



International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 2, February 2025



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

VendWise: A Smart Reverse Vending Machine for Sustainable Plastic Waste Management

**Dr. M.K. Lodi, Aparna Ramachandran, Ashil Aruldas, Aryan B Nair, Apeksha Arora, Aparna MA,
Anubhav Raj**

Professor, CMS Business School, Faculty of Management Studies, Jain Deemed-to-be University, Bangalore, India

Management Students, CMS Business School, Jain Deemed-to-be University, Bangalore, India

ABSTRACT: Plastic pollution is a major environmental challenge that threatens ecosystems and public health. VendWise offers an innovative approach to tackle this issue through advanced reverse vending machine (RVM) technology. The system integrates automation, smart sensors, and gamification to encourage responsible plastic disposal by providing users with incentives. This research paper examines the technological framework, business model, market opportunities, financial projections, and potential risks associated with VendWise. The study evaluates existing literature on recycling behaviours, technology adoption, and waste management strategies. The findings highlight the necessity of innovative solutions to improve recycling rates, reduce landfill overflow, and increase consumer participation. Additionally, the paper explores the financial feasibility of VendWise, estimating a break-even period within three years through revenue streams including per-bottle disposal fees, corporate sponsorships, advertising partnerships, and government subsidies. With a strong operational plan and strategic market positioning, VendWise presents a scalable and financially sustainable model that has the potential to significantly contribute to environmental conservation and circular economy initiatives. The project integrates automation, smart sensors, and a gamified approach to incentivize responsible plastic disposal. This paper explores the technological framework, business model, market opportunity, and financial feasibility of VendWise, along with an analysis of risks and sustainability.

I. INTRODUCTION

Plastic pollution is a growing environmental crisis, with millions of tons of plastic waste accumulating in landfills, waterways, and oceans worldwide. According to recent studies, plastic waste production has surged over the past few decades, with single-use plastics contributing significantly to environmental degradation. Traditional waste management and recycling systems have struggled to keep pace with this influx, often leading to inefficient disposal and contamination of recyclable materials. As a result, innovative solutions are required to address this crisis effectively.

VendWise is a pioneering initiative aimed at transforming plastic waste management by leveraging reverse vending machine (RVM) technology. The solution integrates automation, sensor-based validation, and an incentive-driven system to encourage responsible disposal of plastic bottles. The RVM technology allows users to deposit plastic waste, which is then verified using infrared and ultrasonic sensors before being collected for recycling. This approach ensures higher efficiency in waste sorting, minimizes landfill overflow, and promotes a circular economy by reintroducing recyclable materials into the production cycle.

One of the major barriers to effective plastic waste management is the lack of user participation due to inconvenient disposal systems and the absence of tangible incentives. VendWise addresses this challenge by implementing a gamified reward system where users earn digital credits or redeemable points for each plastic bottle they deposit. These incentives not only foster a recycling culture but also encourage long-term behavioural change towards sustainable waste management practices.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

In addition to its user-centric approach, VendWise is designed to integrate seamlessly with existing waste management infrastructures. By strategically placing these machines in high-footfall areas such as shopping malls, metro stations, corporate offices, educational institutions, and public parks, VendWise maximizes accessibility and encourages widespread participation. Furthermore, real-time data analytics and IoT connectivity allow for continuous monitoring of machine performance, tracking of deposited materials, and automated alerts for timely waste collection.

Another critical aspect of plastic waste management is corporate responsibility. Companies producing plastic packaging are increasingly being held accountable under Extended Producer Responsibility (EPR) regulations. VendWise aligns with these policies by providing corporations with a measurable and transparent solution to track their recycling efforts. Through corporate sponsorships and partnerships, the initiative can further expand its reach and impact, helping businesses fulfil their sustainability commitments while enhancing their brand image.

Despite the advantages of VendWise, several challenges must be addressed to ensure long-term success. These include regulatory compliance, financial sustainability, and public awareness. The project requires continuous investment in technological advancements, public education campaigns, and strategic partnerships to optimize efficiency and scalability. Additionally, potential risks such as vandalism, machine downtime, and user adoption rates must be carefully managed.

This research paper aims to analyse the feasibility and potential impact of VendWise by evaluating its technological, economic, and environmental aspects. By integrating innovative waste management solutions with incentive-based consumer participation, VendWise presents a promising model for reducing plastic waste and promoting sustainability. The paper will further explore market opportunities, financial projections, risk mitigation strategies, and the broader implications of adopting reverse vending machine technology for global waste reduction initiatives. Plastic pollution is a growing global crisis, with millions of tons of plastic waste generated annually, much of which ends up in landfills, oceans, and other natural habitats. This waste poses a severe threat to marine life, ecosystems, and public health. Despite numerous initiatives to encourage recycling, traditional waste management systems remain inadequate due to limited accessibility, lack of incentives, and inefficient collection processes.

VendWise aims to revolutionize plastic waste disposal by introducing an automated and user-friendly reverse vending machine (RVM) solution. By integrating smart sensors, real-time monitoring, and a gamified rewards system, VendWise incentivizes users to participate in responsible plastic disposal. Unlike conventional recycling bins, which rely on voluntary participation without immediate benefits, VendWise motivates users through redeemable rewards, increasing engagement and long-term behavioural change.

Governments and businesses worldwide are under increasing pressure to adopt sustainable practices and reduce their environmental footprint. The implementation of smart recycling solutions such as VendWise aligns with global sustainability goals, including the reduction of single-use plastics and the promotion of a circular economy. Additionally, urban areas, corporate offices, educational institutions, and commercial spaces present significant market opportunities for the deployment of VendWise machines, ensuring widespread accessibility and participation.

This paper explores the potential of VendWise in addressing plastic pollution through technological innovation and community engagement. It evaluates the feasibility of the business model, market opportunities, and financial sustainability, while also analysing potential risks and regulatory considerations. By leveraging technology and behavioural incentives, VendWise represents a transformative approach to sustainable waste management, paving the way for a cleaner and more environmentally responsible future. Traditional recycling methods lack accessibility and incentives for participation. VendWise aims to bridge this gap by providing a user-friendly, automated system for responsible plastic disposal, encouraging recycling behaviour through financial rewards and environmental awareness.

II. LITERATURE REVIEW

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances* - This study quantifies global plastic production and waste accumulation. It highlights the urgent need for efficient waste management systems like reverse vending machines to mitigate plastic pollution.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. *Philosophical Transactions of the Royal Society - The paper discusses the challenges in plastic recycling, emphasizing the importance of technological interventions like automated sorting and incentives to improve recycling rates.*

UNEP (2018). *Single-Use Plastics: A Roadmap for Sustainability* - This report evaluates global strategies for reducing single-use plastics, supporting the implementation of smart recycling solutions such as VendWise.

Ellen MacArthur Foundation (2016). *The New Plastics Economy: Rethinking the future of plastics* - It advocates for a circular economy approach, emphasizing the need for innovative recycling solutions and extended producer responsibility (EPR) frameworks.

Zhao, X., Cornish, K., & Vodovotz, Y. (2021). Narrowing the loop for the circular economy: Recapturing value for sustainable plastics. *ScienceDirect* - The paper explores sustainable recycling models and highlights the role of consumer incentives in increasing participation in recycling programs.

Singh, N., Hui, D., Singh, R., Ahuja, I., Feo, L., & Fraternali, F. (2017). Recycling of plastic solid waste: A state of the art review and future applications. *Composites Part B: Engineering* - A comprehensive review of plastic waste recycling technologies and their efficiency, supporting the adoption of smart reverse vending machines.

Cecchini, L., Bellini, F., & Mola, F. (2020). Reverse Vending Machines for Plastic Waste Recycling: A Behavioural Approach. *Sustainability* - Examines consumer behaviour towards reverse vending machines, indicating that financial incentives significantly increase recycling participation.

Gonzalez, L., & Santonja, G. G. (2018). Waste management strategies and circular economy: The case of plastic waste. *Journal of Environmental Management* - Discusses the impact of various waste management strategies and the potential of RVMs to improve plastic waste collection efficiency.

OECD (2019). *Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade* - Reviews international policies on plastic waste management and the importance of industry collaboration in enhancing recycling infrastructure.

III. OBJECTIVE OF STUDY

- To analyse the efficiency and feasibility of VendWise as a sustainable waste management solution.
- To assess the market demand and opportunities for reverse vending machines.
- To examine the technological and financial viability of VendWise.

IV. RESEARCH METHODOLOGY

This study employs a comprehensive secondary research approach, drawing insights from various credible sources. Industry reports and regulatory frameworks from global organizations, such as the United Nations Environment Programme (UNEP) and the Organization for Economic Cooperation and Development (OECD), provide critical data on plastic waste management trends and policies. Case studies on existing reverse vending machine (RVM) implementations in regions like Europe, North America, and Asia offer valuable lessons on consumer behaviour and operational efficiency. Technological advancements, including sensor-based sorting, Internet of Things (IoT) integration, and AI-driven waste classification, are examined to evaluate their applicability in enhancing recycling efficiency. Additionally, market research reports and trade publications contribute to understanding industry trends, competitive landscapes, and the financial viability of the VendWise model. Financial feasibility is assessed by analysing revenue streams such as per-bottle disposal fees, corporate sponsorships, and government subsidies. This secondary research methodology ensures a well-rounded evaluation of VendWise's potential impact, scalability, and contribution to sustainable waste management practices.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

V. NEED FOR INNOVATION

The current waste management landscape faces numerous challenges, including inefficient collection systems, lack of consumer participation, and the absence of economic incentives for recycling. Traditional waste disposal methods, including landfills and incineration, contribute significantly to environmental degradation, leading to soil, air, and water pollution. Despite various awareness campaigns, recycling rates remain suboptimal due to the inconvenience and time-consuming nature of the process.

VendWise addresses these challenges by offering an automated, technology-driven solution that simplifies and incentivizes recycling. The integration of smart sensors ensures efficient waste sorting, reducing contamination and improving recycling rates. Real-time monitoring via IoT connectivity enhances operational efficiency by enabling predictive maintenance and optimizing collection schedules. Additionally, the gamified reward system encourages user participation by providing tangible incentives, such as redeemable points or discounts, fostering long-term behavioural change.

Moreover, regulatory frameworks like Extended Producer Responsibility (EPR) and international sustainability commitments are driving corporations toward eco-friendly initiatives. VendWise aligns with these goals by offering businesses a measurable and transparent method to track and fulfil their environmental commitments. The rise of smart city initiatives further emphasizes the need for intelligent waste management systems, positioning VendWise as a viable solution for modern urban landscapes.

By combining technological innovation, behavioural incentives, and sustainability-driven policies, VendWise presents a groundbreaking approach to waste management. This innovation not only enhances recycling efficiency but also contributes to environmental conservation and the development of a circular economy.

VI. MARKET AND MARKET OPPORTUNITY

The global waste management industry is experiencing rapid growth, driven by increasing environmental concerns, regulatory mandates, and advancements in recycling technologies. Governments and businesses worldwide are investing in sustainable waste management solutions to meet international sustainability goals, such as the United Nations Sustainable Development Goals (SDGs) and the European Green Deal. The reverse vending machine (RVM) market, in particular, is gaining traction due to its ability to streamline recycling efforts and engage consumers through incentive-driven participation.

Urban centres, corporate offices, educational institutions, and public spaces present significant opportunities for VendWise deployment. These high-footfall locations ensure maximum accessibility and user engagement. Shopping malls, metro stations, and supermarkets serve as ideal placement zones, where consumers frequently dispose of plastic waste. Additionally, businesses and municipalities looking to enhance their corporate social responsibility (CSR) initiatives can integrate VendWise machines to meet sustainability targets.

The demand for smart waste management solutions is further fuelled by government policies promoting sustainable practices, such as plastic deposit refund schemes and bans on single-use plastics. Countries with established RVM programs, such as Germany and Norway, have reported significant increases in recycling rates, demonstrating the potential for similar success in other regions. Emerging markets in Asia and Africa also offer vast opportunities as governments invest in infrastructure to combat rising plastic pollution.

VendWise capitalizes on these trends by providing an innovative and scalable solution tailored to evolving consumer behaviours and regulatory requirements. With strong market potential and strategic placement, the project is well-positioned to drive widespread adoption and contribute to a cleaner, more sustainable future. Current waste management systems suffer from inefficiencies due to inadequate collection infrastructure, lack of public participation, and limited economic incentives. VendWise introduces an automated, sensor-based sorting mechanism, real-time monitoring, and digital reward systems to enhance recycling participation and operational efficiency.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

VII. BUSINESS MODEL CANVAS

Key Partners <p>Recycling facilities, corporate sponsors, government agencies, smart waste management companies, retail chains & shopping malls, logistics & maintenance providers.</p>	Key Activities <p>Machine manufacturing & maintenance, marketing & awareness campaigns, data collection & analysis, user engagement & loyalty program, regulatory compliance & partnerships, technology development.</p>	Value Propositions <p>Convenient & incentivized recycling, reduces plastic pollution, encourages corporate sustainability, real-time monitoring & reporting, smart recycling solutions, educational & behavioural impact.</p>	Customer Relationships <p>Gamified engagement through reward systems, loyalty programs, educational content to drive long-term recycling habits, corporate partnerships to enhance sustainability efforts, real-time user support through digital platforms.</p>	Customer Segments <p>Environmentally conscious individuals, businesses supporting sustainability, educational institutions, municipalities, large event organizers, hospitality & tourism industry.</p>
Key Resources <p>Smart vending machines, AI & IoT technology for waste sorting, data analytics for tracking recycling behaviours, corporate sponsorships & funding, partnerships with recycling facilities, mobile app for user engagement.</p>			Channels <p>Direct installation, digital engagement via an app, retail partnerships, municipal waste collection programs, corporate collaborations, online & offline marketing.</p>	
Cost Structure <p>Purchase cost, maintenance, marketing & promotions, operational logistics, data storage & processing, customer service & support, compliance & legal expenses.</p>			Revenue Streams <p>Advertisement partnerships, subscription model, data insights sales, service & maintenance fees, government incentives, brand collaborations & sponsorships.</p>	

OPERATIONAL PLAN

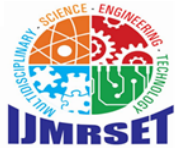
Operational Plan VendWise’s operational plan ensures efficient deployment, maintenance, and management of reverse vending machines (RVMS) to facilitate seamless plastic waste collection and recycling. The project follows a strategic approach, beginning with the identification of high-footfall locations such as shopping malls, metro stations, corporate campuses, and educational institutions. The machines will be installed in collaboration with municipal bodies and private stakeholders to maximize reach and accessibility.

Once deployed, each machine will be monitored through an IoT-enabled system that provides real-time data on fill levels, machine status, and usage analytics. Routine maintenance will be scheduled based on predictive analysis, minimizing downtime and ensuring optimal functionality. A dedicated team will oversee logistics, including timely waste collection and transfer to partnered recycling facilities. Additionally, customer support services will be available to assist users and address technical issues.

VendWise will implement an awareness campaign to educate the public on responsible recycling and the benefits of using the machines. Partnerships with local authorities and corporate sponsors will further enhance visibility and engagement. The company aims to scale operations by expanding its network of machines, integrating advanced AI-driven sorting mechanisms, and continuously refining its incentive system to encourage higher participation.

VIII. PROJECTED FINANCIALS AND FUNDING

Projected Financials and Funding VendWise's financial model is designed to ensure sustainability and long-term growth. The initial investment required for manufacturing, installation, and technological infrastructure is estimated at INR 50 lakh. Key revenue streams include per-bottle disposal fees, corporate sponsorships, advertising partnerships, and government subsidies. Based on projected adoption rates, revenue is expected to grow at an annual rate of 20%, with a break-even point anticipated within three years.

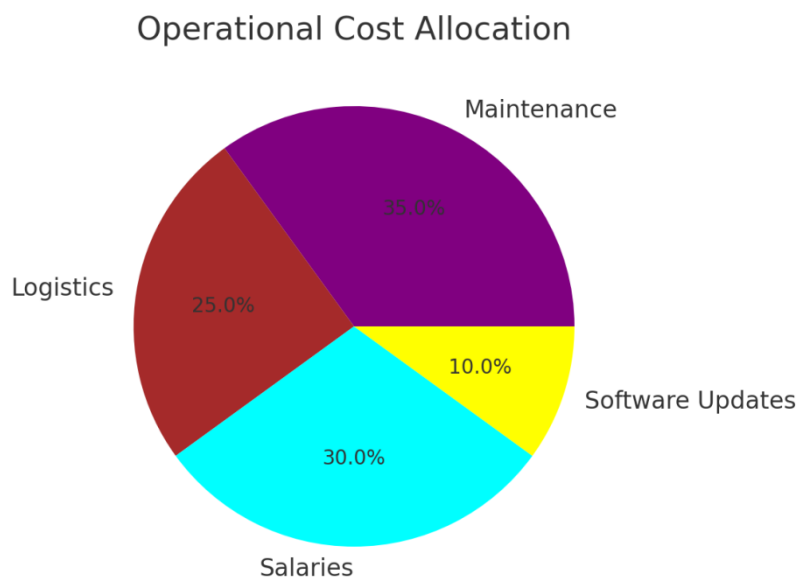
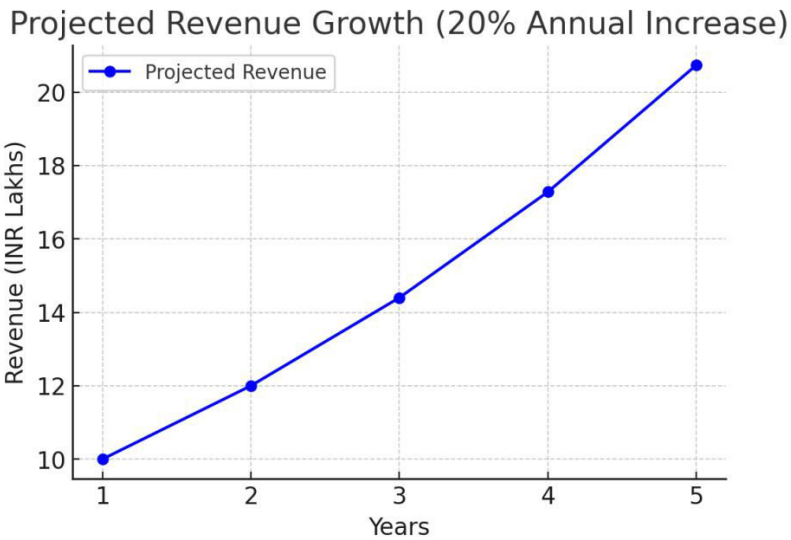


International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Corporate sponsorships from companies looking to improve their Corporate Social Responsibility (CSR) initiatives will be a significant funding source. Additionally, VendWise will seek grants and subsidies from government programs focused on environmental sustainability, such as Swachh Bharat Abhiyan and Start-up India. A portion of revenue will be reinvested into research and development to enhance machine efficiency and user engagement.

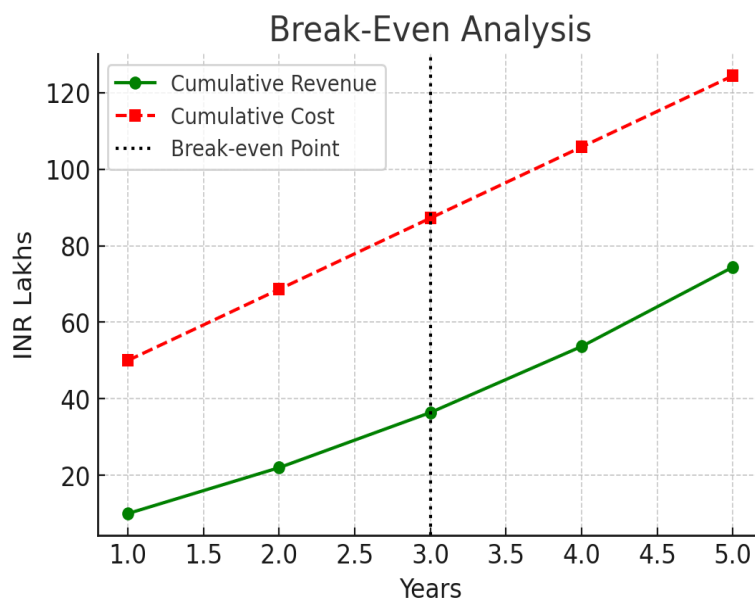
Operational costs, including maintenance, logistics, employee salaries, and software updates, will be closely managed to optimize profitability. The scalability of the model will be determined by performance metrics such as machine utilization rates, customer engagement, and partnerships secured. Long-term funding strategies may include venture capital investment and crowdfunding initiatives to accelerate expansion.



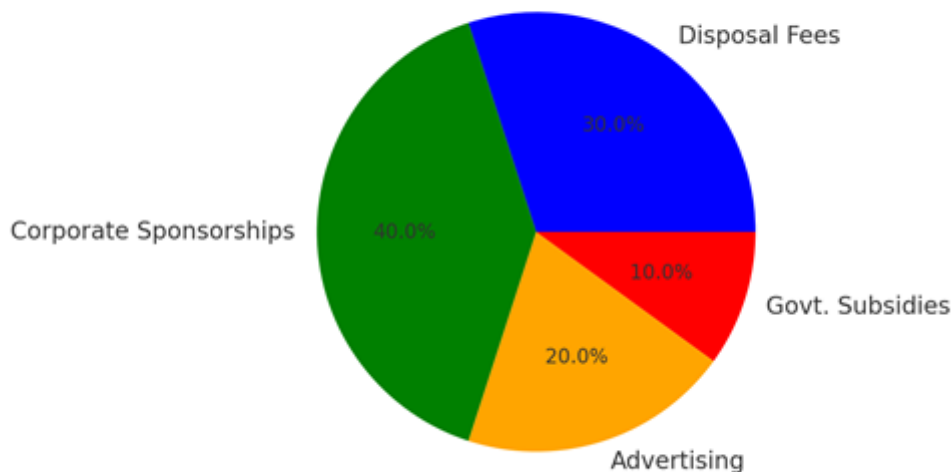


International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Funding Sources Breakdown

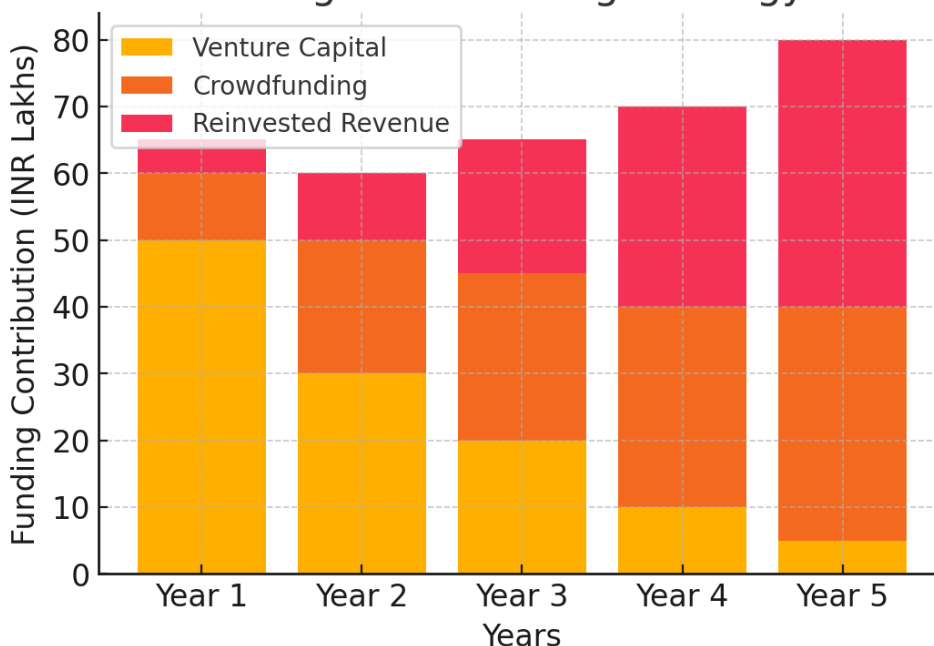




International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Long-Term Funding Strategy



The projected revenue growth is set at an annual rate of 20%, with a break-even point expected in Year 3, based on the cumulative revenue surpassing cumulative costs. Revenue sources are diversified, including disposal fees, corporate sponsorships, advertising, and government subsidies. Operational costs are allocated across key areas such as maintenance, logistics, salaries, and software updates to ensure efficient management. Over the long term, funding will be secured through a combination of venture capital, crowdfunding, and reinvested revenue, supporting financial sustainability over the next five years.

IX. RISK FACTORS

Despite its strong market potential, VendWise faces several risks that must be managed effectively. Regulatory risks include evolving government policies on plastic waste and recycling, which could impact machine operations or financial incentives. Technological risks involve potential malfunctions in sensors, IoT connectivity issues, or software glitches, requiring continuous upgrades and maintenance.

Market risks include user adoption rates, as public participation is essential for the model's success. If consumers do not engage with the system, revenue projections may be affected. Financial risks include reliance on external funding sources, and any downturn in sponsorship or government subsidies could impact operations. To mitigate these risks, VendWise will establish contingency plans, diversify revenue streams, and build strategic partnerships.

X. PROTOTYPE DEVELOPMENT

The VendWise prototype incorporates key features to ensure efficiency, ease of use, and sustainability. The machine is designed with a compact and durable frame to withstand high usage in public areas. It integrates infrared and ultrasonic sensors to validate and sort plastic waste accurately.

The system includes an automated bin opening mechanism, an LCD display for user interaction, and a reward system that generates redeemable points. IoT connectivity allows for remote monitoring and real-time notifications to optimize collection and maintenance schedules. Safety features include tamper-proof locks and emergency shutdown protocols.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

A pilot deployment of the prototype will be conducted in select locations to gather user feedback and operational insights. The data collected will be used to refine the machine's design, enhance user experience, and improve incentive structures. Continuous iterations and technological advancements will ensure the machine remains efficient and scalable for broader implementation. VendWise's operational strategy revolves around efficiency, accessibility, and sustainability. The deployment of reverse vending machines (RVMs) is planned for high-traffic locations such as shopping malls, metro stations, corporate campuses, educational institutions, and public spaces to maximize visibility and usage. Each machine will be equipped with IoT-based real-time monitoring to ensure operational efficiency, track bin capacity, and enable predictive maintenance. A dedicated logistics network will handle regular collection and transportation of deposited plastic waste to certified recycling centres, ensuring that materials are processed in compliance with sustainability standards. Additionally, a technical support team will be available for regular servicing and troubleshooting, minimizing downtime and enhancing user experience. Strategic partnerships with municipalities, waste management firms, and corporate sponsors will further streamline operations, helping to integrate VendWise seamlessly into existing waste management infrastructures. Public awareness campaigns and digital engagement strategies will also be employed to increase participation and encourage sustainable disposal habits among users.

XI. CONCLUSION

VendWise represents a significant advancement in plastic waste management by leveraging technology, incentives, and strategic partnerships to encourage responsible disposal practices. With the growing concern over plastic pollution and the inefficiencies of traditional recycling systems, this innovative approach provides a scalable and sustainable solution to address these challenges effectively.

By integrating reverse vending machines (RVMs) in high-traffic areas, VendWise ensures accessibility and ease of use, promoting widespread adoption among consumers. The incorporation of IoT-enabled monitoring and predictive maintenance enhances operational efficiency, while the gamified reward system fosters long-term behavioural change towards sustainable waste management. Additionally, the collaboration with corporate sponsors, municipalities, and government initiatives strengthens its financial sustainability and market positioning.

Despite potential risks such as regulatory changes, technological challenges, and market uncertainties, VendWise has developed robust mitigation strategies, including continuous system upgrades, diversified revenue streams, and strategic stakeholder engagement. The projected financial model suggests a viable path to profitability within three years, with substantial growth potential in both urban and semi-urban regions.

As governments and businesses worldwide continue to push for sustainable practices, VendWise aligns with global sustainability goals, providing a tangible and impactful solution to plastic waste management. By fostering consumer participation and corporate responsibility, VendWise paves the way for a cleaner, more sustainable future, contributing to the broader vision of a circular economy and environmental conservation. VendWise offers a transformative approach to plastic waste management, combining technology, incentives, and community engagement. By addressing environmental concerns, the project presents a scalable and financially viable model, paving the way for a sustainable future in waste management.

REFERENCES

1. Ellen MacArthur Foundation. (2016). The new plastics economy: Rethinking the future of plastics. Retrieved from <https://www.ellenmacarthurfoundation.org/publications>
2. Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*. Retrieved from <https://advances.sciencemag.org/content/3/7/e1700782>
3. Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: Challenges and opportunities. *Philosophical Transactions of the Royal Society*. Retrieved from <https://royalsocietypublishing.org/doi/10.1098/rsta.2008.0311>
4. OECD. (2019). Improving plastics management: Trends, policy responses, and the role of international cooperation and trade. Retrieved from <https://www.oecd.org/environment/plastics/>
5. UNEP. (2018). Single-use plastics: A roadmap for sustainability. Retrieved from <https://www.unep.org/resources/report/single-use-plastics-roadmap-sustainability>



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

6. World Economic Forum. (2020). Plastics, the circular economy, and global policy responses. Retrieved from <https://www.weforum.org/reports/plastics-and-the-circular-economy>
7. National Geographic. (2019). Plastic pollution and its impact on the environment. Retrieved from <https://www.nationalgeographic.com/environment/article/plastic-pollution>
8. European Commission. (2021). EU strategy for plastics in a circular economy. Retrieved from <https://ec.europa.eu/environment/topics/plastics>
9. The World Bank. (2021). Plastic waste and the challenge of sustainable development. Retrieved from <https://www.worldbank.org/en/news/feature/2021/05/31/plastic-waste-and-sustainable-development>
10. The Guardian. (2022). The future of plastic recycling and sustainability efforts. Retrieved from <https://www.theguardian.com/environment/plastic-recycling>
11. Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances*, 3(7), e1700782. <https://doi.org/10.1126/sciadv.1700782>
12. Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1526), 2115–2126. <https://doi.org/10.1098/rstb.2008.0311>
13. UNEP. (2018). Single-Use Plastics: A Roadmap for Sustainability. United Nations Environment Programme. <https://www.unep.org/resources/report/single-use-plastics-roadmap-sustainability>
14. Ellen MacArthur Foundation. (2016). The New Plastics Economy: Rethinking the future of plastics. <https://ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics>
15. Zhao, X., Cornish, K., & Vodovotz, Y. (2021). Narrowing the loop for the circular economy: Recapturing value for sustainable plastics. *Science of The Total Environment*, 774, 145732. <https://doi.org/10.1016/j.scitotenv.2021.145732>
16. Singh, N., Hui, D., Singh, R., Ahuja, I., Feo, L., & Fraternali, F. (2017). Recycling of plastic solid waste: A state of the art review and future applications. *Composites Part B: Engineering*, 115, 409–422. <https://doi.org/10.1016/j.compositesb.2016.09.013>
17. Cecchini, L., Bellini, F., & Mola, F. (2020). Reverse Vending Machines for Plastic Waste Recycling: A Behavioural Approach. *Sustainability*, 12(18), 7655. <https://doi.org/10.3390/su12187655>
18. Gonzalez, L., & Santonja, G. G. (2018). Waste management strategies and circular economy: The case of plastic waste. *Journal of Environmental Management*, 216, 25-35. <https://doi.org/10.1016/j.jenvman.2017.09.083>
19. OECD. (2019). Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade. <https://www.oecd.org/environment/improving-plastics-management-9789264301016-en.htm>



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com