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NEW TRENDS IN THE GLOBAL SILK PRODUCTION IN THE PERIOD 2011-2022

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Abstract

The purpose of this study was to analyze the dynamics of raw silk production in the period 2011-2022 at the global level and in the top six producing countries using the official data and usual methods in such a research: fixed basis and structural indices, descriptive statistics, regression equations, coefficient of determination, correlations, absolute and relative differences, comparisons etc. The results showed that, at the global level, raw silk production accounted for 91,221 Metric tons in the year 2022 being by 30% smaller than in 2011. The top silk producing countries are China, India, Uzbekistan, Vietnam, Thailand and Brazil. While in China, Thailand and Brazil production has substantially declined (- 52%, -33.5%, -23%), in India, Uzbekistan and Vietnam silk production increased by 58.6%, 116.7% and 113.4%. The share of all these six countries in the global production is 99.2%. In 2022, the highest weight belongs to China (54.8%) and India (40.1%). It is expected as silk production to raise taking into account that it is an eco and skin friendly product, and also a biodegradable product, while synthetic fibers are polluting. However, the high production cost, market price fluctuation and other restraining factors could affect small farmers dealing with sericiculture. For the developing countries, silkworm rearing and silk production sector is a profitable business which offer jobs, income, a better living standard, reducing poverty, hungry, gender discrimination, preserving biodiversity and conserving soil quality and contributing to the sustainable development in the rural areas.

Key words**:** *silk, global production, major producing countries, trends*

INTRODUCTION

Silk is "the Queen" of the natural fibers grace to its special qualities: softness, high fineness, pleasant and delicate touch, a higher resistance than a steel wire, brilliant shining, elegant and shimmering appearance [12].
It is also an environmental and skin friendly product. For these reasons it is processed into silk fabric.
The most known silk is that coming from the cocoons produced by silk worms rearing, a subsector of agriculture largely spread mainly in the developing countries [9].
Silk is carried out in more than 60 countries, and about 90% of silk is produced in Asia where also the non-mulberry silk accounts for 100%.
However, silk production represents only about 0.2% of the global production of natural fibers [15].
Silkworm rearing has **an important social-economic and environment importance consisting of:**
- contribution to the development of the rural areas;
- creating jobs for the rural population, especially for women and family members, including old persons; at the global level, millions of people is dealing with sericiculture, mainly in the developing countries;
- limiting migration from the rural area to the cities;
- it needs just a small investments, less machinery and equity [15, 16].

-it is suitable both for small and large farms;
- it requires simple and mainly manual operations to grow silk worms; therefore it needs more labour force than in other activities and has one of the highest employment rate;
-the production cost for producing cocoons for reeling is very small, being considered the lowest cost compared to other deals;
- it could assure income to the farmer and his family developing a profitable business and resulting in a better living standard [11].
- it makes the most profit at the least cost [9].
- For the same volume, silk fabric has a 20 times higher value than a cotton fiber.
-it is considered an eco-friendly activity, because the mulberry tree growing has a beneficial effect on the soil protection against erosion and produces a green cover over the ground; also, it allows the use of the land which is not utilized for crop cultivation.
- silk is a renewable material and silk producing does not pollute the soil and has just a small amount of CO_2 emissions and wastes which are biodegradable;
-silk worms raising depends on the mulberry trees plantations which needs a small amount of fertilizers and pesticides when it is necessary;
- silk worm growing preserves biodiversity in the rural areas;
-silk worm growing and silk industry assure the sustainable development of the countries and mainly of the rural areas, contributing to the reduction of poverty, hungry, gender discrimination, risk of diseases;
-it encourages silk production for international trade, the exporting countries benefiting of an inflow of foreign currency in their trade balance and the importing countries benefiting by the raw silk yarn they need to processing in various silk products [13, 18].

Because demand and consumption increased at the international level, silk worm rearing and silk production are continuously expanding in the developing countries and it is expecting to be in the future as well.

Silk industry is aligned to the "United Nation Organization which established 17 Sustainable Development Goals (SDGs) in the year 2015, focused on: no poverty, zero hungry, gender equality, decent work, economic growth, industry, innovation, infrastructure, reduced inequality, responsible consumption and production, partnership to reach the goals" [21].

According to their origin, **silk types** are classified into two groups: *mulberry silk*, which is the most known silk representing 90% of the global production, and *non-mulberry silk*, which includes various sorts such as:

-*Tasar silk*, produced by a specific variety of silkworms called *Antheraea Mylitta*, which feeds on the leaves of Arjun and Asan trees in the wild [1].

-*Eri Silk*, a protein fiber derived from cocoons made by the *Samia Cynthia Ricini* moth or *Philosamia Ricini* moth; it is mostly used in weaving, knitting, crochet, and embroidery [10].

-*Muga Silk* is a wild silk produced by the larvae of the *Assam silkmoth* in India and has a high durability and a natural yellowish-golden tint [24].

These are the four most known types of silk. But, there are also other sorts like: *Anaphe, Fagara, Coan, Mussel, Spider silk* produced in Africa and Asia.

Silk products are of a large variety and regarding textile and clothing industry, cosmetics industry, medical sector and others [14].

Clothing industry based on silk products is continuously developing due to the higher and higher temperatures connected to climate change and because the increased demand of a large range of silk clothes, most of them being luxury garments produced especially from the mulberry silk type. These clothes are efficiently protective against warmth and also against cold.

The main products achieved from silk are: blouses for women, sarees-traditional dresses for Indian women, scarves for women, collars for men, shirts, suits, luxury dresses, wedding dresses, evening gowns, jerssey dresses, kimonos, silk ties, socks for men, lengerie, pijamas, swimming suits, etc.

Eri silk is utilized for shawls and sophisticated clothes created by fashion designers [4, 6, 20].

Textile Industry is also expanding based on Tasar materials, spider silk for bed covers, tasar holstery and cushions, bed sheets, pillows, draperies, curtains, table cloths, carpets etc.

Cosmetics Industry is fast developing due to the existence of the silk protein which consists of important amino acids, a reason to use silk in producing: liquid soap, shower gel, shampoo, cleansing foam, cremes, lotions, conditioners, nail enamel etc. [4, 6, 20].

Medical sector benefits of the special features of the silk: bio-compatibility and environment friendly. It is successfully utilized in producing smart textiles. As silk has a poor conductivity, metal particles, graphene and other materials are added resulting a useful combination which is used in carrying out specific products and apparel for monitoring hospitals and patients demand.

"Smart textiles have multiple applications in health care, protective clothing, firefighting clothing, smart clothing, sport clothing, military clothing, electronic apparel etc." [23].

Modern measuring instruments include smart fabric and sensors which could detect: temperature, make a cardiogram, myography, could listen to the heart beats, lungs breathing, digest track. They could measure blood flow and pressure, breathing and could help the diagnosis process and the detection of microbes. Among this type of smart fabric it could be cited: clothing and vest for patients, every day apparel for health self-monitoring and treatment without any help from the doctor; caps to treat disorders at the level of the nervous system, therapeutic gloves, devices to sustain heart and correct beats and blood circulation, oximeters for self-monitoring of breathing quality, T-shirts for sportsmen for detecting the effort risk and preventing heart attack, temperature and pressure sensors for self monitoring, smart gloves with electrical stimulation to diminish and eliminate pain for the patients with arthritis etc. [6].

Other utilizations of silk includes: parachutes and bicycle tires etc.

Under the competition of the synthetic fibers which are very cheap, but have a negative impact on health and pollute the environment, a special attention has been paid to natural fibers which are healthy and bio-degradable [12]. This has stimulated production of natural fibers, among which silk is the most precious raw material for luxury products of high quality and which have a high return to producers, manufacturers and traders.

In 2022, silk market size reached USD 24.83 Billion and it is expected to grow to USD 39.12 Billion in 2028.

About 202,000 Metric Tons of silk are produced every year representing about 0.2% of the total fiber use. Taking into account a price of USD 15 per kg of silk, this means a production value of USD 3.03 Billion per year [19].

In 2023, in India, one kg of raw mulberry silk accounted for Rupees 4,590, which means USD 56 per kg, at an average exchange rate of 1 USD = 81.94 Rupees.

In this context, the goal of this study was to analyze the dynamics of raw silk production at the global level and in the main producing countries in order to identify the changes that have appeared in the period 2011-2022 and also in the period 2017-2022 versus 2011-2016. It also aimed to emphasize the changes in the hierarchy of the top producing countries: China, India, Uzbekistan, Vietnam, Thailand and Brazil. This is a continuation of the study which was carried out in the year 2018.

MATERIALS AND METHODS

For this research, the data were collected from various official information sources such as: International Sericicultural Commission, 2024, Statistics, Production, Silk Market Reports, United Nations Development Programme.

Raw silk production was analyzed for the period of reference 2011-2022 for which the data are available at present.

To make a comparison about the dynamics trend, the period was divided into two equal sub intervals: 2011-2016 and 2017-2022, calculating the absolute and relative differences between the period 2017-2022 versus 2011-2017.

The analysis was extended from the global level to the main silk producing countries: China, India, Uzbekistan, Vietnam, Thailand and Brazil, the data being studied applying the same procedure like in case of global production.

Descriptive statistics was used to characterize the main statistical features of silk cocoon production and raw silk production at the global level and by selected country.

Polynomial regression equations displayed the main trends and the changes produced across the time have been judged interpreting the R square values. Fixed basis and Structural index were also calculated to quantify the differences at the end of the period in comparison with the level at the beginning of the interval. Graphical illustrations and the tables showed the data and results being accompanied by suitable comments.

Finally, the main conclusions have been drawn and the author's opinion on the future development of raw silk production was expressed.

RESULTS AND DISCUSSIONS

Silkworm cocoon production

The global production of silk cocoons decreased in the interval 2011-2017 from 501,772 MT in the year 2011 to 414,788 MT in 2022, meaning a reduction by 17.4% (Fig. 1).

Figure 1 has a bell shape as while in the first sub-period, the silkworm cocoons production had an upward trend, reaching the maximum level in the year 2015 (750,309 MT), in the second period, the production has continuously decreased reaching the lowest level of 414,788 MT in 2022.

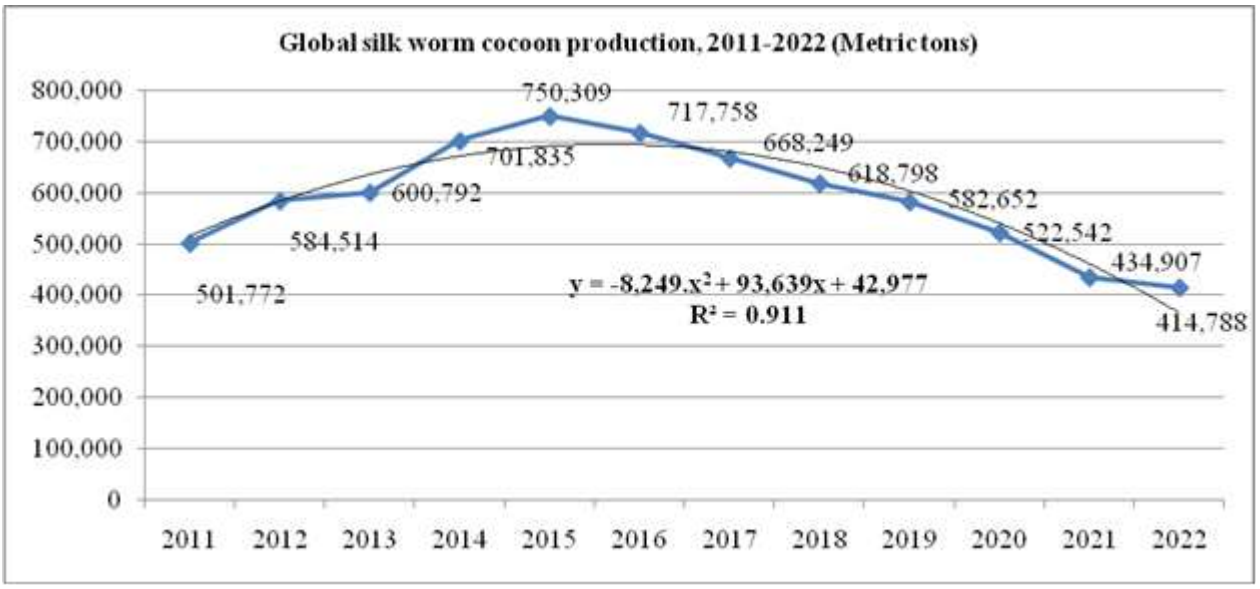

Fig. 1. Global silkworm cocoons production, 2011-2022 (Metric Tons)
Source: Own design based on the data from FAOSTAT, 2024 [2].

This reflects that we could expect to a downward tendency in raw silk production as well.

If we compare the raw silkworm cocoon production in the two subintervals, we may easily observe that in the last period of six years 2017-2022, silk production accounted for 3,241,936 MT being by 16% smaller than 3,856,980 MT in the sub period 2011-2016 (Table 1).

Table 1. Differences in global silkworm cocoons production between the period 2017-2002 versus 2011-2016

2017-2022	2011-2016	Absolute differences 2017-2022 versus 2011-2016 (MT)	Relative differences 2017-2022 versus 2011-2016 (%)
3,241,936	3,856,980	-615,044	-16 %

Source: Own calculation.

World raw silk production

In the period 2011-2022, the global raw silk production registered an ascending trend from 2011 to 2015, and, in this last year, it accounted for 202,073 MT, the maximum level recorded in the whole analyzed period. Since 2015, raw silk production declined reaching the minimum level of 86,311 MT in the year 2021 and, in 2022, it increased a little to 91,221 MT. In 2022, raw silk production was by 30% smaller than in 2011 and by 55% smaller than the peak registered in 2015 (Fig. 2).

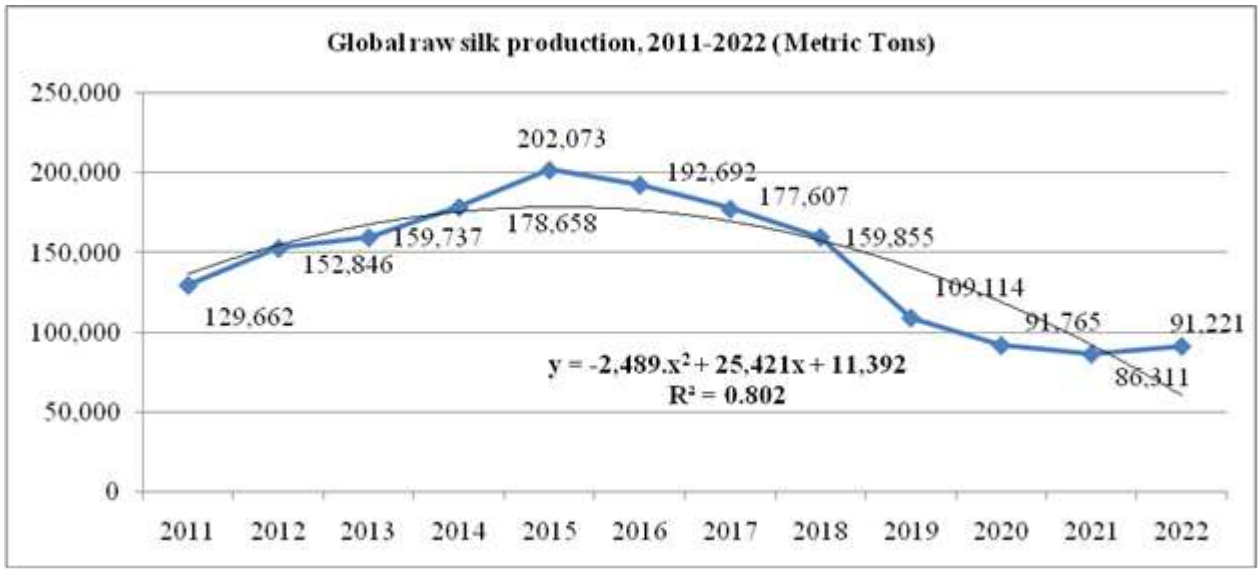

Fig. 2. Global raw production, 2011-2022 (Metric Tons)
Source: Own design based on the data from [3, 4].

Taking into comparison the two sub-periods, we noticed that in the period 2017-2022, the global raw silk production accounted for 715,773 MT, being by 29.53% smaller than the production carried out in the period 2011-2016 (Table 2).

Table 2. Differences in global raw silk production between the period 2017-2002 versus 2011-2016

2017-2022	2011-2016	Absolute differences 2017-2022 versus 2011-2016 (MT)	Relative differences 2017-2022 versus 2011-2016 (%)
715,773	1,015,668	- 299, 895	-29.53%

Source: Own calculation.

Regression equation regarding the determination relationship of raw silk production (y) by silkworm cocoons production (x)

The regression equation reflecting the connection between raw silk production considered Y- the dependent variable and silkworm cocoons production considered the independent variable X is shown in Table 3.

The regression equation shows that an increase by one metric tons in silkworm cocoons production will determine an increase by 0.3561 metric tons in raw silk production.

The determination coefficient, R square = 0.8632 tells us that 86.32 % of the variation in raw silk production is determined by the variation in silkworm cocoons production.

The correlation coefficient r = 0.929 reflects that between the two productions it is a positive and strong relationship.

Table 3. Regression statistics for Y- raw silk production depending on x- silkworm cocoons production

Variable	Coefficient	St. Error	t - stat	Prob.
Regression analysis for Y- Raw silk production; X- Silkworm cocoons production				
C-constant	-66, 384.44	26,922.10	-2.465	0.0333
X - Silkworm cocoons production	0.3561	0.0448	7.944	1.251
R squared	0.8632	Mean of dependent var. Y	144,286.75	
Adjusted R squared	0.8495	St. Dev. of dependent var.	41,467.38	
St. Error of regression	16,084.08			
Sum squared residuals	2,586,978,912			
Regression equation: y = -66,384.044 + 0.3561 x				

Source: Own calculation.

Raw silk production in the top six producing countries

China is the world leader in silk production. Its production increased in the analyzed interval from 2011 till 2015, when it reached the peak level, accounting for 170,000 MT, and then it started to decline accounting for only 50,000 MT in 2022, after the minimum level of 46,700 MT in 2021.

Therefore, in the analyzed interval, silk production in China decreased from 104,000 MT in 2011 to 50,000 MT in 2022, meaning a loss of 52% (Fig. 3).

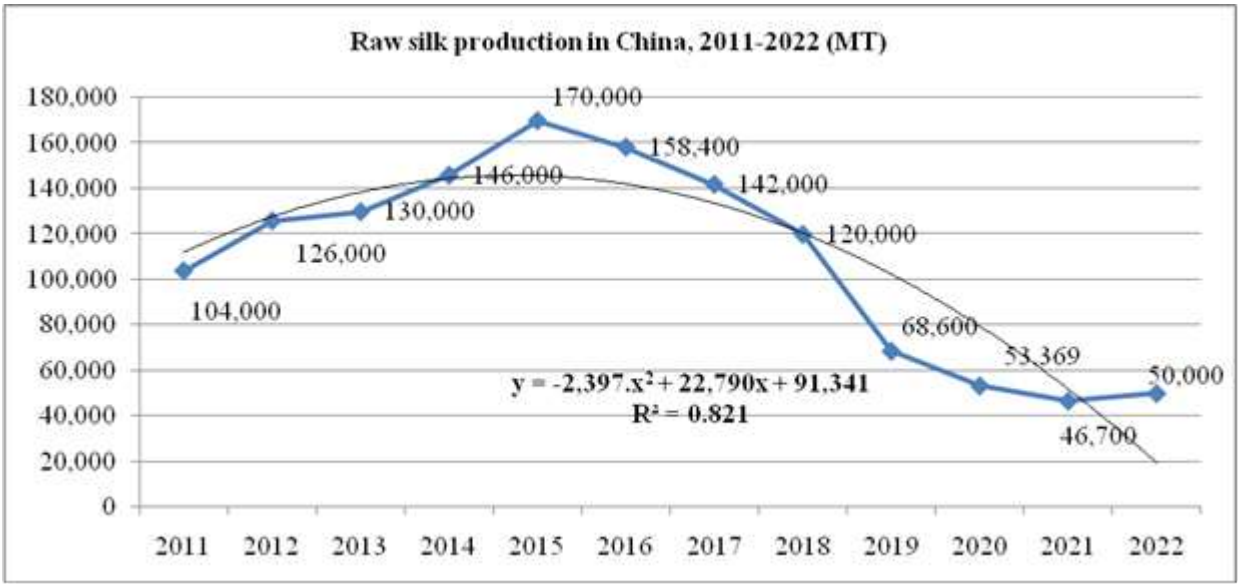

Fig. 3. Dynamics of raw silk production in China, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

India comes on the 2nd position after China, but it has a completely different evolution of raw silk production. In the analyzed interval it registered a continuous increasing trend from 23,060 MT in 2011, the lowest level, to 36,582 MT in 2022, the maximum level, which was by 58.6% higher than in the first year of the study (Fig. 4).

Despite of the production growth, the demand in India is high and for this reason the country is also a silk importer [7].

Uzbekistan is ranked the third at the global level for its raw silk production. Its production is much smaller than the one of China and India. In 2011, it was 110.6 times smaller than in China and 24.5 times smaller than in India. In the analyzed interval, this country had an increasing evolution of silk production, raising from 940 MT, the lowest level in 2011 to 2,037 MT in 2022, the maximum level (Fig. 5).

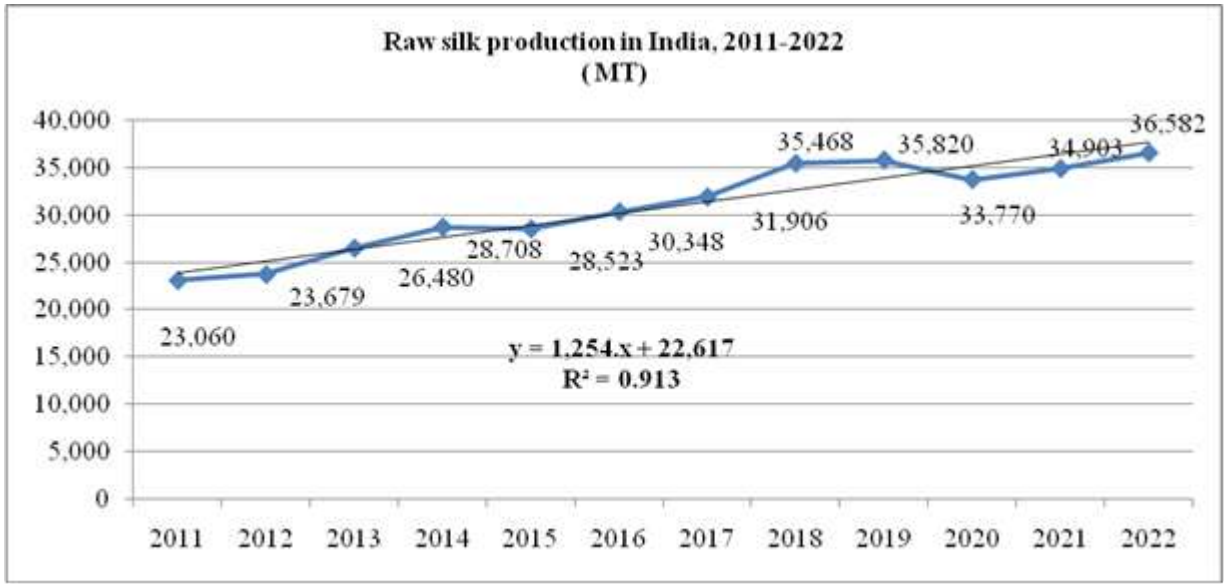

Fig. 4. Dynamics of raw silk production in India, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

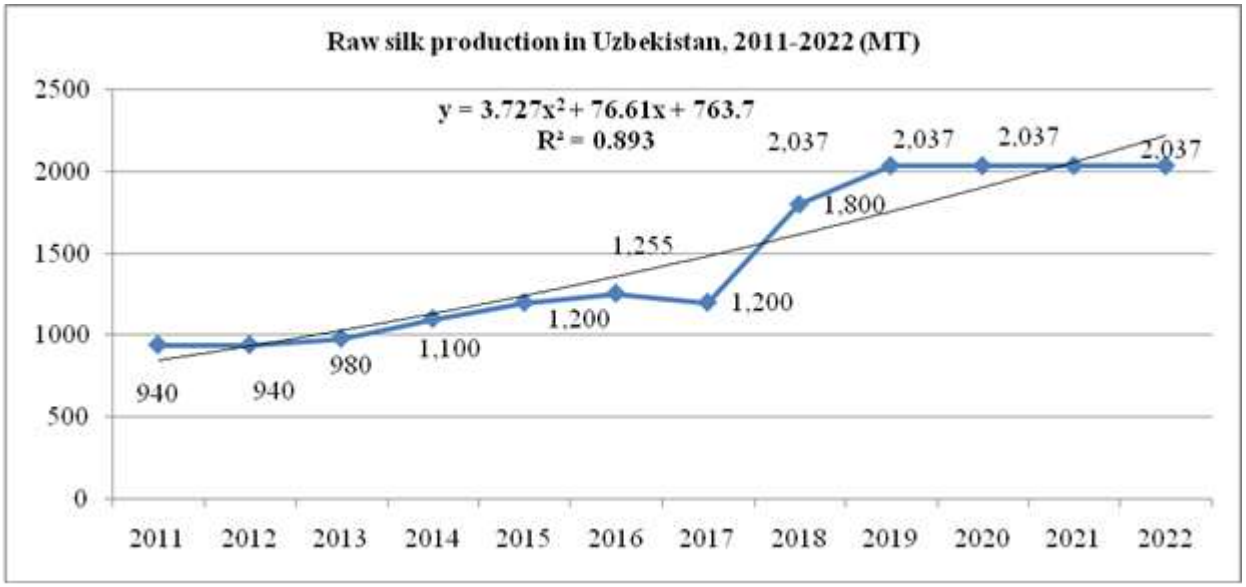

Fig. 5. Dynamics of raw silk production in Uzbekistan, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

Vietnam is on the fourth position regarding its silk production. It registered a relatively upward tendency in the analyzed interval, because in the first six years, production declined from 500 MT in 2011 to 420 MT in 2014, but, then it started to increase year by year, so that in 2021 and 2022 it reached 1,067 MT, the peak level being 2.13 times higher than in 2011 (Fig. 6).

Thailand is situated on the fifth position in the world for silk production. Its production declined from 655 MT in 2011 to 436 MT in 2022, meaning a loss of 35.5%. However, the dynamics had an ascending trend in the first six years up to 712 MT in 2016, but then, in the following six years, it recorded a continuous decrease from 680 MT in 2017 to 436 MT in 2022 (Fig. 7).

Brazil is ranked the sixth in the hierarchy of the silk producing countries. Its raw silk production recorded a relatively increasing trend from 558 MT in 2011 to 650 MT in 2016, but then, it started to decline since 2019 up to 375 MT in 2022, which marked the lowest level in the analyzed interval.

In 2022, silk production was by 32.8% smaller than in 2011 (Fig. 8).

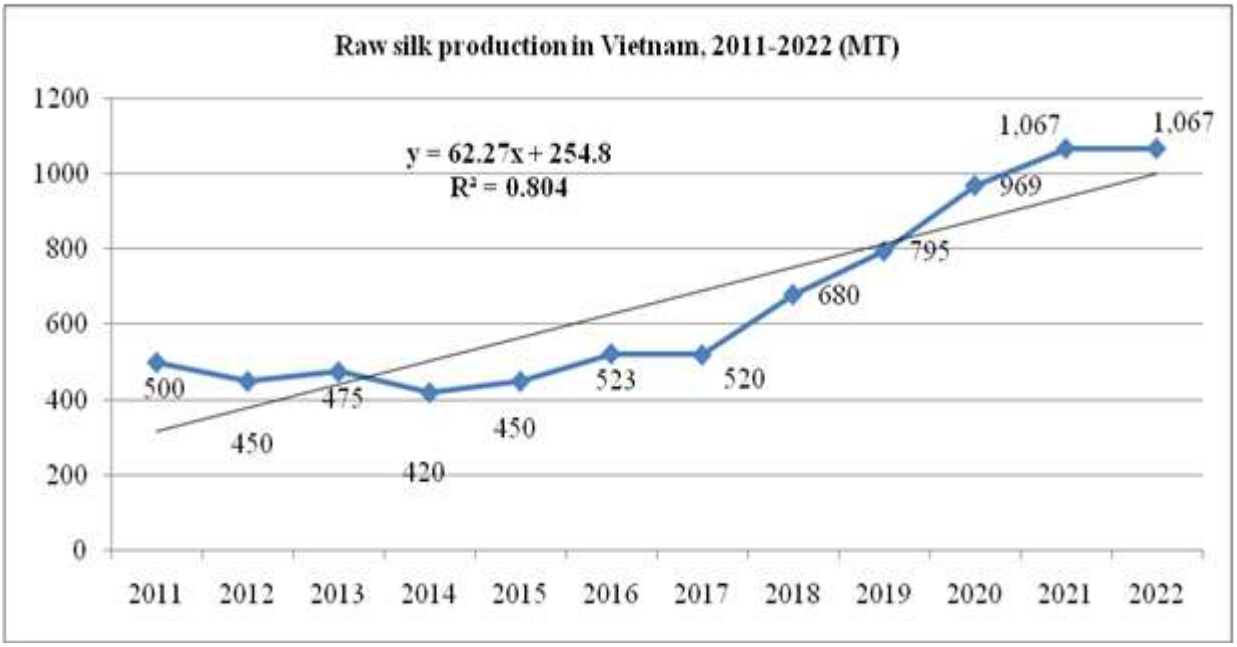

Fig. 6. Dynamics of raw silk production in Vietnam, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

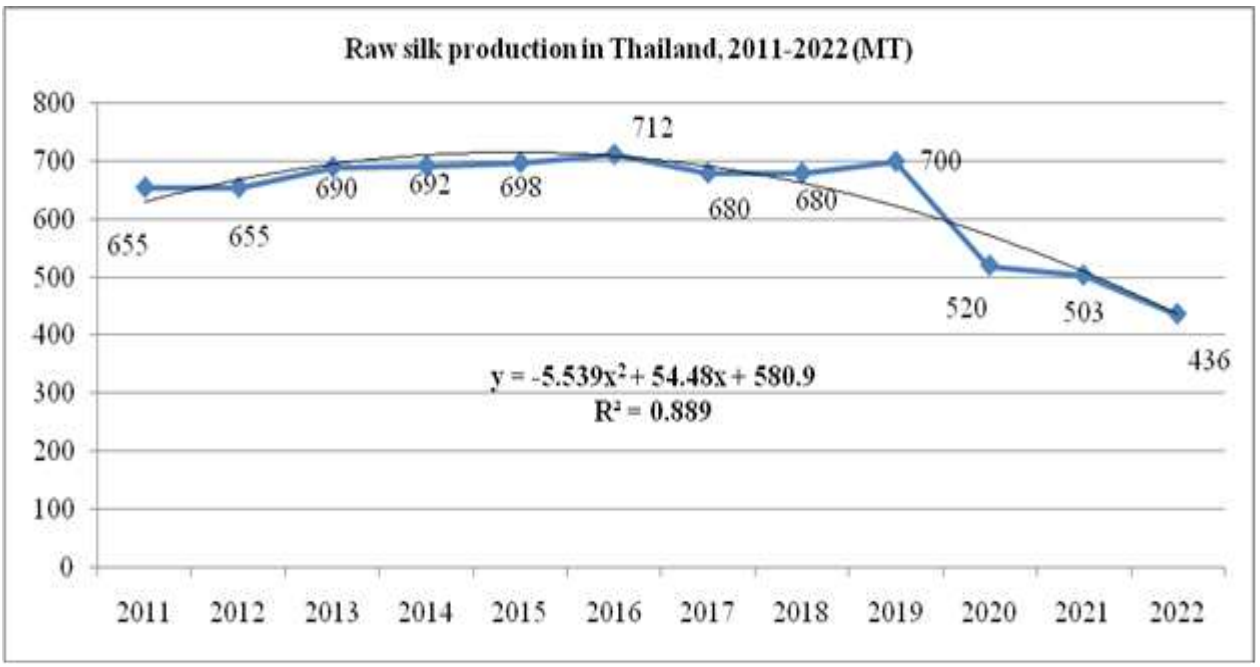

Fig. 7. Dynamics of raw silk production in Thailand, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

Silk production and international trade was affected during the Covid-19 pandemic in many producing countries, but mainly in China where both producers, silk industry enterprises and traders were facing disturbances and losses during the lockdown [5].

Production differences among the top six silk producing countries

Table 4 shows the absolute and relative differences in raw silk production among the six top producing countries at the global level. **China** registered in the last six years a production by 42.4% smaller than in the first six years (Table 4).

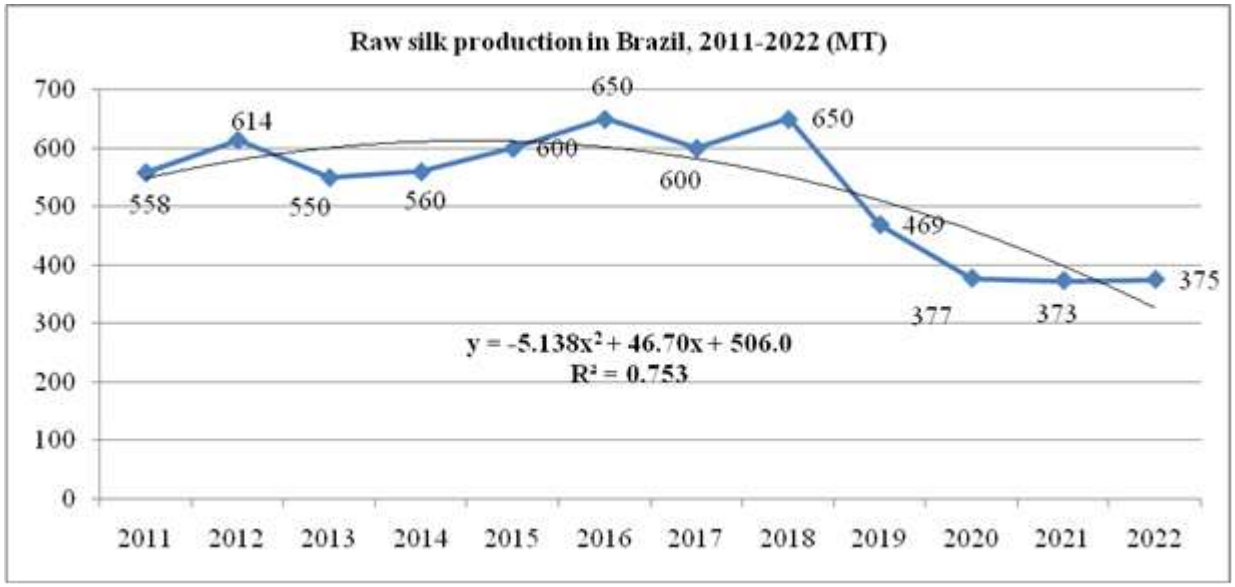

Fig. 8. Dynamics of raw silk production in Thailand, 2011-2022 (MT)
Source: Own design based on the data from [3, 4].

India recorded a surplus of production accounting for +59.7% in the last six years compared to the first six years.

Uzbekistan also had a positive result, accounting for +73.7% surplus of production in the second period of six years versus the first period.

Vietnam also recorded an additional production accounting for +80.9% in the last six years versus the first ones.

Thailand carried out a loss by -14.22% in the last interval versus the first period.

Brazil achieved a decline by -19.5% in the last sub-period versus the first one (Table 4).

Table 4. Production differences among the six top silk producing countries in the period 2017-2022 versus 2011-2016

	China	India	Uzbekistan	Vietnam	Thailand	Brazil
2011-2016	834,400	130,450	6,415	2,818	4,102	3,531
2017-2022	480,669	208,449	11,148	5,098	3,519	2,844
Absolute differences (MT)	-353,731	+77, 999	+4,733	+2,280	-583	-688
Relative differences (%)	-42.4%	+59.79%	+73,78%	+80.90	-14.22	-19.5

Source: Own calculation.

This situation of production variation and trend from a country to another has led to important changes in each country contribution to the global raw silk production.

If in 2011 and also in 2016 and 2017, China contributed by about 80% to the global raw silk production, in the year 2022 its weight accounted for only 54.8%. This means a decline by 25.2 pp.

In case of India, its share in the global silk production increased from 17.7% in 2011 to 40.1% in 2022, meaning an increase by 22.4 pp.

Uzbekistan also had an ascending trend and its contribution raised from 0.7% to 2.2%, that is by +0.15 pp.

Vietnam increased its weight from 0.3% to 1.2%, meaning +0.9 pp.

Thailand and Brazil maintained their low shares at 0.5%, and, respectively, 0.4% (Table 5).

The figures in Table 5 reflects that all these six countries produce about 99.2% of the global raw silk production. Also, that China and India together accounts for 94.9% in the global silk production.

Table 5. The share of the top six raw silk producing countries in the global production (%)

	2011	2016	2017	2022
China	80.2	82.2	80.0	54.8
India	17.7	15.7	18.0	40.1
Uzbekistan	0.7	0.6	0.7	2.2
Vietnam	0.3	0.3	0.3	1.2
Thailand	0.5	0.4	0.4	0.5
Brazil	0.4	0.3	0.3	0.4
Total 6 countries	99.8	99.5	99.7	99.2

Source: Own calculation.

Descriptive statistics for the indicators analyzed in this study

Descriptive statistics is presented in Table 6.

Table 6. Descriptive statistics regarding silkworm cocoons production and raw silk production in the period 2011-2022

	Mean	St. Error	St. Dev.	Kurtosis	Skewness	Minimum Maximum	CV %
Global silkworm cocoons production	591,576.3	31,229.72	108, 182.9	-0.88314	-0.22442	Min 414, 788 Max 750,309	18.28
Global raw silk production	144,295.08	11,970.60	41,467.38	-1.48555	-0.2065	Min 86,311 Max 202,073	28.73
Silk raw production in:							
China	109, 589.1	12,786.25	44,292.88	-1.44677	-0.34389	Min 46,700 Max 170,000	40.41
India	30,770.58	1,366.07	4,732.23	-1.1745	-0.39794	Min 23,060 Max 36,582	15.37
Uzbekistan	1,463.58	138.31	478.12	-2.0022	0.29598	Min 940 Max 2,037	32.66
Vietnam	659.66	72.26	250.34	-1.05429	0.83026	Min 420 Max 1,067	38.10
Thailand	635.08	26.89	93.17	0.4556	-1.3748	Min 436 Max 712	14.67
Brazil	531.33	30.59	105.96	-1.1625	-0.6513	Min 373 Max 650	19.94

Source: Own determination.

The coefficient of variation reflects a high variability regarding both silkworm cocoons production and raw silk production at the global level. In almost all the countries, silk production had a large variability in the analyzed interval 2011-2022.

Global silkworm cocoons production registered CV = 18.28% reflecting a relative homogeneity of the data, and that the mean is partially significant. The same significance has the CV% = 15.57% in India , 14.67% in Thailand and 19.99% in Brazil.

Global raw silk production recorded a CV% = 28.73%, also CV= 40.41% in China, CV = 32.66% in Uzbekistan and CV = 39.10% in Vietnam reflected that the data are heterogeneous and the mean is not representative (Table 6).

Problems in silk worm rearing and silk industry

Even thou production has a descending trend, it is expected to increase in the future because demand and consumption need the extend of the silk production and trade in the international market.

However, there are some restrictive factors which could have a negative influence as presented below:

-Silk producing and processing on a large scale involves high costs compared to other textile products.

-Along the silk chain including silk worm rearing, cocoons collection and reeling, silk fiber extraction, there are needed: skilled labor force and important material and financial resources.

- Mulberry tree growing requires specific climate conditions and also has specific production costs, but it could be a profitable activity [17].
-Pests and diseases could affect silk worms and diminish cocoon and silk production.
-These high costs will limit the extend of production in the small farms [22].
-Silk accounts among the most production costing fabrics as in order to produce 1 kg cocoons it is needed of 2,500 silk worms for which eggs have to be procured, feedstuff has to be assured, and other materials, water, electricity as well [8].
-Fluctuations in silk cocoon and silk price are a limiting factor of the extend of the silk market.
-Also, the lack of skilled work force in sericiculture where usually there are used unskilled workers, who have to be trained what to do.
-Transportation of silk cocoons and silk from the place of production to the place of processing is also costing.
-The lack of enough storage capacity could also be a limiting factor.
-Disturbances along the silk supply chain, like during the Covid-19 pandemic could have a negative impact on silk market.
-The growth in the production cost in mulberry tree growing is also a restraining factor as not all the growers are able to cover these expenses.
-China is facing these aspects which have led to a deep decline in raw silk production starting from the year 2015 as mentioned above [8].
-In conventional silk worm rearing there are ethical problems because the worms are boiled alive, being still in silk cocoons. One trillion worms are boiled annually to produce silk.
-Compared to cotton and wool, silk requires more energy and water.
-During the silk worm rearing, it is produced carbon monoxide which could determine allergies, irritations and respiratory problems to the workers.
-When diseases appear in silk worm growing, the eggs have to be destroyed.
-Silk exposed to sun could be degraded losing its resistance [8].

CONCLUSIONS

Silk cocoons production decreased at the global level by 17.4% in the interval 2011-2017 from 501,772 MT in the year 2011 to 414,788 MT in 2022.
This aspect had a deep influence on raw silk production which in 2022 was by 30% smaller than in 2011 and by 55% smaller than the peak registered in 2015. In 2022, it accounted for only 91,221 MT.
According to the regression equation, an increase by one metric tons in silkworm cocoons production could determine a growth by 0.3561 metric tons in raw silk production. About 86.32 % of the variation in raw silk production is determined by the variation in silkworm cocoons production ,according the R square value and between the two productions it is a positive and strong relationship as conformed by the correlation coefficient r = 0.929.
In China, Thailand and Brazil, raw silk production declined in the interval 2011 - 2022 by - 52%, -33.5%, -23%.
In India, Uzbekistan and Vietnam, raw silk production has substantially increased in the period 2011-2022 by 58.6%, 116.7% and 113.4%.
About 99.2 % of the global raw silk production is achieved in these six countries. In fact, the highest contribution is given by China, 54.8% and India, 40.1% in the year 2022.
A new orientation is at present to natural fibers, silk being one of the most preferred in the fashion, textiles, cosmetics and medical world due to its special features (skin and eco-friendly, and biodegradable).
The growth in input price and silk price variations, the increased production costs will affect the small sericiculturists who will not be able to keep pace and be flexible to adapt to these disturbances. Other restraining factors have been presented in this study and have not to be ignored.
But, at proved so far, for the developing countries, silkworm rearing and silk

production sector are a source of jobs, income, could be profitable activities, which could contribute to the reduction of poverty, hungry, gender discrimination, biodiversity preservation, soil protection, and to the continuous sustainable development of the rural areas.

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