

Empowering Women Entrepreneurs in Sustainable Technology: Integrating STEAM, Fashion and Sustainability

Sonalika Singh¹, Dr. Veena Singh²

¹Research Scholar, Institute of Management, Commerce and Economics, Shri Ramswaroop Memorial University, Lucknow-Deva Road, Barabanki-225003, U.P, India.

²Associate Professor, Institute of Management, Commerce and Economics, Shri Ramswaroop Memorial University, Lucknow-Deva Road, Barabanki-225003

Abstract:

Sustainability has become a very important goal all over the world as it creates new opportunities for entrepreneurship. This paper shows how women entrepreneurs are contributing to sustainable development, particularly in the fashion industry. This research paper explores how integrating STEAM (Science, Technology, Engineering, Arts, and Mathematics) into sustainable fashion can empower women economically and socially. The fashion industry is one of the largest industries but it also creates environmental problems such as waste and pollution. This paper shows how women entrepreneurs can help in making industry more sustainable by using ecofriendly production methods and advance technologies.

This paper reviews existing knowledge and highlights real-world case studies. It also examines initiatives that utilize textile waste as a resource for livelihood generation. The study shows the importance of education, innovation, policy support, and sustainable practices in encouraging women-led enterprises. The study also highlights the challenges that women entrepreneurs face in achieving sustainable technology. It also explores the case study of Sustainable Entrepreneurship among Women in the Apparel Sector of Saudi Arabia. This study also tells the importance of STEAM in transforming the fashion industry.

This paper shows that how women entrepreneurs have achieved a global identity through sustainable startups. And also shows how women entrepreneurs are not only achieving sustainability but are also generating employment for other women also. This paper also shows the evidences to support the arguments through real world case studies. It also suggests some policies and recommendations on how women can contribute to sustainable technology.

Keywords: Empowering women, Entrepreneurs, Sustainability, Economic development, STEAM integration

Introduction:

For economic development and social transformation, women entrepreneurs have emerged as a powerful force. In the recent years women have proved herself a better leader, innovator and creator of sustainable

businesses. As the fashion industry is one of the most polluting industries, there is an urge to the sustainable solution.

Sustainable fashion focuses on eco-friendly production methods, ethical labour practices, recycling, upcycling, waste reduction, and the responsible use of natural resources. Women entrepreneurs are playing a significant role in promoting these practices by introducing innovative business models that combine creativity, sustainability, and social impact. Many women-led enterprises are not only producing environmentally conscious products but are also generating employment opportunities for rural women, preserving traditional craftsmanship, and promoting inclusive economic growth.

At the same time, the integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into the fashion and textile sector is transforming the way sustainable products are designed, manufactured, and marketed. STEAM-based approaches encourage innovation, critical thinking, digital literacy, and problem-solving skills, enabling entrepreneurs to adopt advanced technologies such as sustainable textile production, eco-friendly dyes, digital fashion design, recycling technologies, and smart manufacturing systems. The inclusion of arts and creativity within STEAM further strengthens the fashion industry by blending technical knowledge with aesthetic innovation.

Despite this progress, women entrepreneurs continue to face numerous barriers, including limited access to finance, lack of technological knowledge, gender discrimination, social expectations, and balancing family responsibilities with business activities. These challenges are more severe in developing countries like India, where many women still struggle to access education, resources, and market opportunities. Therefore, empowering women through education, skill development, digital literacy, financial inclusion, and supportive government policies is essential for achieving sustainable entrepreneurship.

This research explores the role of women entrepreneurs in sustainable technology and fashion by examining how STEAM integration can support innovation, environmental sustainability, and women's empowerment. It highlights the contribution of women-led sustainable enterprises, the opportunities created through textile waste recycling and eco-friendly practices, and the importance of policy support, education, and technological advancement in strengthening women entrepreneurship. The study also aims to demonstrate how sustainable fashion can become a pathway for economic independence, social empowerment, and environmental protection, contributing to a more inclusive and sustainable future.

Objective:

- To examine the role of women entrepreneurs in promoting sustainable technology in the sectors like fashion and textile industry.
- To analyse how integrating STEAM into fashion can help improve innovation, creativity, and sustainability.
- To identify the key factors which influences the women to attain sustainable entrepreneurship including social, economic and technological aspects.
- To explore the challenges that women face in sustainable technology and fashion industry.
- To assess the impact of sustainable initiatives, such as recycling of textile waste, on women's socio-economic empowerment.
- To study the case examples of successful women entrepreneurs who are contributing to sustainable fashion technology.
- To suggest some policies and recommendations for strengthening women's participation in sustainable entrepreneurship.

Literature Review:

The analysis of previous studies shows that women-led businesses in the fashion industry are increasing, especially those focusing on sustainable practices. This literature review provides a summary of earlier research on a particular topic. It includes information from books, journals, magazines, and online sources.

Hemantkumar P. Bulsara and his co-authors (2014) conducted a study on women's innovation and entrepreneurship in Gujarat, India. Their research focused on how women entrepreneurs in India are growing and achieving success despite facing social challenges. With the help of better education and life goals women in India are becoming more independent in business. The study aimed to review existing research on women's entrepreneurship and creativity in India.

Janice Brodman (2027) studied "Revolutionising Prospects for Female Entrepreneurs." This research discusses different strategies at policy, industry, and business levels to support women entrepreneurs. It highlights how e-business has helped to strengthen women-owned businesses. The study found that 66% of women reported business growth after using e-business services, and 87% found these services very useful. Improvements were seen in product quality, customer service, and marketing.

Samuel Sajuyigbe and Isaac Olugbenga Fadeyibi (2017) studied women entrepreneurship and sustainable economic development in South-Western Nigeria. They found that most women start businesses in their middle age and contribute significantly to economic growth. Many women benefited from education and training programs. Their main reasons for starting businesses were independence, self-respect, and confidence.

Priyanka Sharma (2013) reviewed the growth of women entrepreneurs in India. The study highlighted that women play an important role in increasing the country's wealth and improving family conditions. Women are now entering fields that were earlier dominated by men. To succeed in global markets, women need proper skills, knowledge, and entrepreneurial qualities.

Sandy Black (2011) explained the concept of sustainable fashion design. She suggested that designers should consider the full life cycle of clothes, including their use and disposal. Sustainable practices include recycling, reusing, repairing, and reducing waste. Techniques like upcycling (turning old materials into better-quality products) and downcycling (producing lower quality products) were also discussed. Upcycling is more beneficial as it adds value and reduces environmental impact.

Venkata Lakshmi and others (2024) studied the opportunities and challenges faced by women entrepreneurs in the textile and fashion industry. The study found that women face many challenges such as lack of financial support, balancing family and business responsibilities, social barriers, and limited market knowledge. However, despite these challenges, women entrepreneurs are motivated and use effective strategies to grow their businesses. The study also suggested that better policies can help support their growth and success.

Case Studies of Women Entrepreneurs in Sustainable Fashion:

Many women entrepreneurs in India and around the world are transforming the fashion industry by promoting eco-friendly, sustainable, and innovative practices.

1. Anita Dongre :

Anita Dongre built a global fashion brand despite financial challenges. She promotes sustainability, traditional craftsmanship, and women empowerment by employing rural women artisans. Her company, *House of Anita Dongre*, includes brands like AND, Global Desi, and Grassroot. She believes fashion can uplift lives and protect the environment.

2. Sujata Chatterjee :

Sujata founded *Twirl* in 2017 to reduce clothing waste and help women. Her initiative collects unused clothes, gives rewards to donors, and either recycles or donates them. She also provides employment to women by using their skills in upcycling fabrics.

3. Premal Badiani:

Premal Badiani runs a luxury fashion brand focused on sustainability. She gained recognition for her collection supporting breast cancer survivors and for launching an eco-friendly online fashion show. She is known for promoting sustainable luxury fashion.

4. Bhavini N. Parikh:

Bhavini founded *Bunko Junko* in 2017, which creates products from textile waste.

Her brand makes clothing, home décor, and accessories while employing over 1,000 underprivileged women, helping them earn a livelihood.

5. Madhurima Bhattacharjee:

Madhurima started by showcasing her designs in small exhibitions. She later collaborated with brands like Jaypore and showcased her work internationally. Her brand is known for eco-friendly and artistic clothing.

Determinants of Sustainable Entrepreneurship among Women in the Apparel Sector of Saudi Arabia:

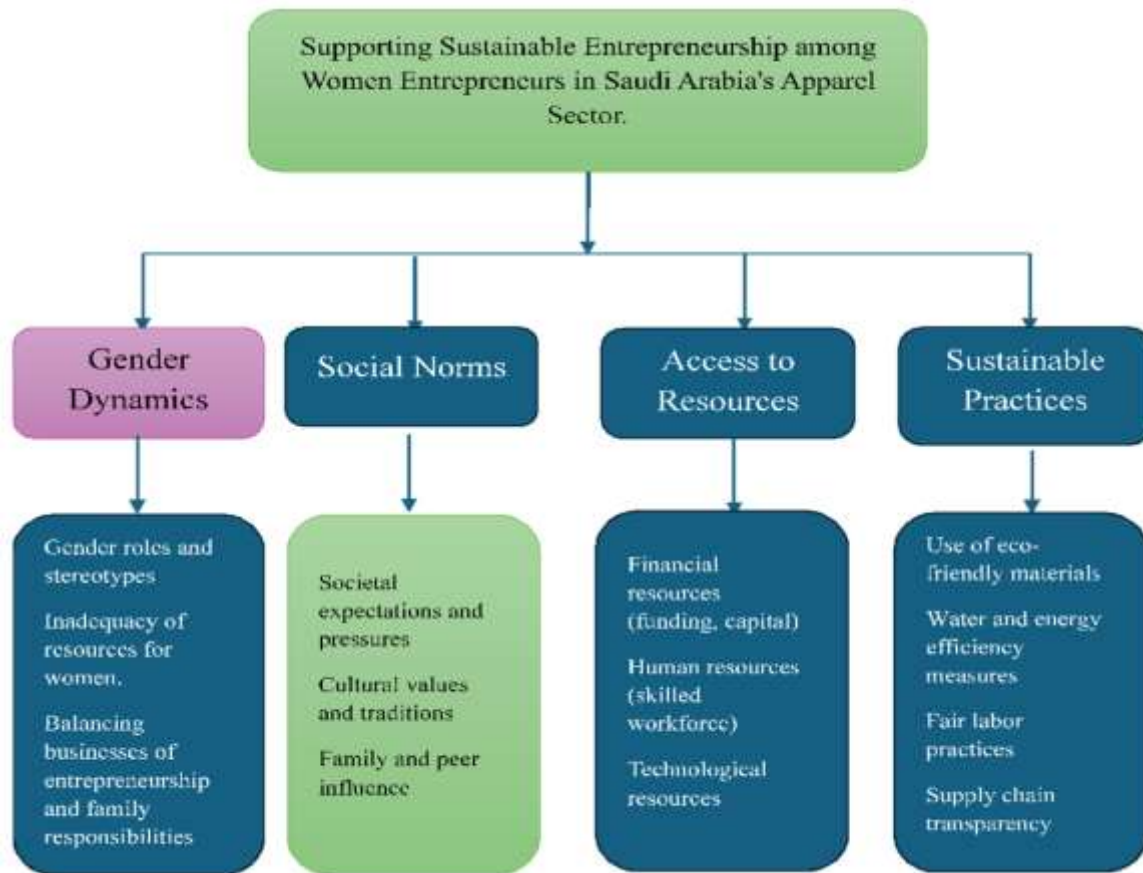
The study “Women Entrepreneur’s Perspective towards Sustainable Entrepreneurship in the Apparel Sector of Saudi Arabia” examines how female entrepreneurs adopt sustainability in fashion businesses.

Findings:

- Women entrepreneurs use eco-friendly practices (sustainable materials, fair labour, efficient resource use).
- Their actions are influenced by beliefs, education, and customer demand.
- They face barriers like social norms, gender bias, and limited resources.

The study identifies 4 main drivers of sustainable entrepreneurship:

1. Gender dynamics (roles, stereotypes, family balance).
2. Social norms.
3. Access to resources (finance, skills, technology).
4. Sustainable practices (green production, ethical supply chain).



Overall conclusion:

Support systems + resources + social change → promote sustainable entrepreneurship among women: The study shows that women's sustainable entrepreneurship in the apparel sector is driven by social, gender, resource, and environmental factors, but constrained by cultural barriers.

Integration of STEAM in Sustainable Fashion:

- STEAM stands for Science, Technology, Engineering, Arts, and Mathematics. It is an interdisciplinary approach to education that combines technology with creativity and critical thinking, helping students become innovative, problem-solvers and entrepreneurs.
- Empowering women through STEAM education is essential for promoting gender equality and driving social change. Although STEAM offer strong career opportunities and foster innovation, women remain underrepresented due to societal barriers and limited support. In India, despite improvements in female literacy, inequalities persist—especially in northern regions where many girls drop out early.
- Enhancing women's participation in education, particularly higher education, requires equitable resource distribution and gender-inclusive policies. Modern education is shifting toward creative, flexible, and inclusive learning approaches that integrate arts, innovation, and entrepreneurship.
- Teachers play a key role by adopting adaptive teaching methods that support female students.
- Global examples show that STEAM-based, inclusive teaching method—such as collaborative learning and real-world projects—can empower women with skills for innovation and entrepreneurship.
- However, challenges remain in implementing these approaches effectively in India, highlighting the need for continued focus on women's education and empowerment.

The integration of STEAM plays a crucial role in transforming the fashion industry:

- **Science & Technology:** Development of sustainable fabrics and eco-friendly production methods.
- **Engineering:** Efficient manufacturing and waste reduction systems.
- **Arts:** Creative design and cultural expression.
- **Mathematics:** Business analytics, cost management, and scaling operations.

This interdisciplinary approach enhances innovation and provides women entrepreneurs with tools to create sustainable and competitive businesses.

Textile Waste as a Resource for Women's Empowerment:

- In 2014, the Going Green project was launched under the SWITCH-Asia programme to promote sustainable textile businesses in six clusters across Rajasthan and Uttar Pradesh. The project builds upon the earlier SUSTEX initiative (2009–2013) and focuses on improving working conditions, promoting eco-friendly production, and increasing demand for green products.
- A major objective of the project is women's empowerment, with approximately 40% of beneficiaries being women. The initiative aims to enhance their access to livelihood opportunities and strengthen their socio-economic position. This study focuses on the Udaipur textile cluster in Rajasthan.

Women's Socio-Economic Profile:

In Salumber (Udaipur), the project mobilised **1,522 women** (aged 18–50):

- 200 women were illiterate, while most others had only primary-level education.
- Around 80% were migrants from Gujarat, mainly after marriage.
- 90% were landless agricultural workers, dependent on subsistence farming.
- The region lacked basic infrastructure.
- No running water.
- Only 50% had electricity access.

Livelihood options were limited to marginal agriculture and small retail activities.

Skill Development through Textile Waste:

The project identified textile waste recycling as a viable livelihood option. Women were trained to produce:

- Fashion jewellery
- Accessories
- Greeting cards
- Paper bags
- Hand embroidery products

Raw materials were sourced from textile hubs like Surat, promoting recycling and eco-friendly production.

Formation of Self-Help Groups (SHGs):

- 70 SHGs formed (700 women involved)
- Each group consists of ~10 women with leadership roles (secretary & treasurer)
- Target: 150 SHGs and 1,500 women by 2017

SHGs enabled:

- Collective decision-making
- Social interaction beyond household roles
- Increased confidence and community participation.

Women were trained in:

- Financial literacy
- Group governance

They were also linked to the National Rural Livelihood Mission (NRLM) for financial support.

Financial Inclusion and Savings:

Before the project:

- Women relied on moneylenders charging ~25% interest

After SHG formation:

- Collective savings: **INR 340,700**
- Loans distributed: **INR 129,100**
- Internal interest rates reduced to ~2%

Achievements:

- **624 women** obtained Aadhaar cards
- Opened bank accounts **under Pradhan Mantri Jan Dhan Yojana**
- Access to loans up to **INR 200,000**

Mobility and Leadership:

Women, previously confined to their homes:

- Began traveling independently for training
- Became trainers in other clusters
- Received stipends for mentoring

This significantly improved their confidence and social mobility.

Health, Sanitation, and Safety:

- **210 toilets** constructed through government scheme linkage
- **Regular medical camps** conducted:
- **243 women** examined
- **49 diagnosed** with fluorosis (due to contaminated water)

Efforts include:

- Collaboration with hospitals for treatment
- Plans for community water filtration systems

Impact on Women's Empowerment:

The project contributed to:

- Economic empowerment through income generation
- Social empowerment via SHGs and mobility
- Financial inclusion through banking access
- Health and well-being improvements
- Environmental sustainability through textile waste recycling

Challenges Faced by Women Entrepreneurs

Despite progress, several challenges remain:

- Limited access to finance
- Balancing family and business responsibilities
- Social and cultural barriers
- Lack of market knowledge
- Limited exposure to technology

Recommendations:

To further empower women entrepreneurs:

- Promote STEAM education and digital literacy.
- Provide financial support and subsidies.
- Encourage sustainable business practices.
- Strengthen policy frameworks.
- Expand access to global markets through e-commerce.
- Develop skill training programs focused on innovation.

Conclusion:

Entrepreneurs are transforming the sustainable fashion industry by integrating innovation, creativity, and eco-friendly practices. The combination of Women STEAM and sustainability provides a powerful framework for empowerment.

Initiatives like textile waste recycling show that sustainable technology can create livelihood opportunities while protecting the environment. With proper support, education, and policies, women entrepreneurs can play a major role in building a sustainable and inclusive economy.

References

1. Ademola Samuel Sajuyigbe, I. O. (2017). Women Entrepreneurship and Sustainable Economic Development: Evidence from South Western Nigeria. *Journal of Entrepreneurship, Business and Economics*, 28.
 2. 99 *Women Entrepreneur's Role in Innovative and Sustainable Fashion and Textiles* Dr. Mili
 3. Al-Aali, A.; Al-Shammari, M.; Al-Sadoon, A.; Al-Ghamdi, S. Factors affecting sustainable entrepreneurship in Saudi Arabia: An institutional perspective. *Sustainability* 2022,14, 5194
 4. Alshibani, S. M., Shabir, S., & Albishri, N. (2024). Women Entrepreneur's Perspective Towards Sustainable Entrepreneurship in the Apparel Sector of Saudi Arabia. *Sustainability*, 16(19),8636.
 5. Brodman, J. (2007). *Transforming Opportunities for Women Entrepreneurs*. The MIT Press,10.
- Ademola Samuel Sajuyigbe, I. O. (2017). Women Entrepreneurship And Sustainable Economic

- Development: Evidence From South Western Nigeria. *Journal of Entrepreneurship, Business and Economics*, 28.
6. Duggal, G., & Jain, L. K. (2019). Challenges and Issues Faced by Entrepreneurs in the Fashion Industry. *Cosmos: An International Journal of Management*, 8(2), Pg. 5-8.
 7. Ellen MacArthur Foundation. (2021). *Circular Economy in Fashion*.
 8. Fletcher, K. (2014). *Sustainable Fashion and Textiles: Design Journeys*. Routledge.
 9. Global Entrepreneurship Monitor (2021). *Women's Entrepreneurship Report*.
 10. Hemantkumar P. Bulsara, J. C. (2014). Women Entrepreneurship & Innovation In India: An Exploratory Study. *International Journal of Innovation*, 14.
 11. McKinsey & Company. (2022). *State of Fashion Report*.
 12. Potluri, S., & Phani, B. V. (2020). Women and green entrepreneurship: a literature-based Study of India. *International Journal of Indian Culture and Business Management*, 20(3), Pg. 409-428.
 13. Shah, P., & Mehta, B. (2009, March). Women entrepreneurs in the fashion design industry at Ahmedabad: issues, challenges and progress path. In *the Proceedings of Eighth Biennial Conference on Contemporary Issues in Entrepreneurship Research*.
 14. Sharma, P. (2013). Women Entrepreneurship Development in India. *Global Journal of Management and Business Studies*, 6.
 15. Tambunan, T. (2009). Women entrepreneurship in Asian developing countries. *Journal of Development and Agricultural Economics*, 14.
 16. United Nations (2020). *Sustainable Development Goals and the Fashion Industry*.
 17. Venkatalakshmi, M., Mathangi, V., & Bhuvaneswari, A. (2024). Decoding the Opportunities and Challenges for Women Entrepreneurs in Textile and Fashion Landscape. *Journal of Informatics Education and Research*, 4(2).
 18. Vossenbergh, S. (2013). Women Entrepreneurship Promotion in Developing Countries.
 19. Maastricht School of Management, 30.
 20. Yousef, M.; Allui, A.; Alaoui, A. Sustainable entrepreneurship in Saudi Arabia: A multi-level perspective. *Sustainability* 2021, 13, 13379.2.
 21. Empowering Women for Sustainable Social Change through STEAM Education: An Overview
 22. Alshibani, S. M., Shabir, S., & Albishri, N. (2024). Women entrepreneur's perspective towards sustainable entrepreneurship in the apparel sector of Saudi Arabia. *Sustainability*, 16(19), 8636. <https://doi.org/10.3390/su16198636> [OBJ]

Websites:

1. <https://www.gofynd.com/thecloset/sustainable-fashioninnovation#:~:text=Advancements%20in%20sustainable%20fashion%20include,printing%20and%20virtual%20fitting%20rooms.>
2. [https://www.gofynd.com/thecloset/sustainable-fashion-innovation#google_vignette.](https://www.gofynd.com/thecloset/sustainable-fashion-innovation#google_vignette)
3. <https://tide-india.org/wp-content/uploads/2023/10/Stove-Builders-of-Myanmar.pdf>