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Sericulture value chain analysis in Gamo Zone, Southern Ethiopia

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Abstract

Silk is a premium priced agricultural commodity. Both Eri and Mulberry silkworms has been reintroduced into the country twenty years ago. Still method of rearing, handling, and harvesting of the cocoons is at an infant stage while the quality of cocoons produced in Ethiopia is in the range of commercial silk produced in major silk producing countries. Value chain analysis may contribute to an increase in marketable surplus by scaling-down the losses arising due to inefficient production, processing, storage, and transportation. Therefore, the objective of this study was to analyze sericulture value chain, production and financial performance in Arba Minch Zuria and Mirab Abaya Woredas of Gamo zone. Three sericulture producer groups were addressed namely; rural sericulture producer youth enterprises; smallholder sericulture producer women and sericulture private limited company. Both primary and secondary data were collected and used to achieve the designed objectives. Undiscounted benefit cost ratio analysis were undertaken to conduct profitability analysis and Cobb-Douglas production function was employed to analyze productivity contribution of production factors used for cocoon production. Value chain analysis result shows that sericulture producer rural enterprises, smallholder women and Bere sericulture private limited company were main chain actors of the study area. Undiscounted BCR analysis result depicted that sericulture business operation in study area was profitable. Among seven variables considered in Cobb-Douglas production function model five variables namely; sericulture production experience, frequency of sericulture production training, number of polythene bags used for bedding silkworm feeding, human labor used and amount of credit used were found to be significant at 1%, 5% and 10% level, respectively. High silkworm egg mortality and absence of competitive market were reported as constraints of sericulture production and marketing, whereas government and Non-governmental organizations' support were considered as opportunity by sericulture producer enterprises. Building marketing

information delivery system and value chain upgrading were recommended for improvement of sericulture value chain of Gamo zone.

Keywords: Value chain actors, Sericulture, Profitability, Cocoon, Cobb-Douglas

Introduction

Sericulture is an agro-based industry. It involves rearing of silkworms for the production of raw silk, which is the yarn obtained out of cocoons spun by certain species of insects (Metaferia and Abera, 2004). Silk is a premium priced agricultural commodity (FAO, 2007). China, India, Brazil, Thailand, Uzbekistan and Vietnam were the known silk producers in the World (Muralidhar, 2011). Ethiopia's bimodal rainfall pattern, ambient temperature, and other agro-ecological factors provide a fertile ground for mulberry and caster seed cultivation and silkworm rearing. Sericulture development of both Eri and Mulberry silkworms has been reintroduced into the country twenty years ago by Melkasa Agricultural Research Centre though the technology has been disseminated to beneficiaries since 2001, in a massive ways. Specifically, the South Nations Nationalities and Peoples Regional Bureau of Agriculture is the first to promote sericulture technology to the rural poor farmers among all the regions (Kedir et al., 2005). Still method of rearing, handling, and harvesting of the cocoons is poor or at an infant stage while the quality of cocoons produced in Ethiopia is in the range of commercial silk produced in major silk producing countries (Ayano, 2017). Due to the sector is new in the context of the country, it needs to provide various supports in terms of training and resource provisions for farmers, extension workers, urban agriculture officers, urban youth and women (Abera, 2016). Unique features of the sericulture sector are its rural nature, ecologically and economically sustainable activity for the poor, small and marginal farmers and women in particular (Prakasam and Ravi, 2014). The most important benefit of sericulture is that it can be practiced on small to medium sized land holdings in rural areas, either as a subsidiary or main occupation. In this regard, sericulture can be one of the income generating activities for rural communities (Assemu et al., 2014). Currently, Ethiopia is the second populous country in Africa after Nigeria. There is a general trend of increasing rate of unemployment in the country. Sericulture, which is an agro based labor intensive and environment friendly industry, can be an efficient and effective agricultural activity for the country. The business holds a ray of hope at village level for Ethiopian citizen migrating to cities searching for jobs (Kedir et al., 2016). It is requiring low investment and acting as a source of livelihood and high profit earning and accounts for a sizable

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

quantum of foreign exchange earnings. So far, Gamo Zone Livestock and Fishery Department cooperates with District Livestock and Fishery Department Offices and concerned stakeholders to lay down a foundation in order to establish sericulture producing rural women and youth enterprises. These intervention impacts are not well investigated to realize overall benefits along the value chain. Further, previously conducted studies on value chain analysis of sericulture were limited to Amhara Region (Assemu et al., 2014). Value chain analysis may contribute to an increase in marketable surplus by scaling-down the losses arising due to inefficient production, processing, storage, and transportation. Because, value chains can be seen as a vehicle by which new forms of production, technologies, logistics, labor processes and organizational relations and networks are introduced (Trienekens, 2011). Therefore, this study was designed to analyze sericulture value chain, production and financial performance in Arba Minch Zuria and Mirab Abaya districts of Gamo zone

Materials and methods

Description of the study area

Arba Minch Zuria and Mirab Abaya Woredas are both found in Gamo zone. Arba Minch Zuria Woreda is located in the Great Rift Valley; includes portions of Abaya and Chamo Lakes. Arba Minch is capital of Arba Minch Zuria is located 505 km south of Addis Ababa. Its elevation ranges from 1200 masl at the Northern end to 1320 masl at the Southern end (Kiya, 2016). The Woreda covers 1001km² and has 29 rural Kebeles and one town. Based on 2007 population census, Arbaminch Zuria Woreda had a total population of 164,529 of whom49.9%are men and 50.1% are women. The mean annual rainfall of the study area is about 963.3mm with two rainy seasons. The main rainy season is March to May which have 172.35mm and 129.13mm mean monthly rainfall in April and May, respectively (Abayneh, 2018). Mirab Abaya Woreda is divided into 24 Kebeles, one urban and 23 rural. The average annual rainfall ranges from 1,000-1,100mm. Birbir is the center of the Woreda and lies about 230 km away from the regional capital. The total area is 107,971ha (Israel and Habtamu, 2008).

Data type, source and collection methods

Both quantitative and qualitative data were collected to achieve the research objectives. Also both primary and secondary data was used. The primary data was collected by arranging

interview schedule for representatives of enterprise members, smallholder sericulture producer women and Bere sericulture PLC manager. To come up with qualitative data, six focus group discussions, each having ten (10) participants were conducted.

Secondary data were collected from reports of Gamo zone livestock and fishery development department, Arba Minch Zuria and Mirab Abaya districts livestock and fishery development offices.

Sampling method and sample size determination

Due to presence of small number of sericulture producer rural youth enterprises, all (33) were addressed from Arba Minch Zuria and Mirab Abaya Woreda and each enterprise chairman was selected purposively for interview. Also 35 sericulture producer smallholder women were interviewed from Mirab Abaya district of Ugayehu kebele. Totally 33 Rural sericulture producer youth enterprises, 35 smallholder sericulture producer women and one modern sericulture production private limited company (Bere sericulture PLC) were addressed.

Method of data analysis

Financial profitability analysis

Gross return, gross margin and benefit cost ratio (BCR) were used to analyze financial performance of sericulture in the study area. Gross Return was calculated by multiplying the total volume of output of an enterprise by the average price in the harvesting period (Dillon and Hardaker, 1993).

$$GR_i = \sum_{i}^{n} Q_{mi} P_{mi} + \sum_{i}^{n} Q_{bi} P_{bi} \qquad (1)$$

Where: GRi=Gross return from sericulture production, Q_{mi}=quantity of cocoon in kg per i^{th} sampled producer, P_{mi}= average price of cocoon per kg (birr/kg) and Q_{bi}=Quantity unproductive cocoons, P_{bi}=Average estimated price of unproductive worms/ cocoons.

Gross Margin: calculation was done to have an estimate of the difference between total return and variable costs for all different level value chain actors. The Following equation used to assess gross margin:

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

$$GM = TR - VC \quad (2)$$

Where: GM = Gross Margin, TR = Total Return earned from cocoon sales and VC = Variable Cost incurred for silkworm rearing.

Benefit-Cost Ratio (BCR): BCR is a relative measure, which is used to compare benefit per unit of cost which was estimated as a ratio of gross return and gross costs. The formula of calculating BCR (undiscounted) is shown below:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Total gross return}}{\text{Total Cost}} \quad (3)$$

Undiscounted BCR was used due to difficulty of estimating depreciation of silkworm rearing enterprises material used for construction and rearing.

Value chain analysis

For value chain analysis, both functional and financial analysis were used. According to FAO (2006a, b, and c), all the data used for constructing the value chain is then either presented in a functional analysis table or in the form of flow chart. For this study, chain mapping and flow chart were used to analyze value chain functional analysis. Financial analysis is used to determine the monetary value added in the various segments of the chain of interest.

Econometrics analysis

Production function is a mathematical relationship specifying the maximum output that can be produced with given inputs for a given level of technology (Samuelson and Nardhaus, 1995). There are several explicit forms in specifying a production function, but authors have chosen to use Cobb-Douglas production function model because the model have several advantages. Among the advantages, the function is flexible in the number of input variables that the researcher uses to explore their effects on the production process (Mohammad, 2011). Also production function is well-known and relatively easy to use (Jason, 2019). Distinctive feature of Cobb-Douglas production function is that the parameters α and β which are output elasticity of each input are constant (Debertin, 1986).

$$Y_i = \partial X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} X_6^{\beta 6} X_7^{\beta 7} e^{ui} \quad (4)$$

Where: Y = quantity of cocoon produced (kg/Enterprise); lnα = Constant or Intercept of the function; X_1 = Human labor used for sericulture production, which is measured man-

day/enterprises/year; X_2 = Sericulture production experience, measured in years; X_3 = Number of polythene sack/bag used; X_4= Land allocated for feeding material cultivation, which is measured in hectare (ha); X_5= Frequency of silkworm rearing training; X_6= Amount of credit received per production year, which is measured in birr; X_7= Number of feeding stand used. β1, β2...β9 = Coefficient of respective variables; ln = Natural logarithm; e = Base of natural logarithm; u_i = Error term; i = l, 2, 3,...,n.

In estimating parameters of the function β1, β2...β7 through the use of ordinary least squares (OLS), we naturally have to make a linear transformation of equation (4), via logarithmic transformation, to arrive at equation (5).

Therefore, parameters of the function β1, β2...β7 were estimated separately using ordinary least squares technique by converting the functions into log-linear forms as follows:

$$LnY = Ln\,\alpha + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + \beta_5 LnX_{5i} + \beta_6 LnX_{6i} + \beta_7 LnX_{7i} + u \quad ...(5)$$

To evaluate the goodness of fit of the regression equation fitted, the adjusted coefficients of multiple determination (R^2) were calculated by using the formula:

$$R^2 = 1 - (1 - \frac{1}{R^2})\frac{(n-1)}{n-k} \quad (6)$$

Table 1. Summary of variables and expected relations

Variables	Types	Expected relation
Human labor used	Continuous	+ve
Sericulture production experience	Continuous	+ve
Number of polthin sack/bag used for bedcovers of silkworm	Continuous	+ve
Land allocated for feeding material cultivation in hectare	Continuous	+ve
Frequency of silkworm rearing training	Continuous	+ve
Amount of credit received	Continuous	+ve
Number of feeding stands used	Continuous	+ve

Source: Own Construction, 2019

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

Results and discussion

Demographic and socioeconomic characteristics of sericulture growers' enterprise

As shown in the Table (2) below on average each enterprise has 13.88 members and there were 8.27 women 6.09 men per each rural sericulture enterprise. This shows that women participation in sericulture sector is higher than men. Studies conducted by Ntaanu, (2008) and Hajare et.al. (2007) on sericulture confirmed that women participation is high; which confirms this study result.

Table 2. Sex distribution per enterprise and production experience

Variables	N*	Min	Max	Mean	Std. Dev.
Number enterprise members	33	8.00	22.00	13.88	4.07
Male	33	2.00	10.00	5.67	2.51
Female	33	5.00	12.00	8.12	1.83
Production experience in year	33	2.00	3.00	2.60	0.49
Education level of respondents	Frequency		Percent		
Grade 5-8	2		6.1		
Grade 9-10	31		93.9		
Total	33		100		

Source: Own Computation, 2019; * N represents number of enterprises

Socioeconomic characteristics of silkworm rearing smallholder women

As indicated in Table (3) below mean age of silkworm rearing women was 39 years. The case of study area women participation in sericulture is high. While studies conducted on sericulture and gender role confirmed that sericulture technology is appropriateness for women. For example study conducted by Kedir et al. (2014) stated that, sericulture is advantageous for women to control their own earnings, helps them to learns, to deal with people outside, to develop their own personality, and they can do it at their home. Silk production in particular, provides women with economic opportunities. Female labors engaged in sericulture activities are more as compared to male labors. The business holds a greater hope at village level for Ethiopian citizen migrating to cities searching for jobs. Silk production from eri silkworm is practiced in different parts of the country especially by poor farmers as an additional income source through

efficient use of family labor (Mestewal et al., 2020). Sericulture can be an excellent job opportunity and income generating activities for rural women, jobless youth and university graduates of Ethiopia. As indicated in Table (3), average silkworm rearing experience of women was three years. The result shows that sericulture is at infancy in study area. Melkam (2020) stated that, silk production industry has been unexploited and lagged behind in Ethiopia. Education level of producers among interviewed silkworm rearing women indicated that 48.6% was not attended formal education, while only 8.6% attended grade 9-10 (Table 3). Sericulture industry requires much technology and an appreciable level of technical skills to produce high quality and competitive silk (Alexis, 2017; Kiyokawa, 1984). To manage life cycle of spans of eri-moth eggs to cocoon, it demands knowledge.

Table 3. Socio-economic characteristics of smallholder silkworm rearing women

Variables	N	Min	Max	Mean	Std. Dev.
Age of respondents	35	27	55	38.86	7.74
Production experience in year	35	1	4	2.86	1.04
Education level	Frequency	Percent			
Not attended formal education	17	48.6			
Grade 1-4	11	31.4			
Grade 5-8	4	11.4			
Grade 9-10	3	8.6			
Total	35	100			

Source: Own computation, 2019

Value chain actors and their role along sericulture value chain

The process of sericulture involves cultivation of mulberry or castor oil plant to feed silkworms, rearing of silkworm, production of raw silk, cocoon drying, reeling the cocoons for unwinding the silk filament for value added benefits such as processing and weaving (Habthyimer and Deressa, 2004).

In the current study, a number of chain actors was participated from silkworm rearing input supply to marketing of yarn. The main actors involved in the sericulture value chain, their roles and inter relationships are discussed below.

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

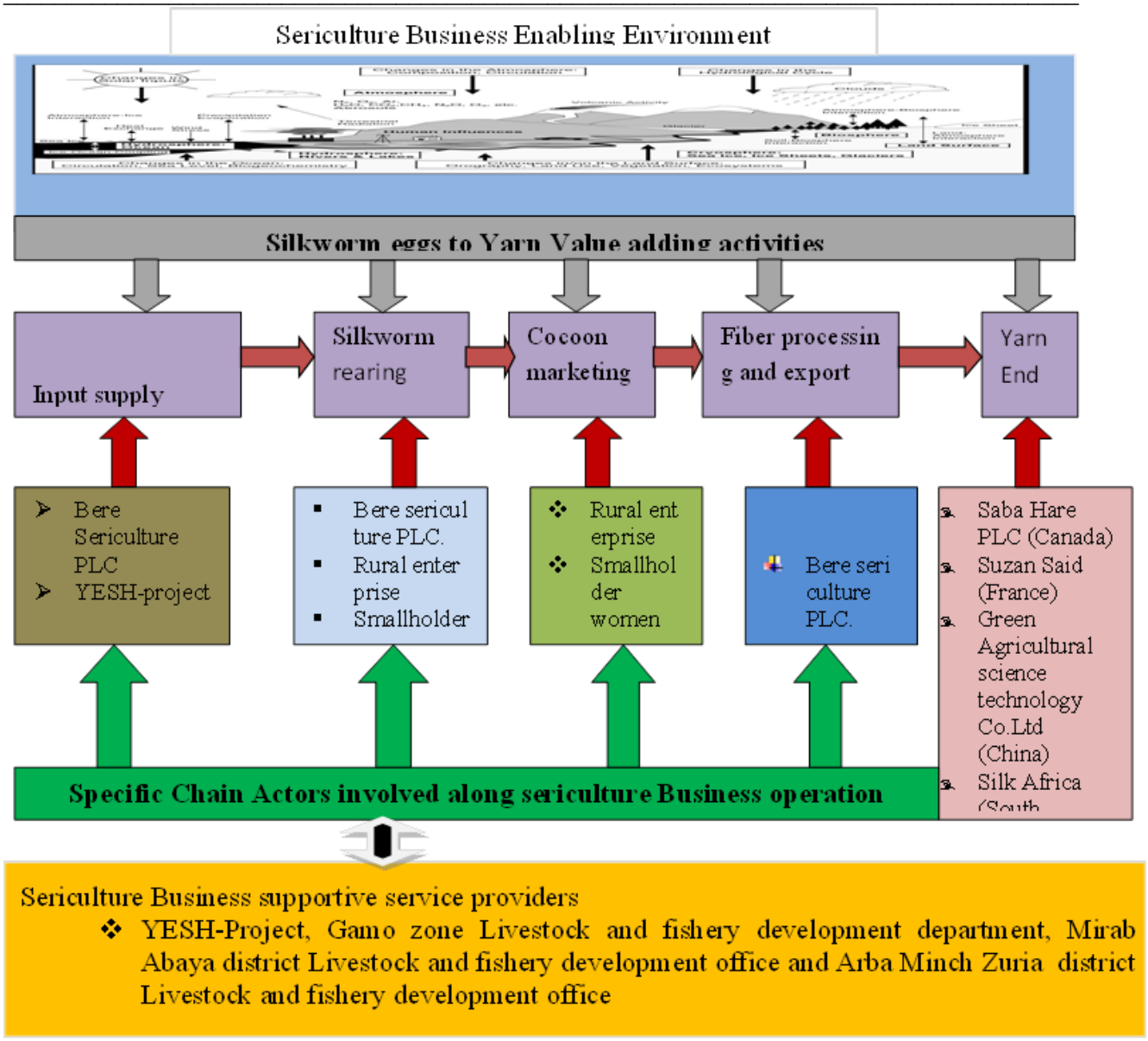

Figure 1. Sericulture value chain map of Gamo zone

Source: Own drawing based on commodity flow, 2019

Input suppliers and their role along chain

Both material input and technical input were supplied by different bodies in the case of sericulture business operation in the study area. According to sericulture producer enterprises, land, house to rear and keep worms from enemies and sun strike, silkworm eggs, rearing kits and technical inputs (knowledge) were required to start silkworm rearing. Land is supplied by local government administration while all other technical and material inputs were supplied by Youth

Entrepreneurship in Silk and Honey (YESH) project and Bere sericulture PLC. During FGD, both enterprise members and smallholder silkworm rearing women articulated that YESH Project is supporting silkworm rearing and sericulture activity in collaboration with livestock and fishery development office. As indicated in Table (4), 100% interviewed rural sericulture producer enterprises reported that they obtained silkworm eggs from Bere Sericulture PLC, while 45.5% took basic silkworm rearing training. Studies conducted by Endale et.al. (2018); Ashenafi, (2015) and Affognon et.al. (2014) confirmed that Bere Sericulture PLC purchases cocoons from smallholder farmers and supplying them with silkworm seeds. The company works with both individual smallholder farmers and farmers' groups to develop the local sericulture industry. In particular, it has been supplying the farmers with seeds of eri silkworms and castor beans, as well as delivers advisory services. Farmers, in turn, supply dry silk cocoons to the Company, which then processes the cocoons and sells to other companies. This shows that Bere Sericulture PLC is serving as center for sericulture technology extension and multiplication.

Table 4. Rural sericulture producer enterprises input source

Variables	Response	Frequency	Percentage
Source for silkworm eggs	Bere Sericulture PLC	33	100
Source for rearing equipment	YESH project	33	100
Access to training	Yes	33	100
Frequency of training	One during establishment	15	45.5
	Twice	2	6.1
	Three time	14	42.4
	More than three times	2	6.1
Types of training given	Basic silkworm rearing	15	45.5
	Fiber processing	5	15.2
	Basic silkworm rearing and entrepreneurship	8	24.2
	Silkworm rearing, feed plant selection, cultivation and feeding	5	15.2

Source: own computations, 2019

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

As shown in Table (5), 68.6% reported that they got sericulture training among sampled sericulture producer women. Concerning training diversity. 41.7% of smallholder women took training about silkworm rearing, feed plant selection, cultivation and feeding, while only 8.3% took fiber processing training.

Table 5. Smallholder sericulture producer women input source

Variables	Response	Frequency	Percentage
Source for silkworm eggs	Bere Sericulture PLC	35	100
Source for rearing equipment	YESH project	35	100
Access to training	Yes	24	68.6
	No	11	31.4
Frequency of training	One during establishment	6	25
	Twice	7	29.2
	Three time	11	45.8
Types of training given	Basic silkworm rearing	9	37.5
	Fiber processing	2	8.3
	Basic silkworm rearing and entrepreneurship	3	12.5
	Silkworm rearing, feed plant selection, cultivation and feeding	10	41.7

Source: own computation, 2019

Silkworm growers and their role along chain

Silkworms feed on either mulberry or castor plant leaves depending on type of silkworm race. Hence the rearing of silkworm involves cultivation of feeding resource which provides a regular supply of leaves. In the study area, three groups were participated in silkworm rearing and cocoon production: Bere Sericulture PLC, rural youth enterprises and smallholder women. Bere sericulture PLC is rearing both mulberry silk and Eri silkworm, but both silkworm rearing groups were rearing only Eri silkworm. Sericulture producer rural youth enterprises had separate silkworm rearing house; however, the houses were not ventilated and well constructed. Walls of

all silkworm rearing houses were florid with mud and did not allow airation, but silkworm feeding trays were arranged with appropraite spacing. All smallholder women did not have separated rearing house and they use their dining room and salon for silkworm rearing and feeding tray arrangement was not well spaced and some women used the chair and table as feeding tray bed. Both smallholder women and rural enterprsies used dry banana leaf as cooconing tray.Both rural youth sericulture producer enterprises and smallholder women bring silkworm eggs from Bere Sericulture PLC and then, they started feeding castor plant leaf. When larvae reached dormant stage they scattered larvae on dry banana leaf to spin silk filaments. When larvae completed silk filament spinning it became cocoon and then, they harvested it at 10^{th} day of spinning and dried the cocoon with sun after well pupation physiological growth performed.

Figure 2. Rural enterprise and smallholder women sericulture value adding activities

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

As indicated in Figure (3) and (4), silkworm rearing at both youth enterprise level and smallholder women is not well ventilated and kept sanitized. But, studies conducted in sericulture production identified that silkworm management practices are of vital important success factors for sericulture industry. Among the management practices, silkworm bed spacing plays a major role on growth and productivity of silkworm. Good quality cocoons are produced through applying appropriate silkworm bed spacing and significant deviations from these levels make the cocoon quality poorer (Tilahun et.al., 2017; Pandit et.al., 2008). Rearing room for young silkworm larvae, rearing room for grown silkworm larvae, room for mounting of silkworm larvae, and tools for silkworm rearing must be sanitized and cleaned before, during and after rearing, hands must be washed and shoes changed when entering the rearing room to prevent the introduction of disease-causing bacteria (Pandit et al., 2008). The rearing room surroundings cannot be said to be a sanitary, and rearing rooms that have a dirt floor, clay walls, and a wooden cocooning frame are difficult to disinfect. Furthermore, the rearing bed in direct contact with the silkworms is covered with a plastic sheet, which is used repeatedly, and disinfection and cleaning cannot be completely carried out (Sharma et al., 2015). These shows that sericulture production in study area needs pay attention to upgrade producers' management level.

Figure 3. Silkworm rearing at smallholder women

Figure 4. Silkworm rearing at youth enterprise

As shown in the Figure (5a, b and c), there is great difference in cocoon size, neatness and contamination. Cocoon produced by smallholder women and rural youth enterprise were small in size than cocoon produced by Bere sericulture PLC, which revealed that silkworm larvae were not fed sufficient caster plant leaf during the growth periods and they were using dry banana leaf as cocooning tray. With current rearing equipment, materials, and technology, cocoon production with required quality would be very difficult. Cocoon produced by Bere sericulture PLC is big in size and purely white in color and the PLC was using wooden cocooning tray for spinning silk filaments. Study results conducted by Tilahun et.al. (2017) and Jayaramiah and Sannappa (1998) stated that productivity of silkworms is affected by bed spacing and good quality cocoons are produced through applying appropriate silkworm bed spacing and significant deviations from these levels make the cocoon quality poorer. Quality of the sericulture fed to the silkworm greatly influences the rearing achievement of the silkworm. To achieve such quality cocoon, development of a sericulture field in a breezy and sunny location, and the use of high quality sericulture varieties which are adapted to the local weather, sericulture cordon and fertility management adjusted to the harvest are required (Kar et.al., 2008). These indicated that sericulture rearing is still in infant stage the case of smallholders' women and rural youth enterprises level in the current study area.

(a) (b) (c)

Figure 5. (a) Coon produced by Rural enterprise (b) by smallholder women (c) by Bere sericulture PLC

Cocoon to yarn processors and their role along the sericulture value chain

Processing stages of sericulture starts with cocoon washing and boiling, while ends at yarn dying. In the present study area, Bere sericulture PLC was the only processing company

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

employed in sericulture industry. Bere Sericulture PLC was established in 2009. The Company has intention of escalating its silk production by cultivating Castor oil and Mulberry plants, rearing of silkworms, and producing and processing of Cocoons into silk thread, garment and creating employment opportunity and market link. Concurrently, it is also introducing sericulture technology to the local community by providing the expertise to the community through training, providing new silkworm seeds. This private limited company has introduced new machines for boiling, steaming, drying, reeling, re-reeling and twisting (Endale et al., 2018; Ashenafi, 2015). Sericulture production and silkworm rearing in the case of Bere sericulture PLC was well-organized and relatively owned modern sericulture rearing and processing equipment (Figure 6). The company has been contributing the local communities by creating job opportunity, sharing experiences and providing trainings for farmers and out-growers, distributing and supplying castor oil and mulberry seed, selected silkworm eggs, cocoon and larvae to farmers. In terms of market access, it has buyers like; Saba Hare PLC, Paradise fashion and Suzanne Said. Market linkage was also created with Green Agricultural Science and Technology Co. Ltd (China) and Silk Africa (South Africa).

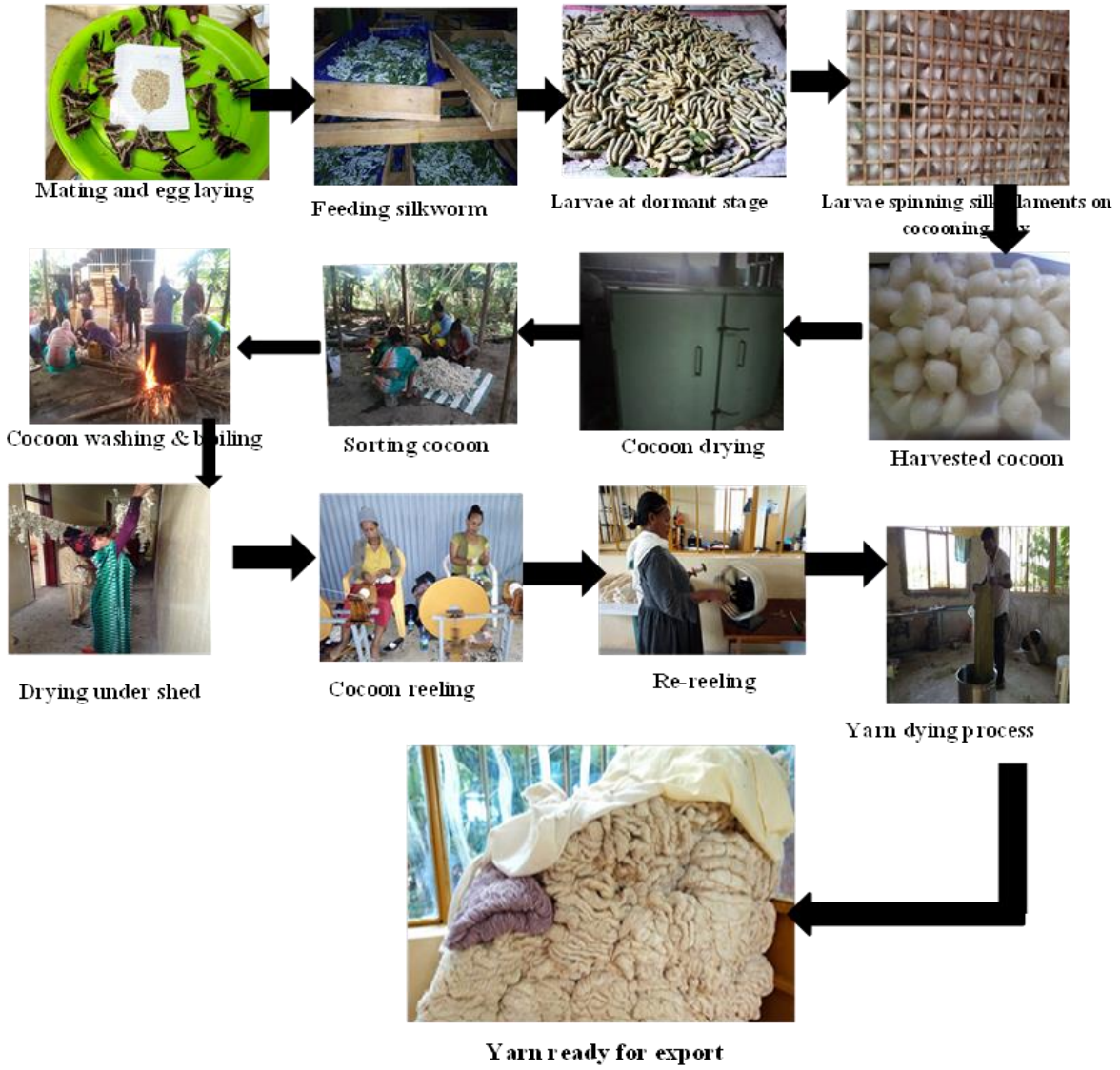

Figure 6. Sericulture value adding activities done by Bere sericulture PLC

Financial profitability analysis of sericulture value chain actors

Costs and return were analyzed separately for all the three sericulture farm sizes namely: rural youth enterprises, smallholder women sericulture producer and Bere sericulture PLC. Rearing house construction costs deprecation was calculated for rearing house for rural enterprises and Bere sericulture PLC. To estimate financial profitability of sericulture business operators of study area, undiscounted benefit-cost analysis (CBA) was used because it helps to compare the costs incurred for sericulture business operation and returns earned from the business via sale of cocoons and other value added products. As indicated in the (Table 6), 2017/18 production of each enterprise benefit-cost ration (BCR) was calculated, while their values were 1.43, 1.18 and

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

1.31 for rural youth enterprise, smallholder women producer and Bere sericulture PLC, respectively. To accept business as profitable; ratio should be greater than or equal to unity and rejected otherwise (Yaser et.al., 2009). Sericulture producers BCR of study area is greater than one, which shows that sericulture production is profitable in the study area.

Table 6. Cost of Cocoon production and profitability analysis cocoon producers

No	Cost items	Rural enterprises (birr/year)	Smallholder women (birr/year)	Bere sericulture PLC (birr/year)
1	Labor cost			
	Land preparation cost	41,000.00	2,555.65	60,000.00
	Silkworm rearing cost	23,520.00	3,550.00	30,000.00
	Spinning cost	-	-	700,763.00
2	Material cost			
	Rearing wood tray	-	-	1,500.00
	Bamboo mountages	-	-	12,000.00
	Disinfectants	-	-	1,200.00
	Feeding stand	14,050.00	1,851.42	2,000.00
	Hydrometer/thermometer	-	-	160.00
	Polthin bag/paper	3,600.00	4,240.30	-
	Total variable cost	82,170.00	12,197.37	807,623.00
3	Fixed cost			
	Depreciation on rearing house	60,500.00	3,120.75	20,000.00
	Depreciation on rearing and processing equipment	-	-	1,000.00
	Depreciation on processing room	-	-	15,000.00
	Total fixed cost	60,500.00	3,120.75	36,000.00
4	Revenue collected			
	Total cocoon produced in kg	2,034.00	181.20	1,020.00
	Cocoon price (birr/ Kg)	100.00	100.00	100.00
	Income from cocoon sales	203,400.00	18,120.00	102,000.00
	Total yarn produced in Kg	-	-	1,001.09
	Yarn price (birr/kg)	-	-	1,000.00
	Total income from yarn sales	-	-	1,001,090.00
	Gross return	203,400.00	18,120.00	1,103,090.00
	Total cost	142,670.00	15,318.12	843,623.00
	Gross Margin	60,730.00	2,801.88	259,467.00
	Benefit-Cost-Ratio (BCR)	1.43	1.18	1.31

Source: Own Computation, 2019

Monetary value addition and profit sharing along sericulture value chain

In the sericulture value chain in study area, rural youth enterprise added 8.32% of cost, while received 14.74% of profit; Smallholder women added 1.71% and received 7.63% of profit; Bere sericulture PLC added 89.97% of cost to transform cocoon to yarn and sharing 77.63% of profit generated along chain, *citrus paribus* (Table 7).

Table 7. Monetary value added and profit shared along value chain

Chain actors	Cost per 100 kg			Profits per 100 kg			
	Unit cost	Add cost	% cost added	Unit price	Gross profit	% profit shared	Rate of Return
Rural youth enterprises	7,014.25	7,014.25	8.32	10,000.00	2,985.75	14.74	0.43
Smallholder producer women	8,453.70	1,439.45	1.71	10,000.00	1,546.30	7.63	0.18
Bere Sericulture PLC	84,270.44	75,816.74	89.97	100,000.00	15,729.56	77.63	0.19
Total		84,270.44	100.00		20,261.61	100.00	

Source: Own Computation, 2019

Productivity analysis of production factors used for sericulture production

Out of seven explanatory variables estimated in Cobb-Douglas production function model five variables namely: human labor used, sericulture production experience, number of polythene bag used, frequency of sericulture training and amount of credit used were found to be significant at 1%; 5% and 10% significance level (Table 8). The co-efficient of multiple determinations, R^2, was 0.73 which indicated that the explanatory variables included in the Cobb-Douglas production function model explained 73% of the variation in cocoon production.

As regression result shown in the Table (8), the coefficient of human labor used found to be positive and significant at 10% level which indicated that 1% increase in human labor increases quantity of cocoon produced by 0.061%. Similarly, quantity of labor used coefficient was positive and statistically significant in study result conducted by Kumaresan et.al. (2005). Coefficient of sericulture production experience in year found to be positive and significant at 1% level which showed that 1% increase in experience increases quantity of cocoon produced by 0.172 % of enterprises. It is believed that increase in experience expected to improve producer knowledge of sericulture production. Also coefficient of number of polythene bags used for

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

bedding to feed silkworm found to be positive and significant at 5% level which indicated that 1% increases in use of polythene bags increases quantity of cocoon produced by 0.342% of enterprises, keeping other factors constant. Sericulture training frequency coefficients also found to be positive and significant at 1% level which revealed that 1% increase in sericulture training frequency increased quantity of cocoon produced by 0.59% of enterprise, keeping other factors constant. Access to training improves production and productivity by filling knowledge gap of sericulture production. Coefficient of amount of credit used for sericulture production was also found to be positive and significant at 10% level, which showed that 1% increase in credit use increases quantity of cocoon produced in 0.039% of enterprise, keeping other factors constant. Credit helps producers to invest in production activities when producers lack money to invest, which fills gap of capital shortages and facilitates continued cocoon production.

Table 8. Estimated values of coefficients of Cobb-Douglas production function

Explanatory variables	Coefficients	Standard error	t-value
Human labor used (Labor_ln)	0.061*	0.032	1.90
Sericulture production experience (rearing_expln)	0.172***	0.055	3.10
Number of polthin bag used(Nu_polth ln)	0.342**	0.161	2.12
Land allocated for feeding material(land_in_hecln)	0.410	0.510	1.24
Frequency of sericulture training (Nu_traingln)	0.590***	0.119	4.94
Amount of credit received (Crdtln)	0.039*	0.021	1.86
Number of feeding stands used (nu_fedln)	0.610	1.22	0.50
Constant	0.302		
F-value	7.38		
R^2	0.73		

***=significant at 1%; **=significant at 5%; *=significant at 10%

Source: own computation, 2019

Sericulture production constraints and opportunities at rural enterprises level

Almost 100% sericulture producer rural enterprises have reported that year round availability of feeding material, YESH project and Agriculture office support as opportunity for sericulture production, whereas poor harmony and fail to take equal responsibility, low cocoon production and absence of modern silkworm rearing equipment were weakness of enterprises. As indicated

in the Table (9), all (100%) interviewed rural sericulture enterprises members reported that there is no competitive market for their cocoon and they were selling their cocoon to Bere sericulture PLC located at Arba Minch. This indicated that cocoon market in the case of Gamo zone looks like monopsony because there is only one company Bere sericulture PLC, which buy all cocoon produced by rural youth enterprise and smallholder women. Also producers did not have price negotiation power and they received price set by Bere sericulture production private limited company. On the contrary, study conducted by Pratama, et.al. (2019) realized that silk industry in Wajo district, can improve household incomes for forest farmers, while maintaining their overall bargaining position against the market. In addition to absence of competitive market, interviewed enterprise members reported temperature fluctuation, high silkworm egg mortality, financial shortage and distance to rearing house as constraints for sericulture production in the study area.

Table 9. Sericulture production and marketing of rural youth enterprises

Opportunity variables	Frequency	Percentage
Presence of buyers nearby rearing area	33	100
Availability of feeding material (caster plant)	29	87.87
Government office support	33	100
Nob-government office support	33	100
Local administrative assistance and facilitation	30	90.9
Constraint variables		
High silkworm eggs mortality	33	100
Absence of competitive market	33	100
Rearing house distance from resident house	27	81.81
Lack of modern rearing equipment	33	100

Source: Own computation, 2019

Sericulture production opportunities and constraints at smallholder women level

Presence of buyers and input suppliers nearby, availability feeding materials, agriculture office support and YESH project support considered as opportunity for sericulture business operation in the study area, while producer women's motivation and interest, use of locally available materials and their living house for silkworm rearing were considered as strength of sericulture producer women (Table 10).

Journal of Science and Inclusive Development Vol. 3, No. 2, DOI: 10.20372/jsid/2021-74

Table 10. Sericulture production and marketing of smallholder women

Opportunity variables	Frequency	Percentage
Presence of cocoon buyers nearby	35	100
Year round availability of feeding material (caster plant leaf)	30	85.71
Government office support	29	82.85
Non-government office support (YESH project office)	35	100
Constraints variables		
Year round fixed cocoon price	35	100
High silkworm eggs mortality	30	85.71
Financial shortage	35	100
Temperature fluctuation	35	100
Lack of access to modern silkworm rearing technology	35	100

Absence of competitive market, year round fixed price of cocoon, high silkworm eggs mortality, financial shortage, temperature fluctuation and lack of access to modern silkworm rearing equipment were considered as sericulture business operation in the study area (Table 10). Studies conducted by Assemu et al. (2014) and Alembrhan (2014) in Ethiopia summarized that, major silkworm rearing constraints were lack of knowledge such as training, lack modern house and lack of silk worm production materials. These problems may lead to poor quality and low amount of silk production.

Sericulture Production opportunities and constraints of Bere sericulture PLC

Authors conducted discussion with Bere Sericulture PLC's owner and manager about opportunities and challenges of sericulture the case of Gamo zone. The PLC has been serving as silkworm seed source for both smallholder women and rural sericulture youth enterprises. Also it has been participating in silkworm rearing, cocoon production, processing cocoon to yarn and exporting yarn to abroad. According to PLC manager, lack of reeling technology and seed facilities were considered as weakness of the PLC. International center of insect physiology and ecology (ICIPE) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), government support and supply of cocoon by out-grower rural enterprise and smallholder women

were opportunities to operate business whereas facing difficulty for additional land to introduce mulberry feeding silkworm was considered as a threat for sustainable sericulture business operation.

Conclusion and recommendation

Conclusions

Value chain analysis result indicated that sericulture producer rural enterprises, smallholder women and Bere sericulture PLC were main chain actors of the study area. While, livestock and fishery development offices and YESH project were identified as supportive chain actors. Bere sericulture PLC was serving as silkworm seed source for smallholder women and rural sericulture producer youth associations. All smallholder sericulture producers' women were rearing silkworm in their living house with dense rearing tray arrangement, while rural enterprises were rearing silkworm in separate house, but still houses were not air regulated and temperature monitored. Bere sericulture PLC was rearing silkworms in temperature regulated and scientifically proofed rooms. Considering 2017/18 production year costs incurred to and revenue collected from business operation of each enterprise undiscounted benefit-cost ratio (BCR) analysis depicted that sericulture business operation in study area was profitable. Sericulture production experience, frequency of sericulture production training, number of polythene bags used for bedding silkworm feeding, human labor and amount of credit used were found to be significant at 1%, 5% and 10% level, respectively. High silkworm egg mortality, absence of competitive market and absence of modern rearing material were reported as sericulture production and marketing constraints whereas government office and YESH project technical and material support, presence of Bere sericulture PLC for input supply were considered as sericulture production and marketing opportunity.

Recommendations

Based on findings, the following points were recommended to improve and transform the industry:

- Value chain need to be upgraded to help chain actors to respond effectively to production and market opportunities upgrading the industry is vital important and which would transform sericulture industry from subsistence type of operation to a modern one.

- End-market demand and build marketing information delivery system need to be focused. End markets are a key driver of value chain growth and development, while chain actors would benefit adding value for their product to achieve end market demand.
- Technical knowledge assistance like cleaning and sterilization of rearing equipment, maintaining appropriate rearing environment and sanitary condition technical training need be given for chain actors to reduce sericulture producers' weakness.

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