows were set 1.2 meters apart in single rows. Then, holes were dug in rows, one meter apart from each other. Brgy. Bariquir area is a Low External Input and Sustainable Agriculture (LEISA) farm fertilized with both organic and inorganic fertilizers. The compost fertilizers were applied at the rate of 10-ton ha^{-1} at the sides of the plants while inorganic fertilizers such as UREA and complete at the rate of 150-50-50 kg NPK ha^{-1} were drilled also at one side of the plant at one month after planting. The holes were planted with two saplings per hole. These plants were raised as tree type for easier leaf harvesting. In other two lots, the land area was prepared as in lot 1 with the same row

distance but distance of plants in furrow was 0.5 cm then planted with one potted sapling per hill. One month after planting, the area was cleared of weeds by under brushing. The weeds were then used as mulch for the mulberry plants, while some weeds were pulled out and used as fodder for animals. The foliage was collected half a year after being planted and thereafter stored in a bag before being transported to the rearing facility for the purpose of nourishing the silkworms.

Mulberry fruit garden was established in a 300 square meter area in Brgy. Imelda, Naguilian, La Union. Three varieties of mulberry var. Alfonso, open pollinated varieties Alf 004 and Alf 025 secured from SRDI was used for planting the area employing the pit systems of planting. Dug holes with a dimension 20 x 20 x 20 cm were prepared at a distance of 1 x 1 m then applied with silk waste compost at the rate of 10-ton ha^{-1}, covered with soil then planted with saplings at two plants per hill. The crops were weeded, fertilized with inorganic fertilizer one month after planting then irrigated thereafter. The leaves were harvested six months after planting for the first rearing and every two months thereafter.

Mulberry maintenance (Second year onwards)

Selective pruning was done at the onset of rainy season then every leaf harvest during the months of Aug-Sept and Nov-Dec. Only plants with 2 m high and stem diameter of 2 cm were pruned leaving plants that were still immature for pruning. No pruning was done during the months of January to April so as not to severe the plants on the onset of summer season. After pruning, Brgy. Imelda area were applied with organic fertilizer (silk waste compost and swine manure compost) at the rate of 10-ton ha^{-1}. The fertilizer materials were place at 20 cm away from the base of the plants. This was done on the second and fourth year of establishment. Brgy. Bariquir area was applied with inorganic fertilizer at the rate of 150-50-50 kg NPK ha^{-1}. These were drilled at 20 cm away from the base of the plants then covered with thin soil. This was done only on the second year of establishment. Weeding was done when weeds over grew the mulberry plants. Weeds like the *Lantana camara (*lantana*)*, *Mimosa pudica* (sensitive plant) and *Saccharum spontaneum* (fodder cane) were cut and placed around the mulberry plants as mulch or placed in dikes as additional fertilizer when composted. Fencing the area with mulberry trees served as live fence, additional source of leaves during rearing and fuel wood for the family.

Sanitized silkworm rearing

Disinfection of rearing house and its facilities

Three days before rearing, the rearing house and its facilities were disinfected with calcium hypochlorite and soap solution by spraying all the parts of the house and all facilities. All rearing nets and bedding nets were properly washed while cocooning frames and plastic mountages were properly disinfected using a blow torch.

Delivery of silkworms

The different project sites secure their silkworm larvae at SRDI on specific dates/schedules. The silkworms were usually delivered at fourth instar, second-feeding stage early in the morning using a delivery van. They were transferred in each rearing racks lined with blue nets prepared by the farmer before delivery. Likewise, mulberry leaves were already harvested to feed the silkworms immediately after transfer.

Late-age rearing

The silkworms were placed in rearing racks lined with blue nets to give way for bigger and heavier growth. At fourth instar, they were fed with whole leaves for four times at 5:00 AM, 10:00 AM, 3:00 PM and 8:00 PM. More leaves were fed in the evening as the worms are nocturnal in nature. During the molting process, feeding was halted and the silkworms were dusted with rice hull or lime until all of them had completed molting. Following the molting process, the silkworms were treated with a specialized disinfectant developed by SRDI. Subsequently, they were moved to a separate tray that had been thoroughly cleaned. The cleaning of the bed was carried out subsequently.

At fifth instar, the worms were spaced further and fed with mulberry leaves with branches alternately placed over the worms. Diseased worms were regularly monitored every before feeding and discarded. When branches piled up, bed cleaning was done on the third day. Before disposing the waste, dead larvae were collected to separate it from the beddings and disposed or buried in a pit along with other dead or sick worms that were discarded in beds. All of the bedding was either put in bins for composting or dumped outside and covered with nets.

Spinning

The silkworms spun their silk threads after 23-25 days after brushing. These were mounted in a rotary frame and plastic mountages placed in the rearing trays. Silkworms that did not spin their cocoons within 72 hours were collected and disposed of appropriately. The silikworms produced their silk filaments for duration of three days, and the cocoons were collected on the 5th to 6th day after being mounted.

Cocoon sorting and classification

The cocoons were sorted and good cocoons were placed in basket trays for air drying until pick up of cocoons. Good cocoons were thick and hard, and no stains inside or outside the shell. Bad cocoons, on the other hand, were soft, misshapen, had stains, and had two cocoons inside one. In addition, cocoons that were rejected were soft and dirty on the inside. Good cocoons cost PhP350 per kg, and cocoons that couldn't be reeled in cost PhP60.00 per kg. Reject cocoons were no longer sold to filature because they were thrown away properly because they were trash.

Product and by-product development

Crop diversification in sericulture farms

Vegetable crop gardening in sapling area

Vegetables were integrated in mulberry sapling production area by planting them in vacant spaces, peripheries or edges. The areas were cleaned and drilled with vegetable seeds of okra (*Abelmochus esculentus*), bitter gourd (*Momordica charantia*), squash (*Cucurbita maxima*) and string beans (*P. vulgaris*) while seedlings of snow cabbage (*B. rapa*), tomatoes (*S. leporsecum*), pepper (*C. frutescens*) and eggplants (*S. melongena*) were also planted in bunds and vacant areas.

Intercropping mungbeans in mulberry fruit garden

Mungbeans (*Vigna radiate*) were intercropped in between mulberry trees as source of food and income. The seeds were drilled in between mulberry trees and allowed to bear fruits for harvesting. Some fruits were allowed to mature as source of seeds for next planting. The biomass was pulled and placed at the base as mulch then allowed to decompose as organic fertilizer.

Edge planting or periphery planting in plantation area

The areas in both barangays were secured from intruders and astray animal by planting live madre de cacao (*G. sepium*) poles as posts for the wires of the fences and fuel wood for the family. Likewise, moringa (*Moringa oleifera*), hummingbird tree (*S. grandiflora*) and other fruit trees like banana (*Musa* spp) and sour orange (*Citrus aurantium*) were planted in edges or boundaries of the plantation. The farmer cooperator also planted mulberries in boundaries as fences that secured the area from astray animals and other intruders.

Product diversification/Value adding

Mulberry is a highly adaptable plant. While the primary purpose of growing this plant is to provide leaves as the exclusive food source for silkworms, other parts of the plant, such as its fruits, can be consumed either fresh or processed into food products. The young shoots of the plant can be eaten alongside other vegetables, such as in salads or blended with other dishes, or they can be processed into mulberry teas. The stems/branches of the plant can be harvested for cutting and used to produce saplings, or they can be utilized as fuelwood.

Mulberry fruit processing

The introduction of the Alfonso mulberry variety, a type that bears fruit, has opened up opportunities for

fruit processing such as vinegar, wines, jams, jellies, and candies. The mulberry jam, both with and without pineapple, is made by combining high-quality fruits with sugar and boiling the mixture until it reaches a ball-like consistency. The jam is then bottled and sterilized. The mulberry jelly, whether with or without pineapple, is made by blending and juicing high-quality fruits. The mixture is then combined with sugar and cooked until it reaches a solid consistency. Finally, it is bottled and sterilized. The mulberry-pastillas candy is made by combining high-quality fruits with sugar and boiling the mixture until it becomes a solid ball. The candy is then wrapped in candy wrappers, placed in bags, and sealed. Subsequently, the jam, jelly, and confectionery items were appropriately identified and securely enclosed for preservation and safekeeping at ambient conditions.

Mulberry leaf tea processing

Young shoots of mulberry were gathered, washed with water then chopped into 13 square cm, blanched, drained and air and oven dried before packing and labelling.

Fuelwood production

Pruned mulberry branches were collected and utilized as firewood. These were cut off from the base with a bolo or pruning saw, then the leaves were removed, dried, and bundled with a rope. Moreover, the stems that were cut off throughout the rearing process were collected, dried, and bundled. These stems were then utilized as igniters for culinary purposes. They decreased their energy costs for cooking.

Sapling production

Mulberry cuttings suited for sapling production area available in every after pruning. From 2016 to 2020, the family members engaged in mulberry sapling production. At first, mulberry cuttings were planted in pots, cared and managed for 5-6 months then used for replanting and some were sold to walk-in visitors and support to the mulberry production to produce cocoons to the PhilFIDA farmers in other barangays of Naguilian, La Union (Lioac Sur, Gusing and Bariquir); municipality of Binalonan in the province of Pangasinan; Brgy. Pideg in the municipality of Tubao and San Juan both located in the province of La Union. For pot-planting, each family was given polyethylene pots for potting garden soil and rice hull in their respective household using cuttings from barangays Imelda and Bariquir mulberry area. The branches were cut into desired sizes and incubated for a week before planting in pots, watered, weeded and fertilized until they were ready to be distributed to other farmers. In 2019, the family planted cuttings in nursery beds. All family members collaborated in preparing the area, utilizing a tractor rotavator for initial cultivation and a carabao-drawn plow for furrowing. Afterwards, beds were arranged with dimensions of 1 meter in width and 9 meters in length, and were elevated to a height of 18 centimeters. The distance between rows of beds was set at 40 cm to ensure optimal water flow during flooding. The beds were mulched with rice hay and then moistened or irrigated. The pre-inoculated cuttings were then planted in the bed, spaced 10 x 10 cm apart. These were sprinkled with a hose using a water pump and done every two weeks or as necessary. After a month, the plants were weeded and re-watered then were fertilized with UREA fertilizer at the rate of 150 kg N/ha. The plants were uprooted 5-6 months after planting. The saplings were cleaned of extra roots and trimmed to 100 m high before delivery to project sites.

Production of non-food products through integrated waste recycling

Novelty items making

Unreelable cocoons generated during each rearing were cut, dyed and assembled into different products as roses, corsages, leis and wreaths for additional income and mostly for personal use as ornaments like birthdays, debut and funerals as well as tokens in weddings, birthdays, debuts, graduations and christening. The training on novelty items making provided the farmer participants capability to produce different assemblages/novelty items for their homes.

Compost making

Farm wastes generated in the farm as weeds, silk wastes and animal manures from the farm were gathered and composted naturally in bins, open area under shade of fruit trees in the garden. Livestock manures (cow/carabao) were gathered and piled in one corner of the sapling area, moistened with water then covered with plastic sheet then allowed to decompose before using. Likewise, swine manure was placed in a bin covered with rice hull then added with silk wastes during rearing and allowed to decompose. Also, silk wastes were dumped in a corner then covered with nets to protect it from animals then allowed to decompose before packing and use.

Data gathering procedures

Documentation of the project

Photographs and process documentation were employed to document the project activities and progress and regularly reported through travel and progress reports to monitor and evaluate the project.

Productivity and profitability analysis

A log book or record book was provided at the project sites allowing the farmer to maintain a record of inputs and outputs, documenting all operations. The productivity metrics encompassed the quantities of mulberry, cocoon, and other items generated in the region, while the profitability measure involved assessing the costs and returns. The gross return was calculated by multiplying the marketable yield by the current price of cocoons and other items. The total production cost was computed, including direct costs (materials and labor) and indirect costs (rentals and repairs). The Gross Margin was calculated by subtracting the direct costs (material and labor) from the gross income. Gross income less entire production costs were used to calculate net income. Net income was divided by capital investment and multiplied by 100 to calculate return on investment. Labor productivity was calculated by estimating the number of mandays generated and the corresponding value as a function of the current compensation value in each year.

Strength, weakness, opportunities and threats (SWOT) analysis

The case study report project was also analyzed using the SWOT analysis where the strength and weakness as well as opportunities and threats were identified. Using this analysis, issues and concerns (problems) were identified and that suggestions for improvement were determined for future action**.**

The study employed descriptive analysis to analyze the data. Cost-returns of each production process were estimated.

Results and discussion

Demonstration and documentation of sericulture technologies

The different sustainable technologies were successfully demonstrated in the sericulture areas. The utilization of LEISA technology, such as the implementation of row-pit systems for planting and the integration of nutrient management through the combined use of organic and inorganic fertilizers, has proven to be effective in promoting the growth and productivity of mulberry saplings. This strategy reduced the use of inorganic fertilizers into half thus reducing cash cost of fertilizer while the use of organic fertilizers in the farm cuts cost of inputs and reducing pollutants in the farm. Likewise, mulching using available materials, manual weeding and mulching the weeds reduced weed population and conserved soil moisture then turned into organic fertilizers for plant growth. Other organic farming practices employed were crop diversification like vegetable gardening in vacant areas, peripheries and edges of the area that maximized the use of the land. Intercropping mungbeans in newly established areas increase food supply and the mulching of biomass into the plants enriched soil fertility as green leaf manure to the plants. Periphery or edge planting of mulberry and madre de cacao poles and sparse planting of banana, hummingbird tree,

papaya, oranges and moringa trees provided fuel, food, and security (live fence) to the farm and the family. The practice of sanitized silkworm rearing through maintenance of cleanliness and sanitation in the workplace improved rearing performance. Rearing house and facilities disinfection, silkworm disinfection and bed cleaning, proper disposal of diseased silkworms and silk wastes were important practices to reduce disease infestation. Cocoon sorting dictated the quality and the price of cocoons.

The successful demonstration of sustainable technologies could be due to well defined extension strategies employed in the area. The technologies were fully disseminated through on-the-job training on the whole gamut of sericulture and the distribution of instructional materials that enriched their knowledge and skills. The provision of support systems (technical assistance/ services, material support at cost) and the regular monitoring mitigated problems that arose during implementation. Likewise, the good environmental condition permitted the production of mulberry and its compatibility with other crops maximized the use of the land. The sustainable technologies reduced the costs of production, reduced environmental pollutants through waste recycling and provided a variety of products for food, income and other purposes.

Table 1. Cocoon production in Brgy. Imelda, Naguilian, La Union, Philippines, 2015-2021

Date released	Frequency of rearing	No. of boxes released (box)	Date produced	Cocoon produced (kg)	Ave yield/ box (kg)
2015	3	2	May, August, November	49.30	24.45
2016	3	2.75	February, August, November	41.10	
2017	4	2.25	March, July, October, December	46.5	21.90
2018	3	2	February, June, October	62.25	26.62
2019	2	1	July, December	29.00	26.66
2020	3	1.5	March, July, November	42.72	28.52
2021	2	.75	March, July	22.95	30.60
Total 7 years		12.25		293.82	
Average of 7 years		1.75		41.97	24.97

Table 2. Sales of cocoons from the project, 2015 – 2021

Date produced	Boxes reared	Cocoon produced (Kg)	PRICE/ Kg (PhP)	Gross income (PhP)	Prod cost (PhP)	Gross margin	Net income (PhP)	ROI (%)
2015	2.00	49.30	160.00	7,888.00	9,313.10	1,221.00	-1425.10	-2.37
2016	2.75	41.10	173.30	7,122.63	9,226.60	510.13	-2103.97	-3.50
2017	2.25	46.50	200.00	9,300.00	7,480.10	4,434.00	1819.9	3.03
2018	2.00	62.25	200.00	12,450.00	8,386.10	6,710.00	4063.90	6.77
2019	1.00	29.00	350.00	10,150.00	7,180.10	5,584.00	2969.9	4.95
2020	1.50	42.72	350.00	4,952.00	8,893.60	8,672.50	6058.4	10.09
2021	0.75	22.95	350.00	8,032.50	6,605.35	4,041.25	1427.15	2.38
Total 7 years	5.25	293.82		69,895.13	57,084.95	31,172.88	12,810.18	21.35
Ave	0.75	41.97	176.67	9,985.02	8,154.99	4453.27	1830.02	3.05

Productivity of producing cocoons

For the seven-year rearing period, a total of 12.25 boxes of silkworm larvae were reared with a total production of 293.82 kg of cocoons (Table 1). Average number of boxes reared was 1.75 boxes (a box is approximately 20,000 silkworms) with a production of 41.97 kg per year while average yield per rearing box was 24.97 kg that is still within the standard range of 20 kg/box. It is worth mentioning that the production per unit area in the farms of barangays Imelda and Bariquir has increased due to the creation of cocoons. The previously empty residential lots in Brgy. Imelda have now been transformed into productive areas for cultivating mulberry leaves, which are utilized for rearing silkworms. Similarly, in the Brgy. Bariquir area, the annual rice production has been improved by the introduction of mulberry cultivation for cocoon production. As per interview with the land owner, they

experienced greater advantages from mulberry cultivation by using it as a source of fuel wood for cooking purposes. Likewise, some leaves not used in rearing were used to feed their livestock animals particularly during summer months. Mulberry stems and branches served as their energy source (fuel wood).

Cost-return analysis of producing cocoon 2015-2021

For seven years, a total gross income of PhP69,895.13 from sales of rearing 5.25 boxes of silkworm with a production of 293.82 kg. Gross margin was valued at PhP31,172.88 while net income was PhP12,810,18 and accumulated ROI was 21.23 as shown in Table 2.

Average annual gross income was PhP9,985 from 0.75 box of worms with 41.97 kg cocoon production. Gross margin was PhP4,453.27, net income PhP1,830.02, and ROI 3.03%. Due to high startup costs and low cocoon prices, gross margin was low and net income was negative in the first two years. Gross margin, net income, and ROI grew in subsequent years due to successful agricultural harvests and rising cocoon prices. The July 2017 rearing season had 2.9 kg of cut cocoons sold as novelty goods, reducing fresh cocoon production. Positive gross margin, net income, and ROI indicate that cocoon production is profitable. Successful production may also depend on healthy silkworm larvae (low mortality, vigorous silkworms), coupled with good rearing conditions and well dedicated and competent silkworm rearers. Repeated lockdowns from August to November reduced silkworm rearing frequency during the 2021 pandemic.

Table 3. Generated mandays and its value in the production of cocoons

Year	Generated mandays	Rate/day	Value (PhP)
2015	23.60	150	3,540.00
2016	29.93	150	4,488.75
2017	24.13	150	3,618.75
2018	23.40	150	3,510.00
2019	15.90	200	3,180.00
2020	18.15	300	5,445.00
2021	11.78	300	3,532.00
Total	146.89	1250	27,314.50
Average	20.98	175	3,902.07

Table 4. Combined production of cocoons and other products from mulberry and silkworm rearing, 2016-2021

Products	Year							Total
	2015	2016	2017	2018	2019	2020	2021	
Cocoons (kg)	49.30	41.10	46.50	62.25	29.00	42.72	22.95	293.82
Cuttings (pcs)		200	300					500
Saplings (pcs)		442	580	4,000	7,000	1,400		13,422
Fresh leaves (kg)		50*	100*					150
Silk wastes (kg)		50*	50*					100
Cut cocoons (g)			300	500	1000			1800
Dyed cocoons (g)			300					300
Novelty items –(pc) cc			20		222	50		292
Wines (bottle)			20	12	12	20**	18	82
Vinegar (bottle)			10			20**	5	35
Jam - bottle						10**		10
Jelly - bottle						10**		10
Candy–sachet 10pc						20**		20
Mulberry tea-sachet						20**		20
Fruits & vegetables						***	***	
Fuelwood (bundles)****	60	120	150	150	175	250	250	1,155
Silk waste composts (kg)*****	100			50				150

* shared to students of Nag National High School as Investigatory Project

** shared among family members as food for the family

*** fruits, and vegetable were gathered but not quantified.

**** for home consumption (fuel wood)

***** applied in mulberry plantation

Labor productivity in sericulture farm

Generated mandays (MD) in cocoon production

One of the objectives of sericulture is to offer additional means of livelihood for the farmers. The MD values for the years 2015, 2016, 2017, 2019, 2020, and 2021 were 23.6 (PhP3,540.00), 29.93 (PhP4,488.75), 24.13 (PhP3,618.75), 23.40 (PhP3,510.00), 18.15 (PhP5,443.00), and 11.78 (PhP3,532.00) respectively. The daily rate was PhP150.00 from 2015 to 2018, PhP200.00 in 2019, and PhP300.00 from 2020 to 2021, as indicated in Table 3. Over a span of seven years, a total of 146.89 MD with a value of PhP27,314.00 with an average of 20.98 MD valued at PhP3,902.70 was generated. This enabled the workers to engage in these activities during their free time, therefore providing them with extra revenue and additional means of supporting themselves.

Farm productivity, profitability and generated employment in producing the main product cocoons and other products

Cocoon production

For the seven-year rearing period, a total of 12.25 boxes of silkworm larvae were reared with a total production of 293.82 kg of cocoons as presented in Table 4.

Production of other products from mulberry and silkworm

Sericulture project in Brgy. Imelda integrated other crops in the production area through intercropping and edge/periphery planting, product and by-product diversification, integrated waste and nutrient management that resulted to different products.

Mulberry sapling and cutting production

The increasing number of farmer cooperators of Senator Legarda and PhilFIDA projects and the popularization of mulberry for home gardens using fruiting variety increased the demand of saplings for distribution to farmers. In 2016-2017, the farmer cooperator produced 500 cuttings and sold to walk in buyers. For the period of six years, a total of 13,422 saplings were produced and sold to target clienteles. This clearly demonstrated that the farmers could provide the sapling requirements of their fellow farmer cooperators and other entrepreneurs, thus, complimenting with the Sapling and Distribution Unit of the Institute and relieving some of their workload requirements.

Cut/Dyed cocoon production

Inferior cocoons during rearing were cut, dyed and sold to cocoon novelty enthusiasts and high school students. A total of 2.1 kg inferior cocoons were cut in year 2017, 3.3 kg in 2018 and 7 kg in 2019 that yielded to 300, 500 and 1,000 g of cut cocoons in year 2017, 2018 and 2019 respectively. Three hundred grams of cocoons were also dyed in 2017.

Novelty items production

Other cut cocoons were also crafted into novelty items with the production of 20 roses in 2017, 222 roses in 2019 and 50 roses in year 2020. Other novelty items products that were shared free were tokens for birthdays, debuts and wreaths for funerals.

Fresh and processed fruits and young shoots

Mulberry fruits at the farm were picked as fresh fruits and processed in different products as wines and vinegar and food products as jams, jellies and candies while young mulberry shoots not used in rearing were processed in mulberry teas. In 2020, during the pandemic lockdown, the family engaged in on-the-job training in food processing, resulting in the production of 10 bottles of jam, 10 bottles of jelly, 20 sachets of candies, and 20 sachets of mulberry tea. Additionally, they processed 20 bottles of wine and 20 bottles of vinegar, which were distributed among the family members. In the year 2021, a total of 18 bottles of wine, each containing 750 milliliters, and five bottles of vinegar, each containing 1 liter, were both manufactured and sold.

Fresh fruits, fresh leaves/silk wastes

The initiative formed a collaboration with Naguilian Science Laboratory High School to support their Science Investigatory project. This involved providing consultations, supplying raw materials for

research, and offering a location for students to visit and observe silkworms during the raising process. The utilization of fruits for vinegar production was highly noteworthy, as it earned a prestigious award in the Regional competition and qualified them for the national level. The students were provided with 50 kg of fresh leaves in 2016 and 100 kg in 2017, as well as 50 kilogram of silk wastes each year, for their investigatory project.

Vegetables

Fruits and vegetables were gathered in vacant areas and edges/peripheries that led to production of vegetables and banana fruits along peripheries for home consumption. Though it is hard to quantify the produce, all of the family had their fair share of the products as source of food for the family.

Fuel wood

The production of fuel wood from the mulberry farms was year-round as the plants were regularly pruned during pruning and silkworm rearing. For seven years, a total of 1155 bundles of fuel wood valued at PhP19,825 was generated with a yearly average production of 165 bundles valued at PhP2,832.14. These provided energy source (fuel) for home consumption for the family saving expenses on LPG or kerosene for cooking.

Silk waste compost

Silkworm litters and unused mulberry leaves were naturally composted in a shaded area and in a compost bin and allowed to decompose. After which, the composted materials were applied to new mulberry plantation. A total of 100 kg of composted wastes were applied to mulberry plants in 2015 and 50 kg was also applied in year 2018.

The demonstration of sustainable farming practices in the area improved the farm productivity. The conduct of silkworm for 2-3 times a year provided cocoon harvests more than the usual rice mono-cropping practice (previous land use). As per the landowner in Brgy. Bariquir, the typical annual yield in a 1,000 sq. m area is usually only 3-4 sacks of palay if there is rain, and no planting is done at all if the rain is delayed. On the other hand, in the Brgy. Imelda area, the land was left uncultivated for a period of time when it was converted into residential lots.

Crop diversification and farm waste recycling (fuel wood production) supplement the families' food supply, ensuring that they have access to energy and food when necessary, thereby freeing up their funds for other necessities. A diverse agricultural system has the potential to enhance health and nutrition by promoting the consumption of varied and nutritious diets composed of numerous food crops (Wayne, 2018). According to Mendoza (2015), cultivating a variety of crops in a 0.2-hectare space has demonstrated the ability to consistently yield an abundant supply of food, including root crops, vegetables, herbs, spices, medicinal plants, and fruits, sufficient to sustain a family of six. A study conducted by De Guzman *et al.* (2015) demonstrated that polycultures are more productive than monocultures. Polycultures also utilize natural resources and photosynthetically active radiation more efficiently, exhibit better resistance to pest epidemics, produce a greater variety of nutritious foods, and contribute more to economic stability and social equality.

Improvement of soil fertility

Another advantage of the technology is the improvement of soil fertility. The use of organic farming practices as farm waste composting and organic fertilization, green manuring, mulching with grasses or rice hay may add up to the fertility of the soil. Initially, the Imelda Sericulture farm has a heavy textured soil with a pH of 6.27 and an OM of 0.88 %, available P of 22.5 ppm and Exchangeable K of 73.39 ppm. After 2021, it has a pH of 6.49 and an OM of 1.91%, available P of 42.57 and Exchangeable K of 348.1 ppm (Apilado et al, 2021). Such activities also reduced pollution as waste build-up was avoided.

Combined net income and return on investment

The production of various products aside from cocoon resulted to promising results as shown in Table 5.

For seven years, a total sale of PhP161,505.13 was generated from cocoons and other products as cuttings, saplings, cut cocoons and novelty items, wines and vinegars. Net income was estimated at PhP45,176.21. Return on Investment was 67.27%. On the average of seven years, gross margin was estimated at 10,264.77 while net income was estimated at PhP7,224.36 after deducting the direct cost of PhP13,499.16 and indirect cost of PhP2,623.25 and ROI of 9.92%. The project had acquired a capital investment or assets amounting to PhP65,889.93 comprising of a rearing house and implements and other materials for product and by-product development.

Table 5. Combined net income and return on investment 2015-2021

Gross sales	Year							Total	Ave
	2015	2016	2017	2018	2019	2020	2021		
Cocoon	7,888.00	7,122.63	9,300.00	12,450.00	10,150.00	14,952.00	8,032.50	69,895.13	
Cuttings		400.00	600.00					1,000.00	
Saplings		2210.00	2,900.00	20,000.00	35,000.00	7,000.00		67,110.00	
Cut cocoons		660.00	500.00	1,000.00				2,160.00	
Novelty items			400.00		4,440.00	1,000.00		5,840.00	
Wine			4,000.00	2,400.00	2,400.00			8,800.00	
Vinegar			980.00					980.00	
Total sales	7,888.00	9,732.63	18,860.00	35,350.00	52,990.00	22,952.00	13,732.5	161,505.13	25,253.35
Less									
Direct cost	6,667.00	8,098.05	10,250.42	19,856.63	32,104.30	12,106.30	6,380.55	95,463.25	14,988.58
Gross margin	1,221.00	1,684.58	8,609.58	15,493.37	20,885.70	10,845.70	7,351.95	66,041.88	10,264.77
Indirect cost	2,646.10	2,614.10	2,614.10	2,646.10	2,614.10	2,614.10	2,614.10	28,362.70	2,623.25
Capex	6,0031	6,1931	65,481.00	66,781.00	67,331.00	65,781.00	68,031.00	455,367.00	65,889.33
Net income	-1425.10	-1198.27	5,450.13	12,314.49	17,664.18	7,857.21	4,513.57	45,176.21	7,224.36
ROI	-2.37	-1.93	8.32	18.44	26.23	11.94	6.63	67.27	9.92

By implementing cocoon production, integrating crop diversification into mulberry farms, and diversifying products, a higher income was achieved compared to the previous use of the land. The rice palay produced was solely intended for domestic consumption. As the number of products sold increased, so did the amount of income that was distributed to family members. The parents' portions were allocated for essential needs, while the children utilized their portion for educational expenses, online communication, and leisure activities. Aside from the financial income, the products they produced also provided them with food, fuel, and security through live fences in the workplace.

Generated employment from cocoons and production of other products

Combined production

The total number of mandays generated by the production of the primary crop and other goods was 346.51, with a total value of PhP65,707.18. The yearly average of mandays was 49.50, with a value of PhP9,386.74. This unequivocally demonstrates that the sericulture venture offered sustenance and supplementary earnings to both male and female members of the household, regardless of their age. The production systems offered more options for individuals to make money through daily labor by engaging in various activities during their free time, as shown in Table 6.

The adoption of technologies that can generate income is one of the main strategies to reduce underemployment (NEDA, 2014). One of the goals of the farm was to provide a sustainable source of income, which was accomplished in this demonstration farm.

The diverse production techniques implemented on the farm provided monthly employment

opportunities for family members of various ages and genders, particularly during the pandemic, when they had extra or unoccupied time available. According to Manjunatha *et al.* (2020), mulberry sericulture in India may create 11 mandays of employment every kilogram of mulberry silk output, both on and off the farm. In addition to the employment produced, the farmer and its constituents received training that enhanced their knowledge and improved their abilities in sericulture, which diversified farming. This enhanced their self-assurance in engaging in various activities and fortified their collaborative relationships, as members pooled their resources to achieve a shared goal.

Table 6. Generated mandays and its value in cocoon and other products (2015-2021)

Year	Mulberry and silkworm rearing		Other products-saplings food and nonfood products		Total man-days and value generated	
	Generated mandays	Value (PhP)	Generated mandays	Value (PhP)	Total generated mandays	Total value
2015	23.60	3,540.00			23.60	3,540.00
2016	29.93	4,488.75	7.05	1,057.80	37.28	5,546.45
2017	24.13	3,618.75	11.14	1,670.73	30.75	5,289.48
2018	23.40	3,510.00	69.89	10,936.75	93.29	14,446.75
2019	15.90	3,180.00	100.51	20,152.50	116.41	23,332.50
2020	18.15	5,445.00	15.25	4,575.00	33.40	10,020.00
2021	11.78	3,532.00	----	----	11.78	3,532.00
Total	146.89	27,314.50	199.62	38,392.78	346.51	65,707.18
Average	20.98	3,902.07	39.92	7,678.56	49.50	9,386.74

SWOT analysis of the sericulture enterprise

The strength of the project was that it was managed by available receptive and dedicated farm workers; available, land, equipment and other resources. It had good farm design and adaptable climate for mulberry and silkworm rearing. Technologies were readily available for adoption. The weakness however was the competition with other crops on the use of labor and equipment as they prioritize their major crops and still had limited training on new technologies. The opportunities of the project were the increasing demand for cocoon products and other products and available support and technical services offered by SRDI. The threats however were the rising cost of inputs (fuel, fertilizers, chemicals and labor) that increased production cost thus decreasing net income as the price of cocoons remain unchanged. Since it started in year 2015, prices of inputs like fuel, fertilizers and labor cost almost doubled beyond the capacities of farmers to pay.

To improve farm performance, farmer cooperator should continue to maximize the land by agro-diversification integrating vegetables in mulberry area, fruit trees along boundaries. More product or value adding activities shall be tried blending mulberry fruits with tropical fruits available in the area and improving its product designs and labeling to capture more consumers. Employment of sustainable cost saving production practices that harness the use of locally available materials.

SRDI should continue to provide technical support to farmers by providing quality saplings of other promising mulberry varieties and silkworm varieties or strains, more training on crop, product and by product development and enterprise development.

The use of sustainable farming practices in sericulture farming could an alternative to improve farm productivity, income and livelihood for the family. The sustainability of a small farm is linked to both biophysical and socioeconomic factors, and, the various operations on the farm. To be sustainable, the farm should have stable productivity, economic profitability and ecological security (Nair, 2019). With continues loading of organic fertilizers and using other ecological practices, frequent silkworm rearing for cocoon production is sustained so with the production of other food and nonfood products making sericulture an attractive enterprise to provide livelihood and income

for farmers, providing food and energy source (fuel) in a way reducing unemployment or under-employment and easing poverty in the rural areas by utilizing marginal areas that are still available in the Region. With this practice, more farmers will engage in sericulture to meet local demand for silk.

Conclusion

The Imelda Sericulture project in Brgy. Imelda, Naguilian, La Union clearly demonstrated the use of sustainable technologies like integrated nutrient management, farm waste recycling, increasing agro-biodiversity in the farm like intercropping corn and legumes, vegetable gardening and edge or periphery planting with mulberry and fruit trees that provided food, income and livelihood for the family.

For the 7-year period, cocoon production yielded to a production of 316.67 kg of fresh cocoon. Other products were mulberry saplings, cuttings. fresh leaves, silk wastes/composts and novelty products from dyed cocoons. For food products, wines, vinegar, jams, jelly, mulberry teas and candies were also sold and shared among the family members.

Sales of cocoons and other products in seven years were PhP67,279.00 from 235.5 kg of fresh cocoons with a gross margin of 66041.88, net income of PhP45,176.21 and ROI of 67.07.

As to labor productivity (employment generated) to family for seven years resulted to 10,346 mandays valued at 65,077.18 with an average of 49.50 mandays valued at PhP9,381.74 and were shared among young and old male and female members.

The project success could be attributed to a good farm design and available resources and adaptable climate, dedicated farm workers; available, land, equipment and other resources.

Technologies were readily available for adoption. The weakness however was the competition with other crops on the use of labor and equipment as they prioritize their major crops and still have limited training on new technologies on sericulture farming. The opportunities of the project were the increasing demand for cocoon products and other products and available support and technical services offered by the Institute. The threats, however, were the rising cost of inputs (fuel, fertilizers, chemicals and labor) that increased production cost thus decreasing net income as the price of cocoons remain unchanged.

Recommendation

The sericulture project in Brgy. Imelda Naguilian, La Union is a promising enterprise as a livelihood project for the family to engage as a source of food and income to finance and meet their basic necessities in life. This initiative effectively utilized previously unused land, resulting in increased productivity and profitability through the production of cocoons and other food and non-food products. Therefore, it is strongly recommended for replication and implementation.

To sustain the project, it should continue using sustainable farming practices that could address the problem of rising cost of inputs like fertilizer, fuel and labor by using locally available resources to reduced cost, proper timing and scheduling of activities and introduced more economically viable technologies like fruit processing with fruit blends, handcraft making and integrated waste recycling.

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