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A STUDY ONROLE OF ARTIFICIAL INTELLIGENCE IN SERICULTURE AND PERCEPTION OF FARMERS TOWARDS AI IN KASHMIR VALLEY

RABIYA RASOOL[1], MISARA JAN[1], S.N.Z.GEELANI[2] AND BILAL AHMAD BHAT[2], MUMINA KHAN[3] AND ASIFA AKHTER[4]

[1]College of Temperate Sericulture (CoTS), Mirgund, SKUAST-K, J&K, India
[2]Division of Social and Basic Sciences, Faculty of Forestry, Benhama Ganderbal, SKUAST-Kashmir, J&K
[3]Department of Plant Pathology, National Chung Hsning University, Taiwan
[4]Division of Agril, Economics & Statistics, FoA, Wadura, SKUAST-K, J&K

Corresponding author email:bhat_bilal@rediffmail.com

ABSTRACT

Sericulture, the science and practice of rearing silkworms for silk production, integrates agriculture and cottage industry through mulberry cultivation and silkworm rearing. It is one of the oldest agro-based industries, providing sustainable livelihood opportunities to millions of rural families while producing natural silk, an eco-friendly fiber of global economic and cultural importance. However, the sericulture value chain remains largely labour-intensive and highly sensitive to environmental fluctuations and disease outbreaks. Recent advances in Internet of Things (IoT) devices and artificial intelligence (AI) offer practical routes to modernize sericulture by enabling real-time environmental monitoring, automated disease detection, precision feeding, predictive yield forecasting, and objective cocoon grading. This study explores the application of Artificial Intelligence (AI) in sericulture, India's significant agricultural sector. AI's potential to enhance sericulture productivity, quality, and sustainability is examined. We discuss AI-powered tools for mulberry cultivation, silkworm rearing, and cocoon quality assessment. To assess the perception of farmers towards AI, a well developed validated questionnaire was used to collected the information from 400 farmers selected at random from Kashmir valley. The data collected was analysed statistically and findings of our study suggested that use of AI can significantly improve sericulture's efficiency and profitability.

KEYWORDS:- Sericulture, Artificial Intelligence (AI), Internet of Things (IoT), Cocoon Quality, Disease Management, Mulberry Cultivation and Silkworm Rearing

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INTRODUCTION

Sericulture, a significant agro-based industry, plays a vital role in the rural economy. It provides livelihood and employment to millions of rural households, especially women and marginalized communities, thereby serving as a tool for inclusive growth and rural development (Kumar & Kumar, 2021). The traditional practices employed in sericulture are largely experience-based, often lacking scientific rigor or data-driven insights. Farmers rely on conventional wisdom, which, while valuable, often falls short in the face of increasing environmental and economic pressures. In this context, artificial intelligence (AI) technologies present a transformative opportunity to modernize and optimize the sericulture value chain. AI can provide predictive analytics, automated monitoring, intelligent decision-support systems, and real-time feedback mechanisms that improve resource efficiency, reduce risks, and enhance both the quantity and quality of silk production (Sonal et al., 2024; Li et al., 2024).

Sericulture- the integrated agricultural and industrial process that transforms mulberry biomass into high-value silk—has historically been labor-intensive, climate-sensitive, and knowledge-driven. The production cycle, which encompasses mulberry cultivation, silkworm egg incubation, larval rearing, cocoon harvesting, and post-cocoon processing, requires careful environmental management and precise biological interventions. Any lapse in temperature, humidity, nutrition, or pest control can cause irreversible crop losses. These vulnerabilities demand high levels of expertise, monitoring, and adaptability that traditional systems often cannot guarantee (Attri et al., 2024). With the increasing availability of affordable computing power, sensor technologies, and cloud-based infrastructure, AI has emerged as a practical solution to automate and optimize sericulture operations.

Recent advances in AI—particularly in the domains of computer vision, machine learning (ML), deep learning (DL), natural language processing (NLP), and the Internet of Things (IoT)—are redefining agricultural production systems. AI-powered image recognition systems can detect pest infestations or cocoon quality anomalies in real time, while ML algorithms can forecast disease outbreaks based on climatic data and historical patterns. IoT sensors are used to monitor critical parameters such as temperature, humidity, and leaf moisture in mulberry plantations and silkworm rearing houses, enabling early warning systems and automated controls. These digital tools allow for precise interventions that reduce waste, enhance bio security, and support sustainability in sericulture (Zhang et al., 2022).

ARTIFICIAL INTELLIGENCE

Artificial Intelligence defined by Grewal (2014) as “The mechanical simulation system of collecting knowledge and information and processing intelligence of the universe: (collecting and interpreting) and disseminating it to the eligible in the form of actionable intelligence”. Simply put, artificial intelligence refers to machines' capacity to emulate human behavior.

These machines can think, learn, and act like humans, applying their knowledge in real-time to solve problems. The well-known examples of artificial intelligence are iPhone Siri, amazon Alexa, IBMs Deep Blue, Sophia the humanoid robot etc.

MACHINE LEARNING

Machine learning fundamentally revolves around the idea of learning from experience and examples, forming a subset of artificial intelligence. It employs algorithms and statistical techniques that enable machines to learn from data, generate results based on their training and testing, and progressively improve their performance as they encounter more data and experience. Machine learning makes use of several technologies such as computer vision, robotics, image processing, and symbolic learning. The computer automatically evaluates tens of thousands of samples, generates an algorithm, and then enhances itself through machine learning once it reaches the intended result. Human inputs are required for the machine to learn. The machine is taught by the human that for this specific activity, you should do this and that its output should be what we desire, and then the human leaves the machine to learn automatically from its prior experiences. The qualities of artificial or machine intelligence include mobility, understanding, forecasting modification, spontaneous decision-making, and constant learning (Mohammed, 2019).

ARTIFICIAL INTELLIGENCE IN SERICULTURE

The world silk industry is gaining importance day by day due to the high demand of silk in the market. The sericulture comprises two parts, one is host plant production and the other is silkworm rearing, both are interdependent. Development in both the sectors equally will bring better results to the industry and application of artificial intelligence is now showing the potential of how far the development can go in future. Here in this paper, some of the very few applications of artificial intelligence are discussed in a brief manner.

ARTIFICIAL INTELLIGENCE IN HOST PLANT PRODUCTION

Out of the four life stages of silkworm, the larval stage is the feeding stage that feeds on the host plants and based on host plant the silkworms are classified into monophagous i.e., mulberry and polyphagous i.e., eri, muga and tasar. Quality and quantity of feeds the silkworm gets during its larval period greatly influence the silkworm growth and development, their health and also the production of quality and quantity of silk which is the final product.

Prediction of crop yield by observing the nutritional data of the soil can be achieved by using artificial intelligence techniques. Using machine learning models like regression models, the nutritional data of soil can be computed with which the leaf yield of a host plant can be predicted, which in turn provides a farmer with better plans for future rearing of silkworms. Experimentation on soil samples for different soil parameter data like soil macro and micro-nutrients, soil pH and electrical conductivity, organic carbon content etc. which greatly affects the plant growth, was conducted through an AI model consisting 3 regression model viz. Multiple Linear Regression, Ridge Regression and Random Forest Regression. Such AI models can predict the yield which improves the rearing efficiency (Srikantaiah and Deeksha, 2021).

Disease is another biotic factor influencing the yield of a crop by infesting the crops causing crop failure. Diseases like leaf spot, leaf rust, mildew, leaf and root rot, leaf blast, seedling and leaf blight etc. are some of the few diseases commonly seen in host plant fields. To identify such diseases, expert observation and continuous monitoring is required with a team of experts which is not always possible for farmers. Hence automatic disease detection by expert systems comes in use in such cases which provides more accuracy compared to traditional systems. AI models based on image processing like Convolutional Neural Network is one of the most successful models that helps in accurate disease recognition where the image with diseased leaf is fed to the model and the different layers of the neural network system will work on that image layer by layer to properly identify the disease attacking the leaves. It can help provide the farmers knowledge about the type of disease infesting their crops (Hemma *et.al*, 2019). Expert systems for detection of disease symptoms, spread of disease and even knowledge about favorable conditions for disease and images of diseases, are being developed. The user can ask any query and the system will draw conclusions from the knowledge base which is obtainable from books, magazines, knowledgeable persons etc. and display the conclusion to the user (Salman and Naser, 2019) . Another example of an AI model based on image processing is a model designed with You Only Look Once (YOLO) algorithm that can effectively classify leaf diseases and detect the disease for further treatment (Reddy and Deeksha, 2021).

Similar approach was implemented to detect mulberry plant and silkworm disease, where technologies like CNN, K-means clustering and GLCM were being utilized for sophisticated, accurate and reliable disease detection. This method also aimed for providing literature upon detection of diseases and additionally provides recommended measures for early prevention and spread of the disease (Santosh *et.al*, 2024).

ARTIFICIAL INTELLIGENCE IN SILKWORM SEED PRODUCTION

Silkworm seeds can be hibernating or non-hibernating, sensitive to light and vibration. Some of the crucial information about eggs like date of oviposition, date of hatching, hibernating or non-hibernating, free from any disease or not are necessary to provide along with the eggs being transported for proper planning for rearing. Sometimes, the eggs are induced with hibernation artificially or break the hibernation artificially for the rearing to coincide with availability of feeding.

For these to achieve, artificial intelligence helps obtain the developmental stage of the embryo in a non-destructive manner. Experimentations regarding recognition of the developmental stages of an embryo inside egg shell was done using terahertz imaging technology, where the terahertz images from 8 days prior to hatching are fused with optical images of same duration to get accurate results of the developmental stage of the embryo. This model not only resulted in THz images but also less time consuming with high recognition accuracy (Xiong *et. al*, 2021). This helps in predicting date and time of hatching, hibernation period, initiation and termination period of hibernation etc.

A method was suggested to detect, count, and classify silkworm eggs using modern computer vision techniques like Image processing, Machine learning, and Deep learning. Image processing algorithms such as SSD, RCNN, and Yolo v3 were utilized, along with Machine learning methods like ANN, KNN, and SVM, and Deep learning models such as VGG16, ResNet50, and InceptionV3. The method is structured into four main steps: input images, preprocessing, segmentation, and counting (Pavitra and Raghavendra, 2022).

ARTIFICIAL INTELLIGENCE IN SILKWORM REARING

Out of the four stages in the silkworm life cycle, the larval stage is the feeding stage. The quality and quantity of cocoon or silk production depends largely on this larval stage. This larval stage is the most vulnerable stage to any pest or disease attack and also the most sensitive stage to any fluctuation in ideal environmental conditions.

Therefore, it is important to prioritize maintaining optimal environmental conditions to enhance productivity. Achieving and sustaining these conditions can be facilitated through an AI-powered automated smart sericulture facility. This facility integrates advanced monitoring systems and sensors to promptly detect any deviations from the optimal rearing environment and automatically take corrective actions to restore it (Nithin *et.al*, 2021).

Environmental factors strongly influence disease incidence in silkworms, causing significant threats like flacherie, grasserie, muscardine, and pebrine. These diseases can devastate sericulture, leading to crop losses. To mitigate such risks, early disease warning systems utilizing AI can predict outbreaks by analyzing environmental variables. In 2021, a mobile-based system developed by North Eastern Space Applications Centre and CMERTI provided early warnings for flacherie in Muga silkworms, using temperature, humidity, and anthropogenic data to help farmers take timely precautions (Goswami *et. al*, 2021).

In addition to diseases, pests pose a significant threat to sericulture, leading to substantial crop and economic losses. Pests such as ants, uzi fly, and dermestid beetles attack silkworms, often resulting in death and reduce yield. AI models equipped with deep-learning algorithms such as Inception ResNet, Inception-V3, VGG-16, and VGG-19 can be trained to detect invasive species in rearing houses, enabling consistent monitoring (Pramodh and Thippesha, 2022).

ARTIFICIAL INTELLIGENCE IN SILKWORM GENDER CLASSIFICATION

Silkworm gender can be visually classified during larval, pupal, and adult stages. Certain sex-specific traits, like color variations in eggs, larvae, and pupae, exist but have not been commercially utilized in India for various reasons. Gender classification is crucial in sericulture for breeding and silk production. Male silkworms are typically preferred for commercial silk production due to their higher silk content per cocoon and lower leaf consumption compared to females. This distinction is essential for optimizing silk production and managing resources effectively.

There are two ways of classification of gender viz. destructive and non-destructive way. Gender classification of pupae traditionally requires skilled visual observation without damaging the cocoon, which is crucial since silk is the final product. Destroying cocoons for gender identification isn't economically feasible. The classical method relies on the size difference as females are generally larger, but it has limitations. Hence, AI-based approach uses image processing and load sensors to non-destructively classify pupae by visually comparing cocoons and considering their weight, effectively separating male and female cocoons (Raj *et.al*, 2019). X-ray imaging offers a non-destructive method for cocoon gender separation. Using an AI-based system, it compares the shape features of the pupa inside the cocoon with computed shape features of both male and female pupae and cocoons. This process classifies the gender without the need to cut open the cocoon (Thomas, 2022). Such

systems can easily identify the sex with higher accuracy using less time and labour which is the main aim for using artificial intelligence i.e., less time and labour consuming.

Sorting of cocoons is another important step in sericulture industry as good quality cocoons ensure higher productivity as well as better fecundity. Traditionally, this process is done by experienced persons based on visual examination that is having many drawbacks, of which time consumption & inaccuracy is at top. Sorting of cocoons with the help of Machine Learning methods comes handy in such cases. Use of imaging algorithms, sensors and AI models to detect shape, size and defectiveness of cocoon is the smartest way to overcome the drawbacks as well as getting efficient results (Vasta *et.al*, 2023).

METHODOLOGY

In this paper, we discuss the role of Artificial Intelligence (AI) in Sericulture and Perception of farmers linked with Sericulture towards AI in Kashmir valley. We chose 400 farmers at random from study region using well-designed validated questionnaire (Cochran, 1977). The data collected was analysed using statistical software SPSS (Version 20) and interpreted statistically.

RESULTS AND DISCUSSION

The data presented in Table 1, revealed that majority(38.25%) of the respondents under study were in the age group of 51-60 years, followed by 32.0% respondents who were >60 years and 29.75% respondents where in the age group of 35-40 years. The respondents understudy revealed that their main source of income was agriculture.

Table 1: General information of the studied population

S.No.	Variable	Type	Count	Percentage (%)
1.	Age (years)	35-40	119	29.75
		51-60	153	38.25
		>60	128	32.0
2.	Education status	Illiterate	47	11.75
		Primary	119	29.75
		Secondary	153	38.25
		Graduate & above	81	20.25

The data presented in Table 2, revealed that 73.5% respondents work on the basis of weather predictions, 45.5% respondents reported that they use mobile apps, 43.5% respondents reported that the use AI for disease detection, 23.5% reported that they are aware of automated cocoon grading smart sensors and 24.5% respondents reported that they are aware of pest prediction system.

Table 2: Awareness of Specific AI Applications among farmers under study

S.No.	Variable	Count	Percentage (%)
1.	Weather prediction	294	73.5
2.	Mobile advisory apps	184	45.5
3.	Disease detection	174	43.5
4.	Automated cocoon grading smart sensors	94	23.5
5.	Pest prediction systems	98	24.5

The data presented in Table 3, shows that in response to statement 1, i.e., AI can improve productivity, majority of respondents agree with mean score 4.24, in response to statement 2, i.e., AI can reduce labour cost, majority of respondents agree with mean score 3.92. Further, in response to statement 3, i.e., Government should provide training, majority of respondents agree with mean score 4.41. In response to statement 4, i.e., AI technologies are expensive , majority of respondents agree with mean score 4.16. In response to statement 5, i.e., AI improves sustainability, majority of respondents agree with mean score 3.74. The farmers under study during discussion revealed that AI is a necessary tool to combat climate unpredictability. They view AI as a complementary tool for improvement and not as a replacement for traditional wisdom.

Table 3: Perception of farmers under study towards AI techniques

S.No.	Statement	Mean Score	Decision
1.	AI can improve productivity	4.24	Agree
2.	AI can reduce labour cost	3.92	Agree
3.	Government should provide training	4.41	Agree
4.	AI technologies are expensive	4.16	Agree
5.	AI improves sustainability	3.74	Agree

Using 5 point scale: 1=Strongly disagree; 2=Disagree; 3=Neutral;4=Agree;5=Strongly agree

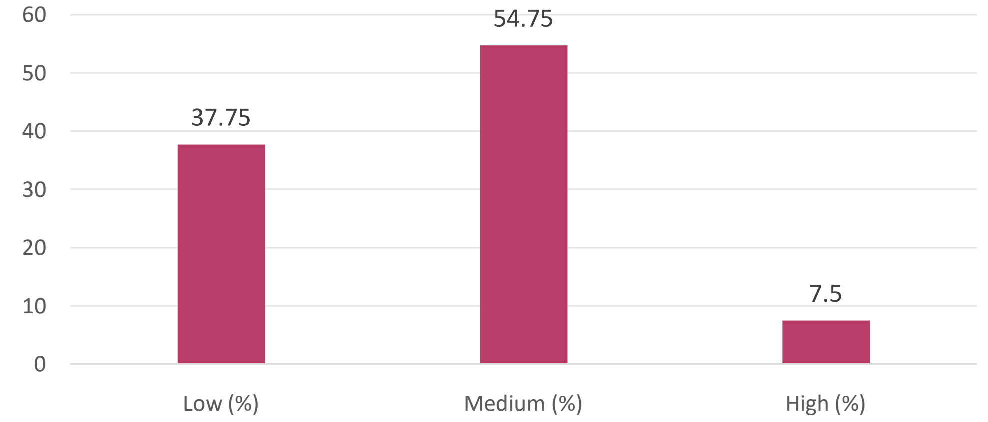
The data presented in Table 4, revealed that the main constraints faced by farmers in adopting AI tools are lack of training (85.5%), lack of awareness (84.5%), poor internet connectivity (82.5%), lack of technical guidance (74.5%) and high cost of technology (72.5%).

Table 4: Major constraints in AI Adoption

S.No.	Variable	Count	Percentage (%)
1.	Lack of technical guidance	298	74.5
2.	High cost of technology	290	72.5
3.	Poor internet connectivity	330	82.5
4.	Lack of awareness	338	84.5
5.	Lack of training	342	85.5

The data shown in Figure 1, revealed that majority of respondents (54.75%) possessed medium awareness, 37.5% respondents possessed low and 7.5% respondents possessed good knowledge about use of AI in Sericulture. Today farmers are showing increasing interest in adopting the latest agricultural technologies to improve productivity, reduce labour, and increase income. The modern tools like mobile-based advisory services, precision farming, drip irrigation, improved seed varieties, weather forecasting apps, drones, and mechanized farming equipment are helping farmers make better decisions and achieve higher efficiency.

Figure 1: Awareness level among studied population



It is important to mention that College of Temperate Sericulture (COTs) Mirgund, SKUAST-Kashmir, J&K, India's premier Institution is working with dedication for the development of high yielding bivoltine silkworm hybrids, optimizing mulberry cultivation, managing disease, and providing skill development to empower local farmers and rural youth of Kashmir based on modern scientific methodologies e.g., AI and IoT. Institute regularly conduct skill development and entrepreneur awareness programs for farmers and youth.


CONCLUSION

The study revealed that farmers showed positive attitude towards use of latest technologies, though are facing many constraints in AI adoption. The main constraints faced by farmers as per their opinion in adopting AI tools are lack of training (85.5%), lack of awareness (84.5%), poor internet connectivity (82.5%), lack of technical guidance (74.5%) and high cost of technology (72.5%). SKUAST-Kashmir is working very hard to make aware farmers about the role of AI in day-to-day farming.

Artificial Intelligence is revolutionizing the sericulture industry by enhancing efficiency, precision, and productivity across all stages—from mulberry cultivation to cocoon sorting. Through technologies like machine learning, computer vision, and IoT, AI enables accurate disease detection, yield prediction, automated environmental control, and gender classification of silkworms, reducing human effort and minimizing errors. These innovations not only improve silk quality and yield but also empower farmers with data-driven insights and sustainable practices. Thus, AI serves as a catalyst for transforming traditional sericulture into a modern, smart, and resilient industry.

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CORRESPONDING AUTHOR

Dr. Bilal Ahmad Bhat, presently working as Professor (Agri.Statistics), Division of Social and Basic Sciences, Faculty of Forestry, Benhama Ganderbal, SKUAST-Kashmir, J&K was earlier working as Head, Division of Agri. Econ & Statistics, Faculty of Agriculture, Wadura and Head Division of Social Sciences, Faculty of Fisheries, Rangil Ganderbal, SKUAST-K, Faculty at COTs Mirgund SKUAST-K. He was earlier working in Mathematics & Statistics Dept University of Kashmir and inSKUAST-Jammu as Assistant Professor (Statistics) before joining SKUAST-Kashmir. Dr. Bilal Ahmad has published five books, more than 380 research papers in various National/International Journals of repute, published a number of book chapters, organized number of national/international conferences and has published more than 500 popular articles. He has delivered a number of invited lectures, guided a number of research scholars for their Masters/PhD programme and has good knowledge of statistical software's like SPSS, MINITAB, SAS, R. Dr. Bilal Ahmad is a member of advisory board in some well known National and International journals of repute and his field of research is probability theory, information theory and applied statistics.