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Demelash Sime

Department of Biology, College
of Natural & Computational
Sciences, Wolkite University,
Wolkite, Ethiopia

Zemedkun Siraj

Department of Biology, College
of Natural & Computational
Sciences, Wolkite University,
Wolkite, Ethiopia

Sericulture in Ethiopia: Production status, opportunities, challenges and potential areas. A review

Demelash Sime and Zemedkun Siraj

Abstract

This review intended to focus on production status, opportunity, challenges and potential areas of sericulture industry in Ethiopia. Sericulture is a rearing of silkworm, which practiced throughout the globe. Silkworm is the primary productive insect species for sericulture industry. Silk has strong attraction to the people of Ethiopia starting from ancient period of country's civilization. Currently, both Mulberry silkworm (*Bombyx mori*) & Eri silkworm (*Samia cynthia ricini*) are commonly practiced in Ethiopia. However, the most silk production in the country is eri silk. Silkworms classified as mulberry and non-mulberry silkworms (eri, tasar & muga). Sericulture is agro-based industry which can be practiced by small scale famers or outgrowers. It has various advantageous; e.g. socio-economic, religious & ecological values, creating job opportunity, alternative source of income, environmental conservation, technology adoption, and others. A total of 3 tons of silk is being produced annually in four parts of Ethiopia. Ethiopia has high potential of silk production due to the existence of suitable conditions such as bimodal rainfall pattern, ambient temperature, different vegetation and others agro-ecological factors. In Ethiopia, the main zones & districts under silk production are; Jimma, Arba minch, Awassa, Bahir Dar, Adigrati, Wolliso, Hawzen, Awash Melkassa, Bishoftu, Abaya district, Dodota district, and others. However, silk production in the country is still limited by several factors that can be classified into institutional factors, farmer related problems, infrastructure factors, and natural factors. Therefore, government & other stakeholders should work on solving these problems and give attention in all directions toward sericulture.

Keywords: Agriculture, commercial, Ethiopia, industry, silk farming, silk Fiber, silkworm

Introduction

Sericulture is an agro-based industry. It is the process of obtaining the natural silk fiber through silkworm rearing, which can be practiced in varying agro-climatic conditions, and is suited to different production systems^[1]. Many studies indicated that sericulture industry has enormous advantages for sustainable developments of any country. The industrial and commercial uses of silk contributed to the silkworm promotion all over the world especially in developing nations^[2].

Historically, sericulture was introduced for the first time, into China by Hoshomin, the Queen of China. Later, it was introduced to rest of the world. Today, the top five silk producing countries in the world are China, India, Japan, Brazil and Thailand^[3]. In Africa, silk has been used for textiles for about thousands of years^[4] and sericulture has a history of more than 30 years in East Africa. The potential of the African indigenous silk moth species for wild silk production has been well documented in Nigeria^[5], Uganda^[6] and Kenya^[7] and other central and southern African countries. Currently, International Centre of Insect Physiology and Ecology (ICIPE, Nairobi, Kenya) is playing a central role in sericulture development in Africa including Ethiopia^[8].

Sericulture is the farming of silkworms (*Bombyx mori*), for the production of raw silk^[9] from domesticated insect called silk moth. Moreover, silkworm is the common name for the silk-producing larva of any of several species of moths; which used by the cottage and small scale industry as well as big silk industry. Silk is "the queen of fibers" because it is a smooth, shining, very soft, lustrous, fabulous, strong and durable and unique natural protein fiber produced by silkworms^[10]. There are more than 3000 silkworm strains available all over the world^[11]. Taxonomically, Silkworms belongs to Phylum: Arthropoda, Order: Lepidoptera, and Family: Bombycidae, Saturniidae, Lasiocampidae, Thaumetopoidae^[12].

Corresponding Author:

Demelash Sime

Department of Biology, College
of Natural & Computational
Sciences, Wolkite University,
Wolkite, Ethiopia

Commercially, the silks are produced from two families of silkworms including Bombycidae (mulberry) and Saturniidae (non-mulberry) [13]. In the world there are five varieties of silkworms (i.e., Mulberry, Tasar, Oak tasar, Muga and Eri silk). Silkworm can be broadly classified into two, namely domesticated (mulberry silk) and wild (non-mulberry silk, e.g. Tasar, Eri and Muga) [12, 14]. Mulberry plant is the most preferable by mulberry silkworm, whereas Castor oil and Cassava plant leaves are used as a feed for Eri silkworm. The majority of the world's silk, about 95-99%, is obtained from the domesticated silkworm, *Bombyx mori* L. (order Lepidoptera; family Bombycidae) [15, 16], whereas the wild silk forms a small percentage [17].

Sericulture involves agriculture, art and industry; silkworm rearing is an art in the hands of rural people; reeling of the silk from the cocoons formed by the worms is an industry of different financial investments; and mulberry, castor oil, cassava plant leaves cultivation in farmland is agriculture. Sericulture processes contains various activities, such as soil ploughing and maintenance of silkworm races, mulberry breeding and cultivation, silkworm rearing and mounting, harvesting, reeling the cocoons, cocoon drying, silk reeling, raw silk testing, to production of silk products by manufacturing and weaving, as well as the silk thread and silk industry.

The development of sericulture industry or silk production can achieve good ecological, economic and social benefit in modern economy. Therefore, it is an essential requirement for general economic and social development in Ethiopia. For example, silk production can contribute to the improvement in the income of small or medium-scale farmers, and farmers in frontier areas [8] and the plantations used as a feed of the silkworms uses in natural resources conservation [18]; tool for poverty reduction [8, 19]; adoption of technology; create employment opportunity, social and religious benefit [20]; and it can be practiced on small to medium sized land holdings in rural areas, either as a subsidiary or main occupation. Study by [21], reveals silk industry holds high promise as an employment intensive occupation especially in rural and semi-urban areas.

The developing countries rely on silk production as an important tool for economic development, for employment generation especially in rural sector and also as a means to earn foreign exchange. In Ethiopia, agriculture is the corner stone of the development policy. Ethiopia is the second highly populated country of African continent and as a result the country has problem of unemployment, under employment and poverty, especially in rural areas due to lack and shortages of farmland and high rate population growth. Hence, for these serious problems another part of agricultural sector such as sericulture industry (silk forming) becomes an important pre-requisite as an alternative source of income, efficient and effective income and employment generating activity and poverty reduction. Sericulture is agro-based urban labor intensive industry that has been identified as an occupation of low investment, high output source of employment and income.

In this regard sericulture or silk production can be an excellent job opportunity and income generating activities for rural women, jobless youth and university graduates of our country (Ethiopia). In view of its potentiality for job oriented or self employment positions at various levels can be suitable to college or university students after successful completion of university training by providing them sericulture courses

with knowledge in theoretical background and skills in practical and/or field work. Hence, students and women can be engaged in work as an entrepreneur or as an employer for effective results in sericulture or silk production industry.

In Ethiopia, silk production industry has been unexploited and lagged behind. Thus, the main goal of this review paper was to assess: constraints of silk production; the performances of sericulture production potential and status in Ethiopia; the advantages of sericulture production and to identify areas under silk production. Finally, to forward recommendation based on the identified gaps or problems from the review done.

Definition and concept of Sericulture, Silk and Silk worm

Sericulture or silk farming is an agro-based industry that involves all the processes/steps starting from mulberry cultivation to silk dyeing and weaving of sericulture activities. Shortly, Sericulture is an art of rearing silkworms for silk production. Its main product is the natural silk fiber. Silk is a functional term used to describe protein fibers that are secreted by insects (from phylum Arthropods) is known as Silk Moth. Silk is a natural protein fiber and is very soft, lustrous, smooth, strong, and durable than any natural or artificial fiber [10, 22]. Silk-fiber is a protein produced from the silk-glands of silkworms. Silkworm (*Bombyx mori* L.) is a small Lepidopteron insect that is economically very important at the national and international level. On the other hand, silkworm is the common name for the silk-producing larva of any of several species of moths, which acquire salivary gland known as "Silk gland" that modified for the production of cocoons. There are two types of silk worms practiced in Ethiopia namely Mulberry silkworm and Non-Mulberry silkworm (e.g. Eri silkworm). The silkworm moth oil can be used to obtain textile dyes and superior soaps [23]. Besides, it has pharmaceutical purposes [24].

History of Sericulture in Global Scenario

Silk is one of the treasures of China. Many countries have been involved in sericulture industry development, but the most (>85%) raw silk producing countries are China, India, Uzbekistan, Brazil and Thailand [3]. At present, more than 10 million farmers raise silk in China and about 4 million people are engaged directly or indirectly in sericulture's activity in India [10].

The potential of the African indigenous silk moth species for wild silk production has been well documented in Nigeria [5], Uganda [6] and Kenya [7] and other central and southern African countries. Sericulture in East Africa has a history of more than 30 years, and the production of cocoons and silk thread from silkworms occurs in Ethiopia, Kenya, Madagascar, and Uganda, and production of cocoons and silk using wild silk insects (wild silkworms) is also performed. However, sericulture and their operations (like, silk reeling technologies) are extremely exists in immature phase and cocoons and silk as materials for traditional handicrafts are poorly supplied to the local market or their market cannot be secured [8]. As a result, productivity and product quality is low and the market is also very limited, so such production has not grown even as local industry [8]. But, Ethiopia is the only country to export wild silk products to the abroad market.

Process of Sericulture

Sericulture is the process of obtaining the natural silk fiber through silkworm rearing, which can be practiced in varying

agro-climatic conditions, and is suited to different production systems ^[1]. The process of sericulture involves major activities such as; cultivation of mulberry leaves or castor oil plant to feed silkworms which spin silk cocoons, rearing of silkworm (for the production of raw silk), silkworm egg production, production of raw silk, rearing equipment, cocoon drying, reeling the cocoons for unwinding the silk filament for value added benefits such as processing and weaving ^[25].

Silkworm rearing is an extensive month-long exercise starting from egg stage and terminating in adults laying eggs and dying their natural death. During this path, they pass through five larval instars (1st, 2nd, 3rd, 4th, and 5th instars) intervened by four moults, cocoon and pupal stage ^[1]. In Ethiopia, silkworm rearing includes life cycle spans through 46-56 days with 10-13 days of egg stage, 21-30 days of larval stage, 2-3 days cocoon spinning, 10-15 days as pupal duration and 3-5 days in adult stage ^[26]. Each female lays 300 to 500 eggs and eggs hatch in about 12 days. The larvae of mulberry silkworm are caterpillars that are about 40 cm long. For raw silk production, the pupae are killed, a process called stifling. First cocoons are cooked in water to remove the gum, which holds it together, and then unwinding the filaments (reeling) takes place, hence, process of the removal of silk yarn from the cocoons is called reeling. Before adults emerge, otherwise the emergence of the moths makes the fibers into pieces. Before weaving, the raw silk is boiled in water to remove remaining gum, dyed and bleached, and then woven into the garment.

Sericulture in Ethiopia

Silk production in Ethiopia is an agro-based industry and silk has strong attraction to the people of Ethiopia starting from ancient period of country's civilization. However, the silk yarns and silkworms (both Eric & Mulberry) used for silk productions were imported in large quantities from India, Arabia and China and stored in huge caverns in the central highlands of Ethiopia ^[20, 27]. Sericulture development of both eri and mulberry silkworms has been introduced into the country very lately. It was initiated by Melkassa Agricultural Research Centre 20 years ago. Until 1930's, there were no known records of silk being produced in Ethiopia. Later on, ^[28] realized that Ethiopia has suitable climatic condition and necessary resource available for the rearing of silk worm. Again, in early 2000's Ethiopian Institute of Agricultural Research and Ministry of Science and Technology confirmed the immense potential of the country for silk production ^[20]. Then, the SNNPR Bureau of Agriculture and Rural Development become the first to promote sericulture technology to the rural poor farmers among all the regions. Subsequently related sectors and interested individuals in and around urban areas of Awassa, Adama, Addis Ababa, Debrezeit, and Bahir Dar were involved in the development of silk production program ^[29]. Currently, silk production from eri silkworm is practiced in different parts of the country especially by poor farmers as an additional source of income through efficient use of family labor ^[20].

Among East African countries, Ethiopia is the only country to export wild silk products to the abroad market ^[8]. Because, silk products produced in Ethiopia are organic by nature as the plantation for rearing uses natural fertilizers ^[29]; the country also granted with diversified climate, vegetation and topography ^[30] and this is also true for diversified options of sericulture industry which are adopted on different vegetation (for rearing of silk-worms) and different species of silkworms ^[20] and in addition the country has bimodal rainfall pattern,

ambient temperature, and other agro-ecological factors provide a fertile ground for mulberry and castor seed cultivation and silkworm production ^[29]. Due to this, the production of cocoons from both mulberry and castor oil plant is growing fast (Ethiopian Ministry of Agriculture and Rural Development ^[31]. The main plant leaves used to feed silkworms in Ethiopia are mulberry, castor oil, cassava and papaya.

Various researchers revealed that Eri silkworms (*Samia cynthia ricini*), a polyphagous insect and its primary feed castor plant (*Ricinus communis* L.) ^[32], and Mulberry silkworms (*Bombyx mori*), a monophagous insect, feeds on only mulberry plant (*Morus* species) ^[33] are commonly practiced in Ethiopia. Previously, Eri silk and Mulberry silkworms were introduced into Ethiopia from different countries ^[20]. But now, Eri silkworm is very suitable for Ethiopian conditions due to different reasons such as its hardness, disease resistant, having short production cycle (46 days). Eri silkworm is the most exploited, domesticated, healthy, easy to cultivate and feed on castor oil plant that environmentally friendly and that grow abundantly all over the country ^[20]. As a result, 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. Hence, the most silk production in Ethiopia is eri silk ^[20, 34]. Castor (*Ricinus communis* L.) is the most preferred host plant for eri silkworm ^[35]. Moreover, about 25-40% of castor foliage can be defoliated (removed) and used for feeding eri silkworm without affecting oil seed production ^[32]. Castor oil plant grows widely and abundantly in many parts of the country and used for rearing of eri-silkworms especially in the rift valley areas and southern Ethiopia ^[20]. Simultaneously, local community used the plant for oil seed production as well.

In the past decade, many researches were conducted research on silkworms in Ethiopia including mulberry silkworms (*Bombyx mori*) and the result showed that silk production from mulberry silkworms is practiced in some parts of the country recently ^[20]. But today, Mulberry silk worms are also cultivated in the country; for instance, it is more adapted to the Eastern Tigray (including areas such as, Wukro, Hawzen & Adigrat), which depends on mulberry leaf or Injori (local name) as a food and people participating in rearing silkworm as a main agricultural sector ^[36]. The researcher further revealed that local people of the region and country increased awareness to rear both Mulberry and Eri silkworms extensively for high silk production. Besides, the country has some companies which are well known in silk production, example, Sabahar (Saba Hare PLC), and Bere Sericulture Production Private Limited Company (Bere sericulture PLC). Sabahar, the pioneer of local silk, is one of company in the country which produces textiles made of Ethiopian silk for export.

The properties of silk fiber produced in Ethiopia are good, smooth in surface and profile, and sometimes nodes also appear ^[37]. The author further stated that the eri cocoons samples those were collected from Bahir Dar, Awassa, and Awash Melkassa and mulberry cocoons samples collected from Awassa and Awash Melkassa, the undegummed eri cocoons looks grey, while mulberry silk varies from grey to yellow and degummed fibers were brighter than the undegummed for both varieties.

Some studies revealed that silkworm varieties are many and the filaments they produce are also diverse in characteristics.

Even in the same species, the filaments they produce vary because the environmental conditions and the host plant they could use are different. Even though the method of rearing, handling, and harvesting of the cocoons is poor, the quality of cocoons produced in Ethiopia is in the range of commercial silk produced in major silk producing countries^[37]. According to^[38] mulberry varieties have strong influence on mulberry silkworm rearing performance. Hence, selection of mulberry varieties for rearing mulberry silkworms based up on rearing performance of mulberry silkworms is very important in order to get better egg production, larval development and cocoon yield.

Area under Silk Production in Ethiopia

Sericulture or silk production is a growing industry in Ethiopia. In the past decade, several research and development efforts were conducted on silkworms in Ethiopia including mulberry silkworms (*Bombyx mori*) and as a result silk production from mulberry silkworms is practiced in some parts of the country recently^[20]. Later on,^[31] reported that the country has huge investment potentials for sericulture investment and government looks to expand the textile industry into different parts of the country; it is poised to grow even more. While production of cocoons from both mulberry and castor is growing fast, the development of the technology to process the cocoon is currently in progress. The interest of the rural population, which is often under employed, to consider cocoon production as a livelihood alternative is very high because the community well understood the benefit gained from silkworm rearing or silk production. This indicates that there would be a sustainable high demand for silkworm seed (egg). Therefore, it could create good work opportunity for women and youth in rearing silk worm, collecting and processing the cocoon into yarn for either export or to farther add value onto it by using it in textile production. Simultaneously, the supply of vigorous silkworm egg is also another area that could be considered by unemployed university graduates.

In the country, some of the areas of investment in sericulture which have incredible employment potential are; Collection and processing of cocoon; Silk based textile production; Silkworm seed production; and Production of cocoon processing (yarn production) equipment. Here are the lists of potential districts (zones) of the country known by rearing silkworms or silk production (summary in Table1). These are; In Oromia region there are some zones known in silk production. Wolliso town is located in the southwest Shewa zone, Oromia region, Ethiopia. This town has a large scale silk production or sericulture factory. The farmers living around this town raise silkworms and sell the cocoon to a factory in the town.

Dodota district, Arsi zone, Oromia, Ethiopia, is also one of the common areas to raise silkworms and farmers sell the cocoon to factory exist in Wolliso town and others companies in Addis Ababa as a raw products. Silk production in this district is practiced by rural women living in Dodota town. Dodota is one of drought-affected district, hence engaging in silk production work is the best alternative way for women to make income source and support and feed their family members. The Castor Oil plant, or Gulo (local name), is a plant that is drought tolerant, prefers disturbed ground, and is prevalent in and around Dodota. The rural women living in this area could produce silk cocoons in their homes then process the cocoons into a final silk product i.e. clothing. The

women would then market and sell their product locally and to vendors in nearby large cities (like Addis Ababa, Adama, etc.). The women who participated on this duty will get training from the experienced professionals working in Melkassa Research Centre.

In Jimma zone, south west, Ethiopia: there is the growth of mulberry plant in the garden and silkworm rearing experiment in rearing house at Jimma Agricultural Research Center (JARC), Jimma, Oromia, Ethiopia. The author^[39] evaluated the growth and performance of silkworm (*Bombyx mori* L.) on mulberry leaves, and reported that silkworm races were growing healthy; and bivoltine mulberry silk worm races were effective for cocoon production and the environment was also good for mulberry plants. The author more stated that the sector has good promise to invest on as a good opportunity for source of income generation and job creation for youth, women and poverty alleviation in rural, urban and semi-urban areas of the country.

From Southern Ethiopia, Abaya district has a smallholder silkworm rearing enterprise (known as Young Entrepreneurs in Silk and Honey). It is a silkworm farming and honey production youth enterprise. This project was established in 2016, by International Centre of Insect Physiology and Ecology (ICIPE) in collaboration with the Ministry of Agriculture and Mastercard Foundation, which gave chance for many youths to fully engage in the rearing of silkworms using castor seed leaves. Nowadays, they could produce 30 Kg's of Cocoons (raw silk) every 5 to 7 weeks, which they sell at a unit price of Birr 100 per kg. Therefore, they generate income about 300,000 Ethiopian Birr (ETB) in cash annually from the sale of silkworm cocoons. But, if the cocoons are processed and converted into silk yarn using manual spinning machines, the yarn can be sold at Birr 1,500 per kilogram. The local administration provided them with suitable farmland are used for growing castor beans for feeding silkworms and other crops for additional income. According to the report of^[40], over 892 youth have been organized into 32 enterprises since 2016 to engage in the production of silk fiber. The project stays for five-years. In the stated period, the project targeted to reach out for 2,500 youth in sericulture in the Southern Nation Nationalities and People Region (SNNPR)^[40]. Hence, with appropriate & sufficient support and market chain the silk production could be key sector of employment opportunity for young people in the country. ICIPE has been contributing to Ethiopia's development by introducing new agricultural technologies, which are useful for generating incomes and improve people's livelihood. In so doing, the technologies enable smallholder farmers to become principal beneficiaries, and have contributed to the agriculture sector of the country.

Arba Minch is another area of the southern region which known by producing silk from silk worms, which exists near Arba Minch Airport. This silk farm is the first in Ethiopia. The people with 10 years experience had engaged in the production are smallholders' farmers. This silk producing sector is known as Bere Sericulture Production Private Limited Company (Bere PLC) and it was established in 2009. The company involves an innovation and adoption of sericulture production and processing in Ethiopia, and generates income to ensure food security. 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 work opportunity and market link (both local and

international market). Concurrently, it is also introducing sericulture technology (new machines) to the local community by providing the expertise to the community through training, providing new plant cultivator, new silkworm seeds and the overall production scheme. Today, this private limited company has introduced new machines for Boiling, Steaming, drying, Reeling, Re-reeling and Twisting. The company has a total of more than 45 employees and brought about 100 individuals from the local community to the system and some of them started producing the Cocoon to generate income ^[41].

At beginning, they used the products imported from China and India, but at this time they able to replace the products by their own cocoon (silk raw). Currently, they produce two types of silk and sell it to textile factories that produce different products for export market. They produce up to 1200kg of silk per hectare. Under support of this company there are about 67 out-growers and 10 farmer started cocoon production respectively. The company has been contributing the local communities by creating job opportunity, sharing experiences & providing trainings for farmers and out-growers, distributing & supplying castor oil & mulberry seed, selected silkworm eggs (known as 'seed'), Cocoon and larvae to farmers, etc ^[41].

In terms of market access, before the company had only one buyer (Saba Hare PLC), but today, it has buyers like; Saba Hare PLC (from Canada), Paradise fashion (local company) & Suzanne Said (from France). Market linkage was also created with Green Agricultural Science and Technology Co. Ltd (China) and Silk Africa (South Africa) ^[41].

In Amhara region silk production is at infant stage and was started in middle of 2004, to assure food security in rain scarcity areas /district/ of the region ^[42]. The researchers

farther revealed that, sericulture production in the region practiced by elders, women and youth at urban and per-urban areas, Amhara TEVT colleges and NGOs like Jerusalem Children and Community Development Organization (JeCCDO). Sericulture in the region was started mainly by Eri types which were highly dependent on castor plantation as feed source. Farmers and cooperative producers were started the work to get additional income to support their life from the work alone with coordination of poultry production.

Sericulture marketing in the region had almost the characteristics of monoposony market situation; means there was only one purchaser in the market which makes producers to be price taker. Still, there is no competition in the market which reveals poor performance of cocoon market ^[43, 44]. There were a few actors in cocoon market, such as, Sabahar enterprise at Addis Ababa and one exporter abroad (namely Mr. Josef Matika) were silkworm cocoon purchasers both in the region.

In Tigray region, the practice of silk production is highly well known in Eastern part of Tigray, especially in areas such as Hawzen, Adigrati & Wukro ^[36]. According to the author, both eri and mulberry silkworms were practiced in the areas, however, mulberry silkworm adapted more and produces more kilograms of silk and income per year than eri silkworm. Mulberry and Castor oil plant leaves were commonly used as main food for silkworms in the areas. The author further stated that the areas have high potential for silk production, despite several limiting factors or constraints exist. Eastern Tigray has an average annual silk production ranges from 100 to 500 kg of silk, which could prospect to the local community and increases the economic development of the country as well.

Table 1: Summary on main areas under silk productions (in Ethiopia).

Regions	Farming Site	Types of Silkworm	Food plant	Status of Production
Amhara	Bahir Dar	Eri silkworm	Castor oil plant	
SNNPR	Awassa	Mulberry & Eri silkworm	Mulberry & Castor	
	Abaya district	Eri silkworm	Castor oil plant	1800kg-2000kg/year
	Arba Minch	Eri & Mulberry silkworm	Castor & Mulberry	1200kg silk/ hectare
Oromia	Awash Melkassa	Mulberry & Eri silkworm	Mulberry & Castor	
	Waliso town	Mulberry silkworm	Mulberry leaf	
	Dodota district	Mulberry silkworm	>>	
	Jimma zone	Mulberry silkworm	Mulberry leaf	
	Nekemte	Mulberry & eri silkworm	Mulberry, Castor	
	Bishoftu	Eri silkworm	Castor oil plant	
	Addis Ababa city	Eri silkworm	Castor oil plant	
Tigray	Adigrati	Eri & Mulberry silkworm	Castor & mulberry	100 to 500 kg of silk per year.
	Wukro	Eri & Mulberry silkworm	>>	
	Hawzen	Eri & Mulberry silkworm	>>	

Source: ^[36, 37, 42].

Silk Production and Its Status in Ethiopia

A total of 3 tons of silk is being produced annually in four regions of Ethiopia – Amhara, Tigray, Southern and Oromia regions. According to ^[36] there is a very high potential of silk production in Eastern Tigray, (e.g. in Adigrat, Hawzen and Wukro areas), despite the absence of food plant, lack of silkworm farming knowledge, and lack of governmental and non-governmental support for the sector. As compared to Adigrati and Wukro, Hawzen area has higher potential of silk production, because of the presence of rearing and other facilities variations. The author further stated that the average annual silk production potential in the area ranges from 100 to 500 kg of silk fiber. The price of 1 kg of silk was on average

165 and 100 Ethiopian birr (ETB) (8.5 and 5.1 USD) from mulberry and eri silkworms, respectively. Therefore, Silk production potential in the Eastern Tigray is very low as compared with other parts of the world ^[4]. This might be due to the ecological variation, rearing capacity or farming technique, awareness of people and availability of food plants to silk worms.

According to Sabahar yearly report, currently the silk production in Ethiopia has increased by almost 200% since 2014 ^[37]. Because of the presence of favorable conditions for rearing silkworm; which rapidly expanding production of silk in the Ethiopia and the need of organic materials in the world will surely increase the export potential and local utilization

of silk ^[29, 36]. According to the physical properties of the eri and mulberry cocoon and their filament in different parts of Ethiopia (e.g., Awassa, Awash Melkassa & Bahir Dar) are observed good and more than 60% of the cocoons ^[37]. However, there is still poor quality of cocoons in areas, due to improper rearing, handling and harvesting of cocoons; lack of post cocoon facilities; and lack of follow up and irregular leave feeding. In all places, the shell percentage of eri cocoons is nearly 14%, while raw silk ratio of mulberry is about 13-14%. The mean value of the fiber fineness for eri silk is 3.09dtex from Bahir Dar, 2.91dtex from Awassa, and 3.11dtex from Awash Melkassa, while fineness for mulberry silk is 2.1dtex from Awassa and 2.4dtex from Awash Melkassa. The mean cocoon weight of eri silk is 3.23g for Bahir Dar, 3.28g for Awassa, and 3.22g for Awash Melkassa cocoons while cocoon weight of mulberry silk is 1.55g for Awassa and 1.52g for Awash Melkassa cocoons. The author further reported that Eri silk fibers have about 10% moisture regain values which is similar with the moisture regain at standard conditions of eri silk as cited in ^[2, 45].

Opportunities of Sericulture in Ethiopia

Sericulture industry is ideally suited to all developing countries in the tropical belt where poverty, unemployment and under employment continue to be a serious problem. For any country silk production has important roles in economic development, poverty reduction & income generation, providing employment for youth, environmental conservation, adoption of technologies, offer medicinal, ecological, social and religious value, contribute to livelihood, rural development & women empowerment, provides biomolecules and easily integrated with other agricultural activities.

Creation of Job opportunity and Income generation

Sericulture can play a very crucial role by providing the job opportunities & generate income. For instances, silk industry provides employment to 30 million families in countries such as China, India, Brazil, Bulgaria, Vietnam, Korea and Thailand ^[46]. Another author ^[47] explained that sericulture provides income & employment to the rural poor especially farmers with small land-holding & marginalized & weaker sections of the society. In Ethiopia, sericulture or silkworm rearing is a new agro-business technology that had been targeted as a tool for employment creation ^[19]. Because, the country is the second most populated country in Africa continent and as result there is migration of citizens to cities, large numbers of unemployment and poverty in the country. Thus, 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 ^[20]. Further, silk production can be regarded as best tools for solving the problem of unemployment and underemployment of many youth in country. As said by ^[20], silk worm introduced in the country showed the promising results have been recorded in terms of creation of employment opportunities. Authors more revealed that sericulture has a great potential in creating job opportunity to the poorer sections of the society and increasing income of the smallholding farmers. Sericulture has an advantage of high employment potential in rural and semi-urban society ^[48]. Sericulture industry provides job opportunities for youth and women could be in two ways; first, as wage employment (e.g., Grainage, Mulberry cultivation, Extension, Rearing silkworm, Reeling the cocoons, Cultivator/ labors). Second,

As self employment (e.g., Mulberry nursery, Grainage, Sericulture service centre, Mulberry grower, Silkworm seed supplier, Mulberry propagator, by-product supplier, Silkworm rearer, Reeler, Silk twister, Seed rearer, Cocoon supplier and Chawki rearing Center.

Contribute to sustainable livelihoods and economy of country

Silk production through silk rearing could be a useful possibility for improving economy ^[12]. Sericulture provides much needed work in several developing countries like Ethiopia. According to ^[20] rearing of silkworms or silk production contributes to the income of individuals and the economy of the country.

Because, it can be practiced by small or medium to large-sized land holdings in rural, urban & sub-urban areas, either as a supplementary or main occupation. Silk production has the potential to make a significant contribution to the economy of many other countries where there is over labor, low-costs of production and a willingness to adopt new technologies ^[49].

It is also considered as tool of poverty reduction ^[21], since, it can be one of the income generating activities for rural communities of the country. Besides, ^[50] also revealed that silk production is a highly profitable business enterprise. Generally, the growing demand of silk in the domestic market can make the industry a valuable enterprise which in turn can provide employment for the rural masses ensuring assured economic returns at the individual family level. Besides, sericulture is a very promising prospective sector for rural household's economies ^[51].

It is a highly labor intensive sector, employs a large number of laborers at various stages of its operation and have much impact on the improvement of rural economy by increasing income of the farmers.

Offer social and religious benefit

Alternatively, the development of sericulture industry can realize religious and social benefit. In Ethiopia, silk has played an important role in the social and religious life of the peoples from the earliest days of the kingdom of Axum to the present time ^[20]. Sericulture can improve the socio-economic status of rural farmers at global level ^[52].

Provides Ecological and Environmental Values

From ecological points of view, the plantations used as a feed of the silkworms are useful in natural resources conservation ^[18]. Silk farming is an eco-friendly, agro-based venture with a great potential for environmental amelioration. Apart from supporting livelihoods and providing employment, sericulture waste (mulberry waste and silkworm excreta) improves soil health through nutrient recycling and reduces the use of chemical fertilizers.

Nutrient recycling along with changes in agronomic practices and water saving measures proved to be effective in controlling soil degradation and reducing the use of precious water. Silkworm larvae plays an important roles in the ecosystem, example; many birds rely on caterpillars for food, especially for feeding their young.

Besides, sericulture can be assumed as a rural micro-enterprise initiative by resource-poor farming communities which depend on the forest for their livelihoods ^[14, 16, 53]. Consequently, this will reduce the pressure on the natural forest and conserve biodiversity ^[14, 16].

Sericulture can easily integrated with other farming practices

Silk production can be integrated with other farming activities like fish farming (aquaculture), beekeeping (apiculture), vegetable production and poultry farming. For instances; after reeling, silkworm pupae from cut cocoons are found to be useful to feed poultry and fish and the waste of silkworm larvae will be used as farmyard manure. In addition to feeding silkworms, mulberry leaves can serve as animal feed and provide fruit. Farmer also integrate silkworm production with poultry production in that, they feed dead and over produced worms (rich in protein) for poultry. Mulberry leaf is also found along road shoulders and fences as well as intercropped with other crops. The seed of castor is used for bio fuel production, and further expansion of sericulture is integrated with this technology and is better sustainable [25, 54]. The pupae and silk waste are being used as poultry or fish feed [55]. Waste silkworm pupae are considered as an important dietary protein source for poultry after proper processing at a reasonable cost [55]. Silkworm pupae were used as food in piggyery, poultry, and pisciculture and as dog feed due to their richness in protein and fatty acids. The deoiled feed of pupae made rabbits to gain better weight and growth of fur [56].

Sericulture for Rural Development & Women Empowerment

Sericulture is an agro- based enterprise highly suited for both large and small land holdings, with low capital investment. Silk products are purchased by the urban rich consumers and the final value of silk fabrics flows back to the primary producers in rural areas. It plays a significant role in transferring prosperity from the rich to the poor sections of the society. Study by [57] reveals sericulture industry is well adapted with into socio-economic structure of the rural areas and can serve as an effective tool for rural reconstruction. As a result, sericulture can also play a very important role in removing rural poverty due to its high work participation rate and can check the migration from rural to urban areas. Another researcher [48], also stated that silk production is advantageous in provision of vibrancy to village economics, women friendly occupation, ideal program for weaker sections of the society, and the satisfaction of equity concerns. Creating rural industries such as sericulture can effectively reduce poverty as it labor intensive industry and bring about rural development [58].

Sericulture is advantageous for women, to control their own earnings, helps them to learn, to deal with people outside, to develop their own personality, they can do it their home, etc. Silk production in particular, provides women with economic opportunities. Female labours engaged in sericulture activities are more as compared to male labors. The business holds a greater hope of hope at village level for Ethiopian citizen migrating to cities searching for jobs [2]. Consequently, 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 [20].

Silkworm gains various resources (Vitamin, minerals, protein and medicinal values)

Silkworm Eggs contain 56% albumin, 19.2% fats, and 7.7% sugars. They are used for eating, serving as male sexual stimulator (in popular tradition) as extract, rich in proteins, embryo inductors, glycoproteins, B1 and B2 vitamins with energizing and hepatic protector action, hypolipidemic &

hypoglycemic effect [59].

The silkworm larvae are used for feeding young animals, reptiles, as proteic flour having the role of dietary supplement; also as etheric extract having high cholesterol isomer content; the Florence lily, used as surgical thread. It can also promote the physiological functions of the gastrointestinal tract. Furthermore, silkworm powder plays an excellent role in lowering blood-glucose levels [60].

Extract made from silkworms is claimed to be effective for treating various health problems. For instance, Serrapeptase is claimed to be beneficial for treating inflammatory conditions too [61]. Extracts made from male silk moths is also said to be effective as an aphrodisiac [62].

Silkworm pupal protein is a complete protein and the amino acids compositions are with appropriate proportions in line with FAO/WHO standards [63]. Pupa contains crude 50-60% proteins, 25-35% fats, 5-8% free amino acids, 8 – 10% sugars, E, B1, B2 vitamins, calcium, phosphorous. 100 g of dried silkworm pupae can provide 75% daily protein requirement of human individual [64]. The vitamins like pyridoxal, riboflavin, thiamine, ascorbic acid, folic acid, nicotinic acid, pantothenic acid, minerals like calcium, iron copper, selenium and phosphorus make the pupae more nutritive and also found used for better lactation in tribal women [64, 65]. The authors further stated that, in terms of protein, fat, vitamins and calories the silk worm pupae are equal to meat and better than the protein of soya bean, fish or beef and has been found used for better lactation in tribal women. Also acts as anti bacterial activity [65]. Besides, glucosamine extracted from silkworm pupae can be used for treating osteoarthritis [13] and used for treating liver hepatitis, pancreatitis, leukocytopenia, neurological, ophthalmic, anti-bacterial, antihistaminic, gastric ailments & in preparation of vitamins A, E & K [56]. Mulberry leaf is also considered as commercial crop because its stems, leaves, roots will be used for industrial and pharmaceutical purposes [20].

Main challenges of Sericulture or Silk Production System in Ethiopia

In Ethiopia, silks are produced in different agro-ecological zones by some companies through commercial as well as smallholder farmers both as a source of income and employment opportunity. Silks are highly profitable activities. Meanwhile, silk production or sericulture is a growing industry in Ethiopia and it offers a solution for the government's quest for ways to expand the textile industry and poverty reduction. However, both practices have never been fully exploited to directly benefit young people, women and local communities. This is directly related with the existences of several limiting constraints on silk process & productions system. Furthermore, silk production system in the country is based on tradition, which is poorly supported by scientific recommendations.

In Eastern Tigray, there is a silkworm rearing and silk production practices as the main agricultural sector, but the income they obtained was very low due to lack of food or host plants, drought, lack of knowledge such as training, lack modern house, lack of market availability, lack of governmental and nongovernmental support, lack of adequate farm land, lack of silkworm production materials and seasonal environmental condition fluctuation such as temperature decreases up to less than 100°C especially from October to January, which allows leaving of plant leaf [36]. For this reason, there is poor quality and low amount of silk

production and the potential silk production are also affected due to absence of food plant and lack silkworm farming knowledge [36]. Hence, the major challenges of silkworm rearing and silk production in Eastern Tigray were lack of food plant, skilled man power, sales market, drought, modern rearing house, financial support, enough farm area, silk production materials, etc [36].

According to [37], in cocoons harvesting areas such as, Awash Melkassa, Awassa, & Bahir Dar there are problems of uncontrolled conditions for rearing stages, the absence of appropriate rearing, handling and harvesting of cocoons; lack of follow up and irregular feeding.

Bere limited private company has also several challenges such as; difficulties to additional land access, lack of skilled personnel & outflow, long process to get machines from custom authority, out-growers challenge (i.e. organized into groups and members of the group fail to take equal responsibility), which cause the end result of less production of cocoon, etc.

Silk production system in Amhara region is also still limited due to many problems such as; difficulty of understanding of market direction and the real purchasers, lack of follow up and care in each and every level of production, lack of monitoring and evaluation techniques towards the technology implementation and the absence of efficiency measure for those experts running the activity [42].

In general, limiting factors of silk production system in Ethiopia are summarized & categorized into institutional factors, farmer related problems, infrastructure factors, natural factors and others. Smallholder farmers' related constraints are inadequate farmer skills, knowledge of production, silk or cocoons product management, effort to select silk worm varieties, uses of fertilizers and traditional management practices affects the supply of silk products. Challenges related to institutions are lack of provision of improved production technologies including supply of relevant varieties, market outlets linkage and on-farm storage system and absence of processing facilities, need marketing information, credit facilities and etc. Natural factors are the presence of shortage of water supply, drought, inadequate rainfall, flood, frost, diseases and pests, location and season specific production are often beyond the control of farmers and institutions that is the main reasons for low productivity as well. Besides, rural roads inaccessibility, high transportation cost and lack of means of information communication for efficient flow of goods unsuitable transportation facilities and market information are belongs to infrastructural factors.

Identified Research Gaps

The current review explained the various issues such as employment and income generation, economy enhancement, adoption of technologies, women empowerment, sustainable rural development, and others through sericulture and the way sericulture will contribute to the poor society to maintain a good standard of living, how utilize of other by-products (resources) from silkworm, opportunities and potential areas of the country and constraints in cocoon and silk production, and trends of sericulture activities in different parts of the Ethiopia and other issues in general viewpoint.

Here are lists of research gap identified during this review work;

- There is no or are few studies conducted on the employment and income generation prospect and its

constraints in sericulture in Ethiopia.

- Lack of studies on youth work participation, opportunity, employment and income generation from sericulture, main factors on production and productivity of sericulture and the constraints faced by the sericulture farmers or companies in different parts of our country.
- Besides, there is less understanding on the potentiality of is this sector in creating job opportunity to youth, poverty reduction & supporting farmers livelihoods and in sustaining national economy.
- Lack of clear focus and understanding by government on income and employment opportunities which silk production could provides for many of our University graduates and jobless youth.
- Lack of sustainable, reliable and strong market chain system and emphasis from government.
- There is no opportunity of using the first and second generation silk worms like top silk producing countries.
- In the case of Ethiopia, because of the difference in culture and eating habits, the pupa will be let to die after producing the silk, while some are converted to butterflies to produce eggs in order to sustain the cycle.

Thus, in this context, the present review is going to forward recommendation for interested researchers or NGO or other stakeholders to fill the above understood research gap by formulating their own strategies, research design, objectives and hypotheses.

Conclusion

Sericulture industry is an agro-industry which can be practiced by large or small scales land holding farmers or groups. Ethiopia has necessary resources, favorable environmental and climatic condition for this investment. There are good attempts regarding sericulture activity in some parts of Ethiopia like Southern, Tigray, Oromia and Amhara regions. If proper support is offered it is possible to scale up the sector to huge industry and production. The result obtained from these areas are also implied the existence of huge sericulture potential areas and condition in Ethiopia. However, there are a number of challenges or problems related to sericulture activity in Ethiopia. Among them lack of capital, lack of necessary facilities and inputs, lack of skill and knowledge, attitude problem, absence of necessary support from government and others, lack of various linkages, etc. On the other hand, even though various challenges exist sericulture plays enormous beneficial roles from individual income generation to country development via job creation, biodiversity conservation, and others. Therefore, the sector requires due attention via proper management practices, continuous follow-up and holistic support as needed in order to enhance the quality and production scales for better future on citizens livelihood.

Based on this review, the following are recommended:-

- Strengthening sericulture industry linkage with experienced professionals from Research institutes, Universities of the country, private company, different project groups, NGO's & others.
- Transferring good experiences of sericulture practices to other areas; encouraging and promoting farmers & out-growers; monitoring & evaluation system towards silk producers; and integrating sericulture activity with others (e.g. fish farming, poultry & vegetable production) are very critical.

- Considering sericulture industry to create new job opportunities for university graduate & women; and to solve the problem of poverty, unemployment & migration to urban.
- Universities in the country are expected to develop curriculum which includes fields of studies that directly related to Sericulture industry for the sake of providing Knowledge & Skill based training for their students both at diploma and degree levels.
- Government must need to facilitate bank loan or providing initial budget to youth, farmers and out-growers, provide adequate farm land use, and give substantial, financial, capacity building & technical support to the small scale holders.
- Scientific research study must be designed and will be conducted to promote sericulture of the country, to enhance income generation and to answer problems related to silk production, marketing channel & linkage for the sake of scaling up the products & productivity..

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