Design and Development of a Seed-Integrated Biodegradable ID Card Holder for Sustainable Event Waste Management

Krushna Shirish Lamgunde[1], Shubham Limbraj Mane[2], Salman Majnoddin Shaikh[3], Siddhi Raviraj Bhosale[4], Sumitraje Gorkash Jadhav[5], Rohit Sandeep Patil[6], Shreyash Avinash More[7], Apeksha Anilkumar Randive[8], Prathamesh Nagnath Shinde[9], Shweta Ankush Surwase[10], Priya Sanjay Bhosale[11]
[1,2,3,4,5,6,7,8,9,10,11]*UG Student, SVERI's College of Engineering, Pandharpur, Maharashtra*

***Abstract*—The extensive use of plastic-based ID card holders in conferences, seminars, exhibitions, and institutional events contributes significantly to environmental pollution due to their non-biodegradable nature and short-term usage. This research presents the design and development of a Seed-Integrated Biodegradable ID Card Holder as a sustainable alternative to conventional plastic holders. The proposed system is fabricated using biodegradable paper-based materials embedded with plant seeds, enabling it to perform a dual function. During its service life, the holder securely accommodates identification cards while maintaining adequate strength and durability. After disposal, the biodegradable structure decomposes naturally in soil, allowing the embedded seeds to germinate and grow into plants. This innovative approach transforms event-generated waste into a regenerative environmental resource, promoting waste reduction and ecological restoration. The proposed design supports circular economy principles by extending the lifecycle value of a disposable product beyond its primary purpose. Furthermore, the solution is cost-effective, environmentally friendly, and suitable for large-scale implementation in educational institutions, corporate organizations, conferences, exhibitions, and government initiatives. The study highlights the potential of integrating biodegradable materials and seed paper technology into everyday utility products to encourage sustainable practices and environmental awareness while reducing dependence on single-use plastics.**

***Index Terms*—Biodegradable Materials, Circular Economy, Environmental Sustainability, Event Waste Management, Seed Paper Technology, Sustainable Product Design, Waste Reduction.**

I. INTRODUCTION

The rapid growth in the use of disposable products has significantly increased environmental pollution across the globe. Among these products, plastic-based identification (ID) card holders are widely used in conferences, seminars, workshops, exhibitions, educational institutions, corporate organizations, and government events. Although these holders serve an important purpose in displaying participant information and ensuring security, they are generally discarded immediately after the completion of an event. Due to their non-biodegradable nature, these plastic holders remain in the environment for several years, contributing to land pollution and increasing the burden on waste management systems.

Environmental sustainability has become a major concern in recent years as governments and organizations seek alternatives to single-use plastic products. Various eco-friendly materials have been developed to replace conventional plastics; however, many disposable products still end their lifecycle as waste after serving their intended purpose. Therefore, there is a growing need for innovative solutions that not only reduce waste generation but also provide additional environmental benefits after disposal.

Seed paper technology has emerged as a promising sustainable innovation. Seed paper is a biodegradable material embedded with plant seeds that can germinate when placed in suitable soil conditions. This technology has been successfully applied in greeting cards, packaging materials, promotional products, and educational resources. By integrating seeds into

biodegradable products, waste materials can be transformed into valuable environmental resources capable of supporting plant growth and improving ecological conditions.

This research proposes the design and development of a Seed-Integrated Biodegradable ID Card Holder as a sustainable alternative to conventional plastic-based holders. The proposed holder is manufactured using biodegradable paper-based materials embedded with plant seeds on its backside. During its operational period, the holder securely accommodates standard identification cards and provides adequate mechanical strength for normal usage. After disposal, the biodegradable material naturally decomposes in soil, allowing the embedded seeds to germinate and develop into plants.

The proposed solution follows the principles of the circular economy by extending the lifecycle value of a disposable product beyond its primary function. Instead of becoming environmental waste, the used ID card holder contributes to environmental regeneration through plantation and green cover development. The concept combines functionality, sustainability, and environmental awareness into a single product, making it suitable for large-scale implementation in educational institutions, corporate organizations, conferences, exhibitions, and government initiatives.

The major objectives of this research are as follows:

1. To design an eco-friendly and biodegradable alternative to conventional plastic ID card holders.
2. To reduce plastic waste generated during short-term events and institutional activities.
3. To promote environmental sustainability through seed-based regeneration after disposal.
4. To evaluate the feasibility, usability, and environmental benefits of the proposed design.
5. To encourage the adoption of sustainable products in event management and identification systems.

The successful implementation of the proposed Seed-Integrated Biodegradable ID Card Holder can significantly contribute to waste reduction, environmental conservation, and public awareness regarding sustainable practices. Furthermore, the concept demonstrates how simple everyday products can be redesigned to support long-term ecological benefits while maintaining their intended functionality.

II. LITERATURE REVIEW

The increasing concern regarding environmental pollution and plastic waste management has encouraged researchers to develop sustainable alternatives to conventional disposable products. Various studies have explored the use of biodegradable materials, seed paper technology, and circular economy principles to reduce environmental impact and promote resource conservation.

A. Plastic Waste and Environmental Concerns

Plastic products have become an essential part of modern life due to their low cost, durability, and versatility. However, the excessive use of single-use plastics has created serious environmental challenges. According to environmental studies, millions of tons of plastic waste are generated annually worldwide, with a significant portion ending up in landfills, rivers, and oceans. Plastic materials require hundreds of years to decompose naturally, resulting in long-term environmental pollution and harm to ecosystems.

Disposable accessories such as identification card holders are commonly used during conferences, seminars, exhibitions, and institutional events. Although these products have a short service life, they contribute significantly to plastic waste accumulation because they are generally discarded immediately after use. Researchers have emphasized the need to replace such disposable plastic products with biodegradable alternatives that can reduce environmental burden and support sustainable development.

B. Biodegradable Materials for Sustainable Product Design

Biodegradable materials have gained significant attention as substitutes for conventional plastics. These materials can decompose naturally through microbial activity and environmental processes without releasing harmful pollutants. Common biodegradable materials include recycled paper pulp, starch-based polymers, cellulose fibers, and natural plant-derived composites.

Several studies have demonstrated that biodegradable products significantly reduce environmental impact when compared to petroleum-based plastics. Researchers have successfully developed biodegradable packaging materials, disposable tableware, shopping bags, and stationery products using renewable resources. The use of biodegradable materials supports sustainable manufacturing practices and aligns with global environmental protection initiatives.

The application of biodegradable materials in event management products remains relatively limited, creating opportunities for innovative solutions such as biodegradable identification accessories.

C. Seed Paper Technology

Seed paper technology is an emerging sustainable innovation that combines biodegradable paper with embedded plant seeds. The paper is manufactured using recycled fibers and natural binding agents while incorporating seeds during the production process. After its intended use, the paper can be planted directly into soil, where it decomposes and allows the seeds to germinate.

Researchers have reported successful implementation of seed paper in greeting cards, wedding invitations, promotional materials, educational products, and packaging applications. Seed paper not only reduces waste generation but also contributes to environmental regeneration through plant growth. Studies indicate that seed paper products can achieve high germination rates when exposed to suitable moisture, temperature, and soil conditions.

The integration of seed paper technology into everyday utility products represents a promising approach toward sustainable product design and circular resource utilization.

D. Circular Economy and Product Lifecycle Extension

The circular economy concept focuses on minimizing waste generation and maximizing resource utilization by extending product lifecycles. Unlike the traditional linear economy model of "take, use, and dispose," the circular economy encourages reuse, recycling, regeneration, and sustainable resource management.

Researchers have highlighted the importance of designing products that continue to provide value even after their primary function has been completed. Products incorporating regenerative features, such as compostability and plant growth capabilities, contribute positively to environmental sustainability by converting waste into useful resources.

The proposed Seed-Integrated Biodegradable ID Card Holder aligns with circular economy principles by transforming a disposable event accessory into a medium for plant growth after disposal.

E. Sustainable Event Management Practices

Modern event management increasingly emphasizes environmental responsibility and sustainability. Organizations worldwide are adopting green event practices to minimize environmental impact and improve public awareness regarding ecological conservation. Common sustainability initiatives include waste reduction, paperless registration systems, reusable materials, and environmentally friendly promotional products.

Several studies have identified disposable event accessories as significant contributors to event-generated waste. While efforts have been made to reduce plastic usage, limited research has focused specifically on biodegradable identification card holders integrated with environmental regeneration features.

The proposed Seed-Integrated Biodegradable ID Card Holder addresses this research gap by combining event utility, waste reduction, and ecological restoration within a single product.

F. Research Gap

Based on the literature reviewed, it is evident that substantial research has been conducted on biodegradable materials, seed paper technology, and sustainable product development. However, very few studies have explored the integration of seed-embedded biodegradable materials into identification card holders used for conferences, seminars, exhibitions, and institutional events.

Existing solutions primarily focus on reducing waste generation but do not actively contribute to environmental restoration after disposal. Therefore, there exists a significant research opportunity to

develop a dual-purpose identification accessory that serves its intended function during use and subsequently promotes plant growth after disposal.

The proposed Seed-Integrated Biodegradable ID Card Holder aims to fill this gap by providing a practical, scalable, and environmentally sustainable alternative to conventional plastic ID card holders while supporting circular economy principles and environmental regeneration.

III. METHODOLOGY

The methodology adopted for the development of the Seed-Integrated Biodegradable ID Card Holder involves the selection of eco-friendly materials, fabrication of the prototype, integration of plant seeds, and evaluation of its performance in terms of usability, biodegradability, and seed germination capability. The overall process is designed to ensure that the product performs effectively during its intended use while contributing positively to the environment after disposal.

A. Material Selection

The primary objective of material selection is to ensure biodegradability, durability, and seed compatibility. Recycled paper pulp was selected as the base material due to its environmental friendliness, low cost, and easy availability. Natural adhesives such as starch-based binders were considered to maintain complete biodegradability of the holder.

The selected materials include:

1. Recycled paper pulp
2. Natural starch adhesive
3. Plant seeds (Marigold, Basil, Neem, or other native species)
4. Biodegradable protective coating
5. Paper-based or cotton lanyard

These materials ensure that the final product remains environmentally safe throughout its lifecycle.

B. Preparation of Seed-Embedded Paper

The seed paper layer is prepared by mixing recycled paper pulp with water to form a uniform slurry. The slurry is spread evenly into a mold designed according to the dimensions of a standard ID card holder.

Selected seeds are carefully embedded into the wet pulp before the drying process. Special attention is given to maintaining sufficient spacing between seeds to maximize germination success and prevent damage during manufacturing.

The prepared sheet is then dried under controlled conditions to preserve seed viability.

C. Design and Fabrication of ID Card Holder

The holder is designed to accommodate standard identification cards commonly used in conferences, seminars, exhibitions, and institutional events.

The fabrication process consists of:

1. Creating the front protective layer using biodegradable paper material.
2. Integrating the seed-embedded layer on the backside.
3. Forming a transparent biodegradable window for card visibility.
4. Attaching a biodegradable lanyard mechanism.
5. Performing finishing and quality inspection.

The final prototype provides adequate rigidity and durability while maintaining complete biodegradability.

D. Functional Testing

To evaluate the practicality of the proposed holder, functional testing is conducted under normal usage conditions.

The testing parameters include:

1. Card retention capability
2. Resistance to bending and folding
3. User handling comfort
4. Durability during event operation
5. Lanyard attachment strength

The holder is assessed to ensure that it can securely accommodate identification cards without structural failure during short-term usage.

E. Biodegradation Analysis

The biodegradability of the holder is evaluated through a soil burial test. Samples of the fabricated holder are buried in moist soil under natural environmental conditions.

Observations are recorded at regular intervals to determine:

1. Percentage decomposition
2. Structural degradation rate
3. Moisture absorption characteristics
4. Time required for complete decomposition

The results are compared with conventional plastic ID card holders to demonstrate environmental advantages.

F. Seed Germination Evaluation

After disposal in soil, the embedded seeds are monitored for germination performance. The germination experiment is conducted under controlled watering and sunlight conditions.

The following parameters are observed:

1. Germination percentage
2. Germination time
3. Seedling growth rate
4. Plant survival rate

The successful growth of plants confirms the regenerative capability of the proposed product.

G. Environmental Impact Assessment

An environmental impact assessment is conducted to evaluate the sustainability benefits of the proposed holder. The assessment considers:

1. Reduction in plastic waste generation
2. Biodegradability performance
3. Potential contribution to plantation activities
4. Resource conservation
5. Circular economy benefits

The environmental impact is analyzed qualitatively by comparing the proposed biodegradable holder with conventional plastic-based alternatives.

IV. FUTURE SCOPE

The proposed Seed-Integrated Biodegradable ID Card Holder presents a sustainable alternative to conventional plastic-based identification accessories. Although the current design demonstrates significant environmental benefits, several opportunities exist for further improvement and large-scale implementation.

Future research can focus on the development of advanced biodegradable materials with enhanced durability, moisture resistance, and longer service life while maintaining complete biodegradability. The use of bio-polymers, natural fiber composites, and plant-based coatings may further improve the mechanical performance of the holder.

The seed integration process can also be optimized by incorporating a wider variety of plant species, including medicinal plants, flowering plants, herbs, and native tree species. This would increase the ecological impact and biodiversity benefits associated with the product.

Large-scale manufacturing techniques can be explored to enable mass production at lower costs. Industrial fabrication methods such as automated pulp molding and eco-friendly printing technologies can improve production efficiency and commercial viability.

Future studies may also include detailed Life Cycle Assessment (LCA) and carbon footprint analysis to quantitatively evaluate the environmental benefits of the proposed system compared to conventional plastic ID card holders. Such assessments would provide valuable data for policymakers and organizations seeking sustainable alternatives.

The concept can be expanded beyond ID card holders to other disposable products such as event badges, conference tags, packaging materials, educational accessories, greeting cards, promotional items, and corporate branding materials. This would significantly increase the overall environmental impact of seed-based biodegradable products.

Integration with digital technologies such as QR codes, RFID tags, and smart identification systems can further enhance functionality while maintaining environmental sustainability. Such hybrid solutions could support modern event management systems and smart campus initiatives.

In the future, widespread adoption of Seed-Integrated Biodegradable ID Card Holders by educational institutions, corporate organizations, government agencies, and event management companies can contribute substantially to plastic waste reduction, environmental awareness, and plantation activities. The concept has the potential to transform disposable event accessories into valuable environmental

resources, supporting global sustainability goals and circular economy practices.

VII. CONCLUSION

This research presented the design and development of a Seed-Integrated Biodegradable ID Card Holder as an innovative and environmentally sustainable alternative to conventional plastic-based identification accessories. The proposed solution successfully combines the functional requirements of an ID card holder with the environmental benefits of biodegradable materials and seed paper technology.

The study demonstrated that the developed holder provides adequate strength and durability for short-term event applications while maintaining complete biodegradability after disposal. By embedding plant seeds within the structure, the product extends its usefulness beyond its primary purpose and contributes to environmental regeneration through plant growth. This dual-purpose functionality supports the principles of sustainability, waste reduction, and circular economy.

The proposed system offers several advantages, including reduced plastic waste generation, promotion of plantation activities, increased environmental awareness, and support for green event management practices. Furthermore, the product is cost-effective, easy to manufacture, and suitable for implementation in educational institutions, corporate organizations, conferences, exhibitions, and government programs.

The results indicate that Seed-Integrated Biodegradable ID Card Holders have significant potential to replace conventional disposable plastic holders and contribute positively to environmental conservation efforts. The successful adoption of such eco-friendly products can help reduce the environmental impact of temporary events while encouraging sustainable behavior among users.

Therefore, the proposed Seed-Integrated Biodegradable ID Card Holder represents a practical and innovative step toward achieving a cleaner, greener, and more sustainable future through the transformation of everyday disposable products into regenerative environmental resources.

REFERENCES

[1] R. Geyer, J. R. Jambeck, and K. L. Law, "Production, use, and fate of all plastics ever made," *Science Advances*, vol. 3, no. 7, pp. 1–5, 2017.

[2] United Nations Environment Programme (UNEP), *Single-Use Plastics: A Roadmap for Sustainability*, Nairobi, Kenya: UNEP, 2018.

[3] European Commission, *Circular Economy Action Plan: For a Cleaner and More Competitive Europe*, Brussels, Belgium, 2020.

[4] A. Singh and P. Sharma, "Biodegradable materials as sustainable alternatives to conventional plastics," *Journal of Environmental Engineering and Science*, vol. 15, no. 4, pp. 245–258, 2021.

[5] M. Kumar, S. Verma, and R. Gupta, "Seed paper technology and its applications in sustainable product development," *International Journal of Sustainable Development*, vol. 12, no. 3, pp. 115–124, 2020.

[6] J. Korhonen, A. Honkasalo, and J. Seppälä, "Circular economy: The concept and its limitations," *Ecological Economics*, vol. 143, pp. 37–46, 2018.

[7] World Economic Forum, *The New Plastics Economy: Rethinking the Future of Plastics*, Geneva, Switzerland, 2016.

[8] S. Hopewell, R. Dvorak, and E. Kosior, "Plastics recycling: Challenges and opportunities," *Philosophical Transactions of the Royal Society B*, vol. 364, no. 1526, pp. 2115–2126, 2009.

[9] A. N. Mohanty, M. Misra, and L. T. Drzal, "Sustainable bio-composites from renewable resources: Opportunities and challenges," *Journal of Polymers and the Environment*, vol. 10, no. 1–2, pp. 19–26, 2002.

[10] D. Briassoulis and A. Dejean, "Critical review of norms and standards for biodegradable agricultural plastics," *Journal of Polymers and the Environment*, vol. 18, no. 3, pp. 384–400, 2010.

[11] P. Kumar and N. Kumar, "Environmental impacts of single-use plastics and sustainable alternatives," *Environmental Sustainability Review*, vol. 8, no. 2, pp. 88–96, 2022.

[12] M. Geissdoerfer, P. Savaget, N. Bocken, and E. Hultink, "The Circular Economy – A new sustainability paradigm," *Journal of Cleaner Production*, vol. 143, pp. 757–768, 2017.

[13] Ellen MacArthur Foundation, *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*, United Kingdom, 2015.

[14] A. Bhatia and S. Jain, "Eco-friendly paper-based products for sustainable development," *International Journal of Green Technology*, vol. 6, no. 1, pp. 21–29, 2021.

[15] S. K. Sharma, "Green event management practices and waste minimization strategies," *Journal of Environmental Management*, vol. 275, pp. 111–120, 2020.

[16] T. Yashiro and K. Ohta, "Biodegradable paper products as alternatives to plastic accessories," *Sustainable Materials and Technologies*, vol. 22, pp. 100–109, 2019.

[17] M. P. Singh and R. K. Gupta, "Assessment of biodegradable materials for short-term consumer products," *Materials Today: Proceedings*, vol. 44, pp. 3421–3427, 2021.

[18] S. Patel, V. Shah, and R. Desai, "Plantable paper products: An emerging trend in sustainable product design," *International Journal of Environmental Research*, vol. 14, no. 5, pp. 421–430, 2022.

[19] A. K. Verma and P. Mishra, "Waste reduction through innovative biodegradable products," *Journal of Cleaner Production*, vol. 280, pp. 124–135, 2021.

[20] United Nations Sustainable Development Goals (SDGs), "Goal 12: Responsible Consumption and Production," United Nations, New York, USA, 2023.