



iJRASET

International Journal For Research in
Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** X **Month of publication:** October 2026

DOI: <https://doi.org/10.22214/ijraset.2026.85172>

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Waste to Wearable: Upcycling Electronic Waste into Sustainable Jewellery for a Circular Economy

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Abstract: *Electronic waste is among the world's fastest-growing waste streams. The Global E-waste Monitor projects generation of about 70 million tonnes in 2026, rising to around 82 million tonnes by 2030. Recycling is not keeping pace. In 2022, only 22.3% of the 62 million tonnes generated worldwide was documented as properly recycled, and only about one-fifth of e-waste is expected to be formally collected and recycled by 2030. This widening gap calls for sustainable recovery approaches. Printed circuit boards contain significant quantities of valuable metals, and turning them into products such as jewellery offers a pathway toward a circular economy. This study explores the transformation of discarded electronic components, including printed circuit boards, resistors, capacitors and transistors, into artificial jewellery through upcycling and sustainable design principles. Rather than treating e-waste as a burden, the study treats it as a resource for creating aesthetically appealing and environmentally responsible wearable products, while promoting resource recovery, waste reduction and circular economy practices.*

Keywords: *e-waste, NEP, wearable jewellery, upcycling, circular economy, electrical components.*

I. INTRODUCTION

Electronic waste has become one of the fastest-growing waste streams worldwide, driven by rapid technological advancement, shorter product life cycles and rising consumer demand for electronic devices. Electronic items, printed circuit boards and other components are routinely discarded after use despite their considerable economic and environmental value. Conventional disposal methods such as landfilling and incineration waste precious resources and also pose serious environmental and health risks through the release of hazardous substances. In line with National Education Policy (NEP) 2020 and Sustainable Development Goals (SDGs) for a Sustainable Bharat, the present study explores an innovative approach to e-waste utilisation that combines material recovery with creative product design. Applying upcycling and sustainable design principles, it converts electronic waste into aesthetically valuable wearable products while promoting resource recovery, waste reduction and circular economy practices. Instead of treating e-waste as a burden, the study examines its potential as a resource for environmentally responsible and visually appealing jewellery and wearable accessories. The approach extends the life cycle of discarded electronic materials and shows how waste can become a high-value product, contributing to sustainable manufacturing, environmental conservation and eco-friendly design solutions.

II. REVIEW OF RELATED LITERATURE

A. The global e-waste challenge

Recent global reports estimate that more than 70 million metric tonnes of e-waste are generated annually, with only a small proportion formally collected and recycled. The remainder is processed informally or sent to landfill, causing environmental pollution and the loss of valuable resources such as gold, silver, copper, palladium and rare earth metals. International studies consistently emphasise the need to move from a linear economy to a circular one, in which waste materials are recovered, reused and transformed into new products with economic value.

B. The Indian policy context

In India, e-waste generation has risen substantially with the expansion of digital infrastructure and consumer electronics. Several national initiatives collectively emphasise sustainable resource use, environmental protection, innovation, entrepreneurship and vocational education. These include NEP 2020, the E-Waste Management Rules, 2022, Swachh Bharat Mission, Digital India, Make in India, Skill India Mission and the country's commitment to the Sustainable Development Goals. NEP 2020 in particular encourages multidisciplinary research, experiential learning, sustainability education and innovative solutions to societal and environmental challenges. The E-Waste Management Rules, in turn, call for scientific recycling and formal resource-recovery systems to minimise the hazards associated with electronic waste.

C. Research gap and the present approach

Despite growing interest in e-waste management, important gaps remain. Existing literature concentrates mainly on efficient metal recovery, the environmental impacts of e-waste, or policy implementation. Comparatively little attention has been given to converting recovered metals and reusable electronic components into commercially viable jewellery and wearable products.

To address this gap, the present study proposes an integrated approach that transforms discarded LED string lights, decorative lighting and electrical circuit components (resistors, capacitors, transistors and similar parts) into aesthetically valuable jewellery and wearable accessories. The approach aligns with NEP 2020, SDGs and the vision of a Sustainable Bharat by promoting resource efficiency, waste minimisation, circular economy practices, sustainable entrepreneurship and environmentally responsible manufacturing.

III. OBJECTIVES

The present study has two objectives:

- 1) To investigate the potential of electronic waste as a sustainable resource for developing aesthetically appealing jewellery and wearable accessories.
- 2) To evaluate the functional, aesthetic and environmental performance of the developed products in terms of durability, design quality, resource efficiency and waste reduction.

IV. METHODOLOGY

A. Research design

The study adopts an experimental, design-based research approach that integrates sustainable product design with circular economy principles to investigate the transformation of electronic waste into value-added jewellery and wearable accessories. The research combines material recovery techniques with creative product development to demonstrate an environmentally sustainable approach to e-waste utilisation. The study promotes responsible resource use, environmental conservation and sustainable manufacturing practices, consistent with national e-waste management policies and global sustainability goals.

V. RESULTS AND DISCUSSION

The findings show that electronic waste can be effectively transformed into aesthetically appealing and environmentally sustainable jewellery and wearable accessories through



Fig. 1. Wearable jewellery made from e-waste: (a) from resistors, (b) from transistors and (c) from decorative LED lights.

upcycling and creative product design. The results are presented in relation to the research objectives (Fig. 1).

Overall, the results indicate that combining hydrometallurgical metal recovery with upcycling and sustainable jewellery design offers an innovative, environmentally responsible and economically viable strategy for e-waste management. The approach turns electronic waste from an environmental liability into a valuable resource, supporting circular economy principles, sustainable manufacturing and the vision of a Sustainable Bharat.

VI. EDUCATIONAL AND ENVIRONMENTAL IMPLICATIONS

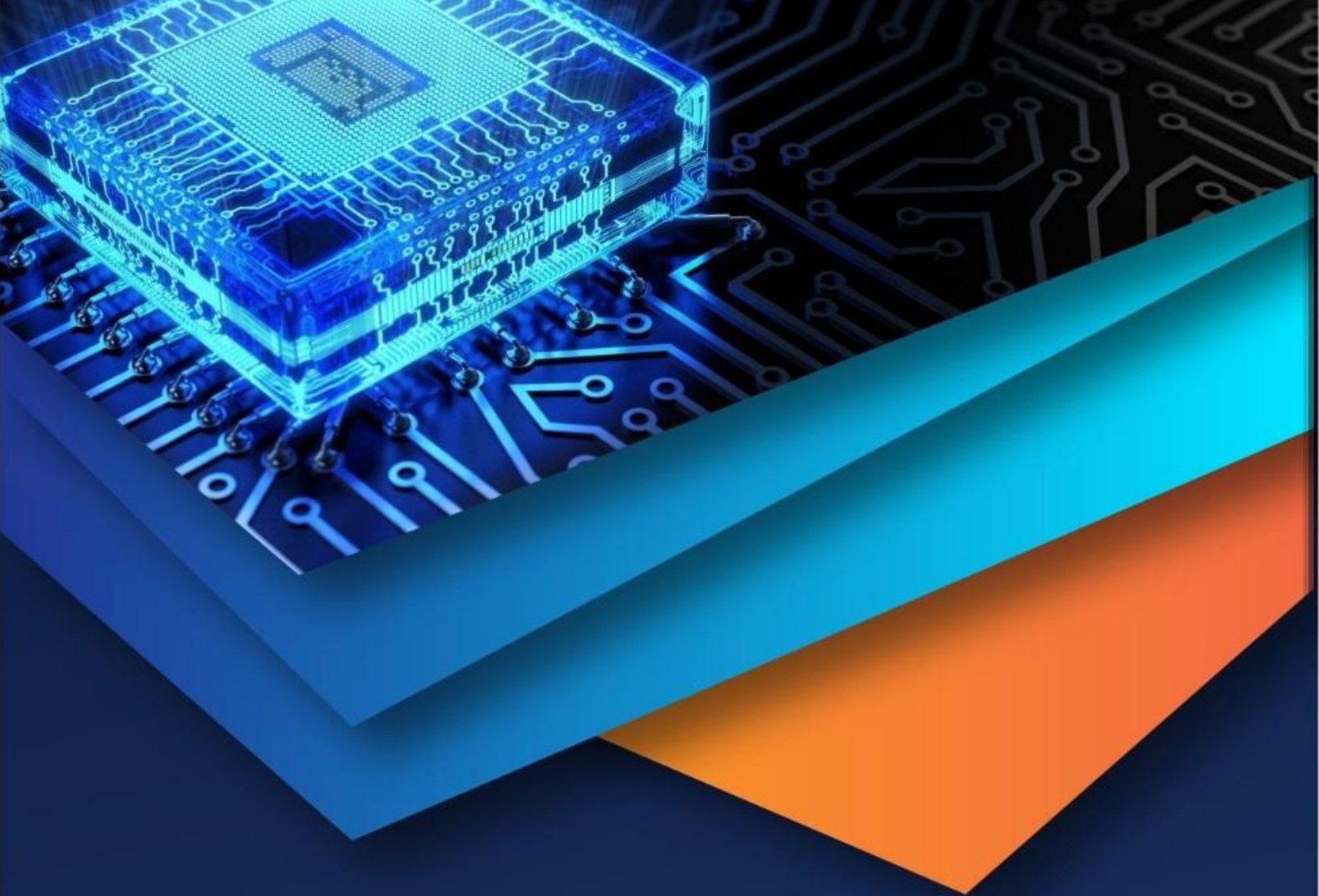
The findings have significant implications for environmental education, teacher education, institutional practice, community awareness, sustainability governance and policy implementation. By demonstrating the conversion of electronic waste into value-added jewellery and wearable accessories, the study offers an interdisciplinary model that integrates environmental science, sustainable design, materials engineering and entrepreneurship.

VII. CONCLUSION AND RECOMMENDATION

This study demonstrates that electronic waste can be turned from an environmental challenge into a valuable resource through sustainable product design. The proposed approach supports resource recovery, waste minimisation and circular economy principles while producing aesthetically appealing and functional wearable products. Beyond product development, the study shows how interdisciplinary collaboration among materials science, environmental engineering, fashion design and sustainability can generate innovative solutions for e-waste management.

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