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Exploring Digitalized Food Waste Management and Urban Farming Sustainability through the Sustainability Tracker 360 in Malaysian Vocational Colleges

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Abstract

This exploratory study investigates how digital innovation, through the Sustainability Tracker 360, enhances sustainable practices in food waste management and urban farming within Malaysian vocational colleges. The Sustainability Tracker 360 is a digital dashboard developed to monitor composting efficiency, fertilizer production, and plant growth in real time. Using a mixed methods design, five vocational colleges implemented composting systems that converted 43.35 kilograms of food waste into 12.95 kilograms of organic fertilizer, with an average conversion rate of 29.9 percent. The fertilizer supported 150 potted plants cultivated across campuses in collaboration with Junior Chamber International (JCI) Bayan and OCBC Bank. Data visualization from the dashboard revealed active project continuity for at least three months after completion. The findings confirm that digital monitoring strengthens accountability, fosters long term engagement, and deepens sustainability awareness among students, lecturers, and community partners. The study contributes to the growing discourse on circular economy practices, green TVET transformation, and digital governance in education for sustainable development.

Keywords: Food Waste Reduction, Urban Farming, Circular Economy, TVET Sustainability, Digital Dashboard

Introduction

Food waste is a pressing global challenge. The Food Waste Index 2024 reports that nearly one third of all food produced for human consumption is lost or wasted throughout the supply chain, contributing to greenhouse gas emissions and resource depletion. In Malaysia, rapid urbanization, changing consumption patterns, and limited waste management infrastructure exacerbate the issue, with approximately 16,000 tons of food waste generated daily.

Educational institutions, particularly technical and vocational colleges, are not exempt from this problem; however, they hold great potential as catalysts for sustainability through applied learning and innovation.

Urban farming represents one such innovative approach, transforming food waste into valuable compost that supports sustainable agriculture. By integrating composting into campus operations, vocational colleges can reduce waste while cultivating edible gardens that enhance food security and environmental literacy. Yet, sustainability projects often lose momentum once funding ceases due to weak monitoring and accountability mechanisms. Digitalization, particularly through dashboards that enable real time data tracking and visualization, can address these issues and sustain long term engagement (Agyemang et al., 2024).

This study investigates how the Sustainability Tracker 360, a digital tool developed for vocational colleges in Penang, supports waste reduction and sustainable farming practices through data driven monitoring and community collaboration.

Literature Review

Food Waste and the Circular Economy

The circular economy advocates for reusing, recycling, and regenerating resources to minimize waste. Composting embodies this principle by transforming organic waste into nutrient rich fertilizer, reducing landfill dependency, and closing ecological loops. Globally, per capita food waste significantly contributes to environmental degradation and economic losses (Tutar et al., 2025). In Malaysia, limited awareness and unsustainable disposal habits remain critical barriers (Ahmad et al., 2021; Azeman et al., 2021). Research further indicates that quantifying and visualizing waste generation can increase public consciousness and promote behavioural change (Sharvini et al., 2025).

Urban Farming and Food Security

Urban farming enhances food resilience by producing fresh food locally and reducing transport emissions. While Malaysian initiatives have shown promise (Saarani et al., 2025), challenges such as spatial constraints and technical skills persist (Yapp et al., 2025). Studies demonstrate that composting within educational institutions not only supports sustainable farming but also strengthens students' awareness of environmental stewardship (Ali et al., 2022; Daud & Mohamed, 2025). Embedding these practices in TVET curricula aligns with Malaysia's sustainability education objectives.

Digitalization and Sustainability Monitoring

Digital tools revolutionize how sustainability initiatives are managed. Dashboards such as the Sustainability Tracker 360 enable transparency, accountability, and participation by translating complex data into accessible insights (Agyemang et al., 2024; Bennett & Müller Loose, 2024). Human centered design approaches, when applied to environmental data systems, significantly enhance user engagement and institutional adoption (Hui et al., 2024).

Green TVET and ESG Integration

TVET institutions play a pivotal role in integrating Environmental, Social, and Governance (ESG) principles into education. UNESCO UNEVOC (2023) emphasizes embedding

sustainability in curricula and operations to nurture environmentally conscious graduates. Studies such as Melnyk et al. (2025) reaffirm that knowledge and environmental attitudes are strong predictors of pro sustainability behaviour.

Development of the Sustainability Tracker 360

The Sustainability Tracker 360 was designed as a cloud based system to collect, visualize, and compare composting data across institutions. It integrates systems thinking (Meadows & Wright, 2024) by linking waste management, agriculture, and digital literacy. The tool not only aids in operational tracking but also serves pedagogical purposes by teaching data analysis and sustainability communication.

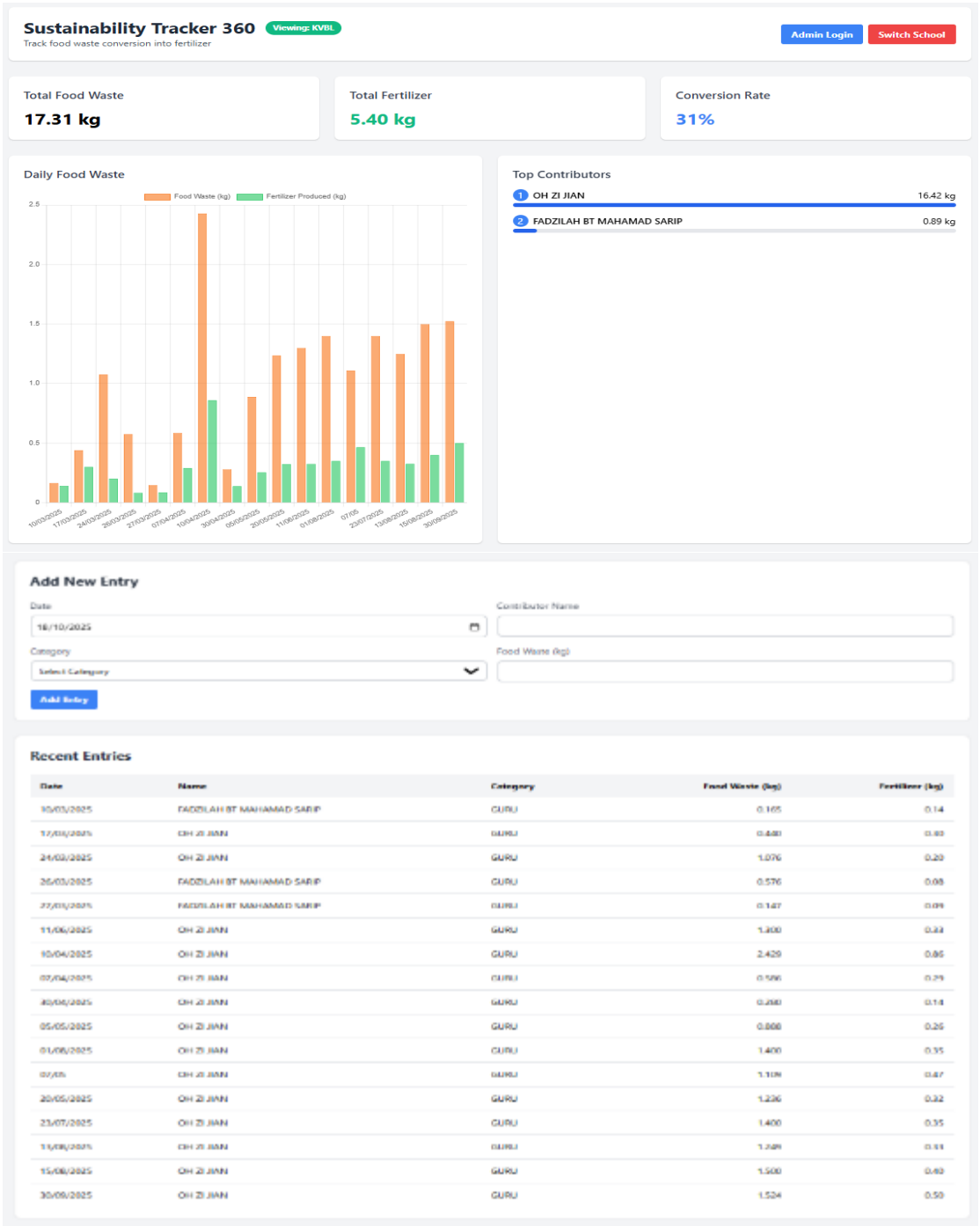

Figure A. Sustainability Tracker 360 Dashboard displaying real-time composting and urban-farming data across participating vocational colleges.

Research Objectives

The overarching aim of this study is to examine how the Sustainability Tracker 360 can strengthen sustainable food waste management and urban farming practices in Malaysian vocational colleges. Specifically, the study seeks to:

i. Evaluate the effectiveness of composting and urban farming initiatives in reducing food waste and promoting sustainable resource use.
ii. Assess the role of the Sustainability Tracker 360 in enhancing monitoring, data transparency, and project continuity.
iii. Explore the perceptions of students, lecturers, and partners regarding digital tools as enablers of environmental awareness and accountability.

Methodology

A mixed methods approach was employed across five vocational colleges: Batu Lanchang (KVBL), Balik Pulau (KVBP), Butterworth (KVBW), Nibong Tebal (KVNT), and Seberang Perai (KVSP). Each institution implemented a composting system to process cafeteria waste into fertilizer for campus urban farming. Data were collected weekly via the Sustainability Tracker 360 over six months (March to September 2025). Surveys and semi structured interviews captured participant experiences.

Quantitative data were analyzed descriptively, while qualitative responses underwent thematic analysis. A total of 43.35 kilograms of food waste were converted into 12.95 kilograms of fertilizer (average 29.9 percent conversion). Across institutions, 150 potted plants were cultivated using the compost produced. All colleges maintained composting activities three months after the project ended, indicating sustained commitment.

Findings and Discussion

Effectiveness of Composting and Urban Farming

Table 1

Summary of Composting and Urban Farming Data Recorded through the Sustainability Tracker 360 (March–September 2025)

College	Waste Collected (kg)	Fertilizer Produced (kg)	Conversion Rate (%)	Continuity (After 3 Months)
Kolej Vokasional Batu Lanchang	16.373	4.801	29.33	Active
Kolej Vokasional Nibong Tebal	7.831	2.377	30.35	Active
Kolej Vokasional Seberang Perai	10.530	3.047	28.94	Active
Kolej Vokasional Balik Pulau	5.721	1.825	31.90	Active
Kolej Vokasional Butterworth	2.895	0.903	31.19	Active

Note. Data were recorded weekly through the Sustainability Tracker 360 during the six-month project implementation period beginning in March 2025 and concluding in September 2025.

Conversion rate refers to the percentage of fertilizer produced relative to the amount of food waste collected

Table 1 summarizes the composting performance across the participating colleges. The results reveal consistent conversion rates between 28.94 and 31.90 percent, demonstrating high efficiency and standardization of composting practices. The active continuity across institutions further highlights the success of the digital tracking system in promoting sustained engagement.

Role of the Sustainability Tracker 360

The dashboard effectively visualized performance trends, motivating participants to sustain composting practices. It enhanced accountability by enabling weekly data comparisons and transparency for external reporting to partners such as JCI Bayan and OCBC Bank. The findings affirm that data visibility directly correlates with user motivation and continuity, supporting Agyemang et al. (2024).

Stakeholder Perceptions

Students appreciated the system's user friendly design, reporting greater responsibility toward waste reduction. Lecturers highlighted its pedagogical value in sustainability and data interpretation, while corporate partners recognized its transparency benefits. These perceptions mirror the community readiness and behavioural models proposed by Haris et al. (2022) and Abdullah et al. (2022).

Challenges and Lessons Learned

Digital literacy gaps and limited space for farming were the main challenges. Regular training and gamified incentives helped maintain engagement. The project underscores the need for supportive ecosystems that integrate technology, pedagogy, and community collaboration.

Conclusion

This study demonstrates that integrating composting, urban farming, and digital monitoring through the Sustainability Tracker 360 enhances institutional accountability and environmental stewardship within Malaysia's TVET system. Across five colleges, consistent composting efficiency and project continuity reflected behavioural transformation driven by data transparency. Digital dashboards such as the Sustainability Tracker 360 can transform short term sustainability projects into long term institutional practices aligned with SDG 12: Responsible Consumption and Production.

This study contributes theoretically by extending the application of systems thinking and digital governance frameworks within the context of TVET-based sustainability education. It bridges the gap between technology adoption and environmental behaviour by demonstrating how real-time data visualization strengthens institutional accountability and pro-environmental attitudes. Contextually, the findings advance the understanding of how Malaysian vocational colleges can operationalize circular economy principles through digital innovation, transforming sustainability from project-based initiatives into institutional culture. By situating the Sustainability Tracker 360 as both a pedagogical and managerial tool, this research underscores its potential to inform national TVET policy, digital literacy integration, and Education for Sustainable Development (ESD) strategies in Southeast Asia.

Recommendations

To institutionalize sustainable practices, it is recommended that the Sustainability Tracker 360 be formally adopted across all vocational colleges as part of standard operational and teaching frameworks. Composting and urban farming modules should be integrated into curricula to strengthen sustainability competencies. Regular digital literacy training for lecturers and students will ensure data accuracy and engagement. Future iterations of the dashboard may include mobile integration, multilingual support, and artificial intelligence based analytics. Expanding the project nationally will promote benchmarking, collaboration, and shared learning among institutions. Through these measures, vocational colleges can become leading exemplars of digital sustainability education in Malaysia.

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