



# Toward a Transformative Circular Pedagogy Model: Teacher Agency and Sustainability Education in Rural Island Schools

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## ABSTRACT

**Background:** Sustainability education in marginalized rural–island contexts remains insufficiently theorized, particularly where material scarcity and weak institutional support constrain pedagogical practice. Existing Education for Sustainable Development (ESD) literature predominantly reflects well-resourced settings, offering limited insight into how locally available materials, such as school waste, can be reconfigured as meaningful learning resources. **Purpose:** This study examines how teacher agency mediates the transformation of school waste into sustainability-oriented learning and develops a context-sensitive model of Transformative Circular Pedagogy. **Method:** A qualitative multiple-case study was conducted in two public senior high schools in Wakatobi, Indonesia. Data were generated through semi-structured interviews, classroom observations, and document analysis, and analyzed using reflexive thematic analysis supported by NVivo to identify cross-case patterns and construct an integrative model. **Findings:** The analysis reveals four interrelated processes: (1) waste as epistemic resource, (2) teacher agency as pedagogical driver, (3) experiential learning and student transformation, and (4) institutional fragility and innovation limits. These processes operate within a recursive system in which institutional dynamics continuously reshape material conditions, generating new cycles of pedagogical innovation. **Conclusion:** This study advances a Transformative Circular Pedagogy Model that reconceptualizes waste as an epistemic catalyst and positions teacher agency as the core mechanism of sustainability learning in resource-constrained contexts. Theoretically, it integrates material, pedagogical, and institutional dimensions into a dynamic circular framework. Practically and at the policy level, the findings highlight the urgency of institutionalizing sustainability education through governance alignment, professional support, and resource provision to ensure long-term scalability and impact.



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## INTRODUCTION

Sustainability has emerged as one of the most critical global challenges of the twenty-first century, affecting ecological systems, economic resilience, and social equity (Huntjens & Kemp, [advance online publication](#); Mikalauskienė et al., [advance online publication](#)). In response, education has been increasingly recognized as a strategic instrument for fostering environmentally responsible citizenship and sustainable development (Chiba et al., 2021; Chasokela, 2024). International frameworks on Education for Sustainable Development (ESD) emphasize that schools must move beyond knowledge transmission to cultivate values, competencies, and critical engagement with sustainability issues (Chasokela, 2024; Precious & Zino, 2025). However, despite growing policy commitments, translating these principles into meaningful classroom practices remains a persistent challenge, particularly in marginalized and resource-constrained settings (Fitriyah, 2025; Nopas, [advance online publication](#)).

Contemporary scholarship underscores that effective sustainability education requires transformative pedagogies grounded in experiential learning, contextual relevance, and participatory engagement (Alam, 2022; Farooq, 2023). Constructivist and experiential learning perspectives suggest that students internalize sustainability values more deeply when engaging directly with real-world environmental problems (Friman et al., 2024; Aribowo et al., 2025). Within

this process, teacher agency plays a pivotal role in mediating curriculum goals and contextual realities, positioning teachers as adaptive change agents who reconstruct environmental challenges into pedagogical opportunities (Sang, 2022; Cong-Lem, 2024). Nevertheless, existing literature predominantly reflects well-resourced institutional contexts, leaving limited understanding of how sustainability pedagogy operates in structurally disadvantaged environments (Prazian & Prykhodko, 2023; Mochere, 2025).

Empirical research on recycled-based learning and circular economy education highlights its potential to enhance creativity, ecological awareness, and problem-solving skills curricula (Belbase et al., 2022; Bărbulescu et al., 2025; Djam'an, 2025). However, these studies are largely situated in urban or resource-rich settings and tend to emphasize product-oriented innovation rather than pedagogical processes. Consequently, limited attention has been given to how sustainability practices are constructed, sustained, and constrained in rural island schools characterized by geographical isolation, infrastructural limitations, and weak institutional governance (Nasir & Mujiati, 2020; Almeida & Daniel, 2025). More critically, the interaction between teacher agency, experiential learning, and organizational capacity in shaping sustainability education remains underexplored (Wang et al., 2021; Walshe & Rushton, 2025).

In Indonesia, these challenges are particularly evident in archipelagic regions such as Wakatobi Regency, Southeast Sulawesi. Despite its ecological richness, environmental education in local schools remains underdeveloped (Ariando, 2021; Coulson, 2024; Karim et al., 2024). Waste management practices are fragmented, and recyclable materials with pedagogical potential are underutilized. Teachers operate under conditions of material scarcity, limited professional support, and minimal policy guidance, creating a paradox in which environmental abundance coexists with pedagogical vulnerability (Symeonidis et al., 2023; Chuene & Teane, 2024). Understanding how educators navigate this paradox is essential for developing context-sensitive sustainability education models (Khosronejad et al., 2023; Christolouka & Verdis, 2025; Singh, 2025).

Methodologically, prior studies have largely relied on survey-based or experimental approaches that privilege measurable outcomes over lived pedagogical (Perez et al., 2023; Adiprasetyo, 2025). Such approaches offer limited insight into how teachers interpret and operationalize sustainability in everyday practice (Priestley et al., 2021; Popa, 2022). To address this gap, this study adopts a qualitative multiple-case design grounded in an interpretivist paradigm and integrates constructivist learning theory, experiential learning theory, and institutional change perspectives to examine sustainability pedagogy across classroom, professional, and organizational levels (Bak-Andersen, 2021; Arachhige & Jayasinghe, 2024; Ruswinarsih et al., 2025).

Against this background, this study addresses the following questions: (1) How do material conditions and waste availability shape sustainability-oriented pedagogical practices in rural island schools? (2) How does teacher agency mediate the integration of recycled-based learning into classroom instruction? (3) How does experiential sustainability pedagogy influence students' cognitive, affective, and behavioral development? (4) What institutional factors facilitate or constrain the long-term sustainability of these practices? This study makes three principal contributions to sustainability education research. First, it reconceptualises recycled materials as epistemic resources that trigger pedagogical and cultural transformation, rather than merely as low-cost instructional tools. Second, it advances the notion of adaptive teacher agency by demonstrating how educators in resource-poor environments construct innovative learning ecosystems. Third, it proposes a context-sensitive model of Transformative Circular Pedagogy that integrates material realities, professional mediation, learner transformation, and institutional capacity.

## METHOD

### Research Design and Paradigmatic Position

This study adopts a qualitative multiple-case study design grounded in an interpretivist paradigm to explore the implementation of Sustainability Teaching through recycled-based learning media in rural island schools. The interpretivist approach was selected to capture teachers' subjective meanings, pedagogical interpretations, and contextual practices in integrating sustainability principles into classroom instruction. This design enables an in-depth examination of how sustainability-oriented pedagogical innovations emerge, evolve, and are institutionalized within specific socio-ecological and organizational settings. A multiple-case approach was employed to facilitate analytical generalization across cases and to enhance the transferability of findings. Each school was treated as an embedded case comprising individual teachers, school leadership, and institutional practices. This structure allowed for cross-case comparison and the identification of convergent and divergent implementation patterns.

### Research Sites and Participants

The research was conducted in nine public senior high schools located in Wakatobi Regency, Southeast Sulawesi, Indonesia. These sites were purposively selected based on three criteria: (1) geographical isolation and rural island characteristics, (2) limited access to educational infrastructure, and (3) the presence of emerging environmental

education initiatives. Participants consisted of 36 individuals across the nine schools, including nine school principals (one from each school) and 27 teachers (three from each school). Teacher participants were selected using criterion-based purposive sampling with the following inclusion criteria: (1) a minimum of five years of teaching experience, (2) active involvement in sustainability-related learning activities, (3) experience in developing recycled-based learning media, and (4) willingness to participate in reflective inquiry. School principals were included to provide institutional perspectives and policy validation. Sampling continued until thematic saturation was achieved, indicated by the absence of new conceptual categories in successive interviews, ensuring analytical sufficiency and depth.

Data analysis was supported by NVivo 14, not only for data organization but also for advanced analytical procedures. Coding hierarchies were systematically developed to structure initial, axial, and selective codes. Query functions, including word frequency and matrix coding queries, were used to explore patterns and relationships across cases. In addition, visualization tools such as thematic maps and coding models were employed to represent interconnections among themes, enhancing analytical transparency and rigor. To strengthen reliability, a consensus-based intercoder approach was applied. Two researchers independently reviewed the coding framework and resolved discrepancies through iterative discussion, in line with reflexive thematic analysis principles (Braun and Clarke, 2023). While statistical measures such as Cohen’s kappa were not employed, this approach prioritizes interpretive validity, reflexivity, and theoretical coherence. Although the study is primarily cross-sectional, the four-month observation period provided a degree of temporal depth, allowing the researcher to capture evolving pedagogical practices and contextual dynamics. This strengthens the credibility of the findings, even though a full longitudinal design was not undertaken.

**Data Collection Methods**

*Semi-Structured Interviews*

Primary data were collected through semi-structured in-depth interviews. An interview protocol consisting of 18 open-ended questions was developed based on literature on Education for Sustainable Development, contextual learning, and teacher agency. The protocol was reviewed by two experts in qualitative research and piloted with two non-participant teachers to refine clarity and relevance.

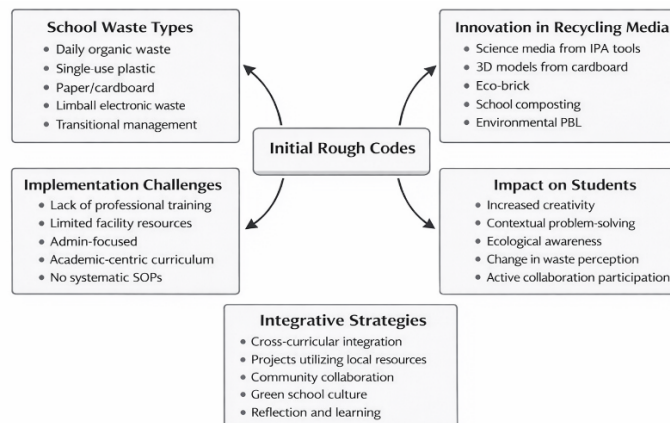
Interviews explored pedagogical practices, innovation processes, institutional support, perceived challenges, and professional development experiences. Each interview lasted between 60 and 90 minutes and was audio-recorded with participants’ consent. Follow-up interviews were conducted when clarification was required.

*Participant Observation*

Participant observation was conducted over a four-month period to capture naturally occurring instructional practices and interactions. The researcher adopted a participant-as-observer role, engaging in selected school activities while maintaining analytical distance.

Research instruments were developed through a four-stage process: theoretical mapping, item construction, expert validation, and pilot testing. The interview protocol was derived from established sustainability education frameworks and adapted to local contexts. Content validity was ensured through expert review, while construct validity was strengthened through iterative refinement. Revisions focused on eliminating leading questions and enhancing conceptual alignment with research objectives.

**Data Analysis Procedures**



**Figure 1.** Initial Rough Codes

Data analysis followed a reflexive thematic analysis approach integrated with Braun and Clarke, (2023) interactive model. Analysis was conducted in six interconnected phases. First, familiarization (Figure 1) was achieved through repeated reading of verbatim transcripts and field notes.

Analytical memos (Figure 2) captured emerging interpretations. Rural schools generate organic, plastic, paper, and limited e-waste, initially seen as a cleanliness issue but later reframed as learning resources. Teachers adaptively use these materials for instructional purposes, driven by resource constraints. This fosters student engagement and shifts perceptions of waste as valuable, although learning often remains product-oriented rather than deeply ecological.

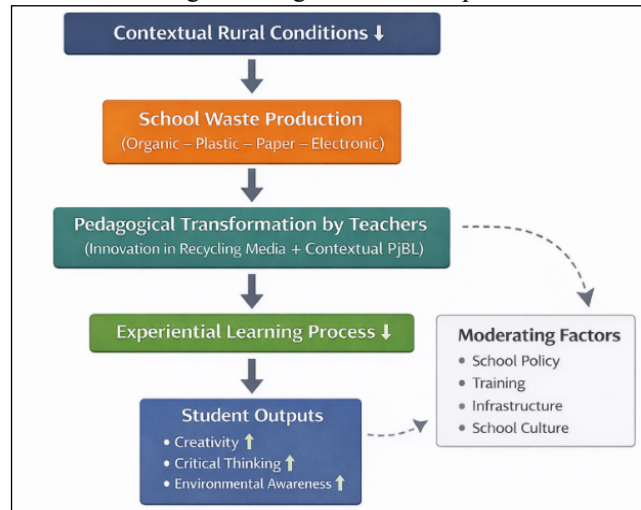


Figure 2. Analytic Memo

The main constraints are structural in nature, including limited professional training, minimal formal policy support, administrative burdens, and the absence of integrated waste management standard operating procedures aligned with the curriculum. Emerging strategies tend to be collaborative and contextual, such as integration into Project-Based Learning, partnerships with local communities, and the strengthening of a green school culture. Substantively, sustainability-oriented teaching practices have begun to take shape. However, they remain in an embryonic phase pedagogically strong but institutionally underdeveloped.

Second, initial coding was conducted using meaning-based open coding. Units of analysis consisted of phrases, sentences, or short paragraphs. Coding (Table 1) was performed manually and supported by qualitative data management software (NVivo 14) to enhance traceability.

Table 1. Initial Codes

Code Name	Operational Definition	Inclusion Criteria	Exclusion Criteria	Example Data Unit
Organic Waste Production	Statements referring to natural waste such as leaves and food scraps generated in schools	Explicit mention of organic waste produced in the school context	Not related to the school environment	<i>“Every day there are many leaves and food leftovers.”</i>
Waste as Learning Resource	Perception of waste as an educational medium	Indicates pedagogical transformation of waste into learning tools	Merely mentioning types of waste without educational meaning	<i>“We use used bottles as teaching aids.”</i>
Creativity from Constraints	Innovation emerging due to limited facilities or resources	Links resource limitations with instructional innovation	Innovation driven by formal policy mandates	<i>“Since we do not have proper tools, we create our own.”</i>
Environmental Project-Based Learning (PjBL)	Learning projects centered on ecological or environmental issues	Project activities involving recycling or environmental action	Regular instruction without a project-based component	<i>“Students make compost as part of their science project.”</i>

Code Name	Operational Definition	Inclusion Criteria	Exclusion Criteria	Example Data Unit
Increased Environmental Awareness	Changes in students' attitudes toward environmental responsibility	Mentions behavioral change related to environmental care	Only refers to student products or outputs	"Now students no longer litter carelessly."
Limited Policy Support	Statements indicating lack of formal regulation or institutional backing	Critiques or refers to weaknesses in institutional systems	Minor technical or operational obstacles	"There are no written regulations in the school yet."
Individual Dependency	Programs dependent on specific teachers rather than institutional systems	Shows the initiative is not systemically embedded	Collective or institutionally sustained programs	"If the teacher transfers, the program stops."
Green School Culture	Collective ecological habituation practices within the school	Routine environmental activities embedded in school culture	One-time or incidental environmental activities	"Every Friday we conduct a community clean-up."

Third, axial coding (Figure 3) was applied to cluster related codes into higher-order categories by examining contextual conditions, interactions, and consequences.

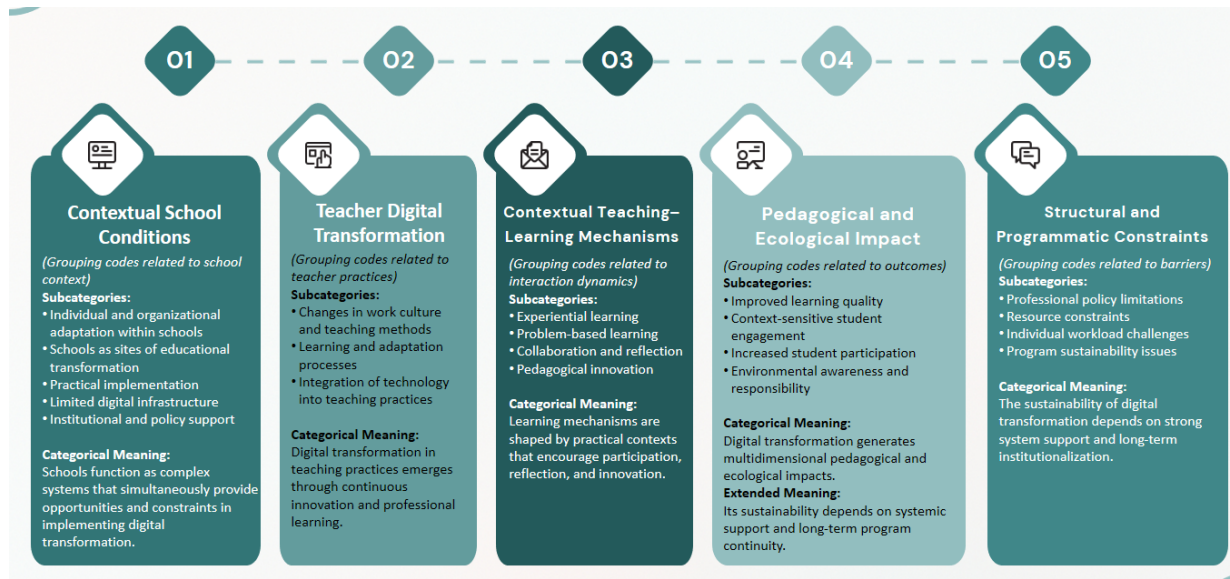


Figure 3. Axial Coding

Fourth, selective coding (Table 2) was conducted to synthesize categories into core themes that addressed the research questions. Theme development was guided by criteria of recurrence, conceptual density, and theoretical relevance.

Table 2. Selective Coding

Theme	Recurring Pattern	Thematic Boundaries
School Waste as Pedagogical Potential	Teachers and students frequently mention the dominance of organic and plastic waste and begin to view it as learning material	Focuses on perceptions and availability of waste as an initial context, not yet on learning outcomes
Teacher Innovation as a Transformative Agent	Innovation emerges from limited facilities and is not always policy-driven	Emphasizes the role and strategies of teachers, not student outcomes
Contextual Learning and Student Impact	Students become more active, creative, and demonstrate environmental behavioral change	Focuses on learning outcomes rather than supporting systems

Theme	Recurring Pattern	Thematic Boundaries
Program Sustainability and Systemic Support	Programs depend on individual initiatives and lack formal standard operating procedures	Highlights enabling and constraining factors rather than the direct learning process

Fifth, thematic mapping was performed to visualize interrelationships among themes and to construct an explanatory model of Sustainability Teaching implementation. Sixth, cross-case analysis was conducted to identify patterns of convergence and divergence between schools, thereby strengthening analytical generalization. To enhance analytical reliability, two independent researchers reviewed the coding structure. Intercoder agreement was discussed until consensus was reached, minimizing subjective bias.

#### Researcher Positionality and Reflexivity

Although the principal researcher does not hold primary disciplinary expertise in this specific area, the study was conducted under the close supervision of a senior academic advisor with extensive scholarly and practical expertise in the field. The principal researcher's background in educational management and sustainability studies, together with prior experience in conducting research within rural school contexts, provided valuable contextual awareness while simultaneously posing potential risks of interpretive bias. To strengthen methodological rigor and ensure analytical credibility, a systematic reflexive approach was implemented throughout the research process. This included maintaining reflective journals, explicitly documenting analytical decisions, and engaging in continuous supervisory dialogue and peer debriefing. Reflexive memos were incorporated into the audit trail to enhance transparency, support critical self-interrogation, and ensure that interpretations remained grounded in empirical evidence rather than researcher assumptions.

#### Trustworthiness and Rigor

Methodological rigor was established following Lincoln and Guba's trustworthiness framework (Lincoln et al., 2011). Credibility was ensured through prolonged engagement, member checking, and triangulation of interviews, observations, and documents. Participants reviewed preliminary interpretations to confirm accuracy. Transferability was strengthened through thick description of institutional contexts, pedagogical practices, and socio-cultural conditions.

Dependability was supported by maintaining a detailed audit trail documenting methodological decisions, coding iterations, and analytical revisions. Confirmability was enhanced through peer debriefing and systematic documentation, ensuring findings were grounded in empirical data rather than researcher predispositions.

#### Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of Universitas Muhammadiyah Kendari. Formal permission was secured from school authorities prior to data collection. All participants provided written informed consent. Confidentiality was ensured through anonymization using pseudonyms and secure data storage. Audio files and transcripts were encrypted and accessible only to the research team. Participants were informed of their right to withdraw at any stage without consequence. Research activities were conducted in accordance with national and international ethical guidelines for educational research.

#### Methodological Limitations

Several limitations must be acknowledged. First, the small sample size may limit statistical generalization, although analytical generalization remains robust. Second, reliance on self-reported data introduces potential social desirability bias. Third, the presence of the researcher may have influenced classroom behaviour (observer effect). Fourth, the cross-sectional design restricts longitudinal assessment of behavioural change. Future studies should consider longitudinal designs, mixed-methods approaches, and expanded institutional samples to enhance explanatory power.

#### Integration of Theory and Method

The analytical framework was informed by constructivist learning theory, experiential learning, and institutional change theory. These perspectives guided instrument development, coding structures, and thematic interpretation. For example, Vygotskian mediation principles informed the identification of teacher agency codes (Edwards, 2019), while experiential learning theory guided the categorization of student engagement patterns (Quibrantar & Ezezika, 2023).

## RESULTS

### Overview of Analytical Process and Thematic Structure

Data analysis generated four major themes through iterative coding, cross-case comparison, and reflexive interpretation. These themes emerged from 214 initial codes, clustered into 17 axial categories and synthesized into four overarching themes. Analytical saturation was achieved after the sixth teacher interview, with no substantially new conceptual categories emerging thereafter.

Cross-case analysis revealed both convergent and divergent patterns between two public schools in Wakatobi. While pedagogical innovation was evident in both sites, differences were observed in institutional support mechanisms and sustainability governance structures. Table 3 presents the thematic structure derived from the analysis.

**Table 3.** Summary of Themes and Analytical Categories

Theme	Core Categories	Analytical Focus
Reframing School Waste	Material awareness, ecological perception, contextual triggers	Cognitive transformation
Teacher Innovation Agency	Adaptive creativity, project integration, pedagogical mediation	Professional agency
Experiential Learning Outcomes	Student engagement, creativity, behavioral change	Transformative learning
Institutional Fragility	Policy gaps, leadership support, sustainability risks	Structural sustainability

#### *Theme 1: Reframing School Waste as a Pedagogical Resource*

Across both schools, teachers initially perceived waste as a cleanliness issue. However, sustained engagement gradually reframed it as a pedagogical resource. Participants described a cognitive shift from “waste management” to “learning resource utilization.” A teacher from Wangi-Wangi noted: “*At first, we only focused on cleaning. Now we see plastic bottles and organic waste as teaching materials.*” Similarly, a teacher from Tomia stated: “*What we used to throw away, we now use for experiments and projects in class.*”

This reframing was triggered by material availability and reinforced through collaborative reflection. Observations showed that waste sorting and collection were integrated into classroom projects, particularly in science and arts. Document analysis further indicated increasing incorporation of recycled materials into lesson plans. Overall, this theme reflects an epistemic transformation in which environmental problems are reconstructed as pedagogical entry points.

#### *Theme 2: Teacher Agency as Pedagogical Driver*

Teacher agency emerged as the central mechanism enabling sustainability-oriented instruction, driven primarily by adaptive responses to resource constraints. A teacher from Tomia explained: “*We didn’t receive special facilities, so we created our own teaching tools from waste materials.*” Similarly, a Wangi-Wangi teacher noted: “*We share ideas with colleagues and develop projects together using available materials.*”

Teachers integrated recycled-based projects into existing curricula through project-based and inquiry-oriented approaches. Observations showed that teachers acted as facilitators, guiding students through design, experimentation, and reflection. Cross-case analysis revealed that innovation was more collaborative in Wangi-Wangi, while Tomia relied more on individual initiative.

#### *Theme 3: Experiential Learning and Student Transformation*

Student outcomes extended beyond cognitive gains to include affective and behavioural development. Hands-on engagement fostered creativity, critical thinking, and environmental responsibility. A teacher from Wangi-Wangi reported: “*Students became more active because they made learning tools themselves.*” A Tomia teacher added: “*They not only learn but also start to care more about waste and their surroundings.*”

Observations confirmed high levels of collaboration, peer mentoring, and problem-solving. Student artefacts showed increasing complexity and relevance, while behavioral changes included improved waste practices and student-led environmental initiatives. Sustained behavioral change was more evident in Wangi-Wangi due to more consistent implementation.

#### *Theme 4: Institutional Fragility and Sustainability Risks*

*Despite strong pedagogical practices, institutional support remained weak, making initiatives vulnerable and teacher-dependent. A school leader from Tomia stated: “There is no written regulation. If the teacher leaves, the*

program may stop.” Similarly, a principal from Wangi-Wangi noted: “We support these activities, but there is no formal system or budget yet.”

Document analysis confirmed the absence of formal policies, standardized procedures, and dedicated funding. Cross-case comparison showed that stronger leadership engagement in Wangi-Wangi contributed to better program continuity, whereas Tomia faced higher risks of discontinuity.

*Cross-Case Synthesis: Convergence and Divergence*

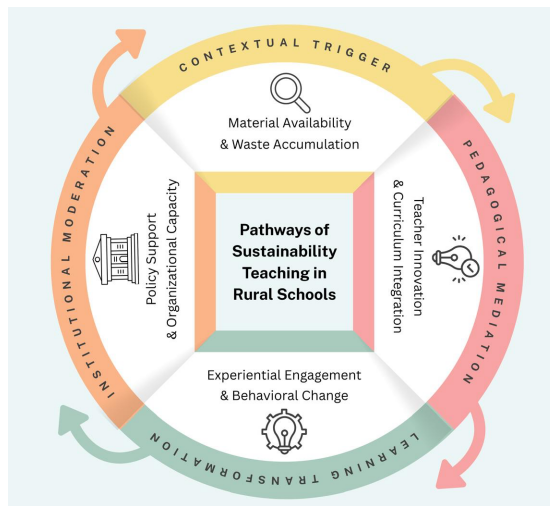
To systematically compare patterns across cases, Table 4 presents convergent and divergent findings across the four themes.

**Table 4.** Cross-Case Comparison of Sustainability Pedagogy Practices

Theme	Convergent Patterns	Wangi-Wangi	Tomia
Reframing Waste Teacher Agency	Shift from waste as problem to learning resource Innovation driven by resource constraints	Structured routines for waste integration Strong collegial collaboration and peer exchange	Informal and teacher-initiated practices Individual-driven innovation with limited collaboration
Experiential Learning Institutional Support	Increased engagement and behavioral change Limited formal policy and funding	Sustained and consistent implementation Moderate leadership support, partial continuity	Intermittent implementation, less sustained impact Weak leadership support, high dependency on individuals

**Integrated Explanatory Model**

The findings support a dynamic four-stage transformation model consisting (Figure 5) of: (1) Contextual Trigger (material availability and waste accumulation), (2) Pedagogical Mediation (teacher innovation and curriculum integration), (3) Learning Transformation (experiential engagement and behavioral change), and (4) Institutional Moderation (policy support and organizational capacity).



**Figure 4.** Integrated explanatory model of transformative circular pedagogy

Unlike linear models of pedagogical change, this framework conceptualizes sustainability-oriented learning as a circular and iterative process, in which each stage not only influences subsequent phases but also feeds back into earlier conditions. In particular, institutional moderation plays a critical recursive role by reshaping the material and organizational environment that constitutes future contextual triggers. Thus, the model explains how sustainability-oriented practices emerge, evolve, and are continuously reconfigured through the interaction of contextual conditions, teacher agency, student transformation, and institutional dynamics.

*Institutional Moderation: Policy Support and Organizational Capacity*

The fourth stage emphasizes the moderating role of institutional structures in shaping the durability and scalability of pedagogical innovation. While teacher-driven initiatives may generate effective learning practices, their long-term sustainability depends on formal governance mechanisms, leadership commitment, and organizational learning

systems. Policy frameworks, standardized operating procedures, professional development programs, and resource allocation function as institutional enablers that stabilize and expand innovation.

More importantly, institutional actions or the absence thereof actively reshape the material and contextual conditions that initiate subsequent cycles of pedagogical practice. For instance, schools that institutionalize waste management systems, allocate resources for recycling activities, and integrate sustainability into formal curricula effectively transform the availability, organization, and pedagogical visibility of material resources. These changes alter the nature of waste accumulation, access to recyclable materials, and the structure of learning opportunities, thereby generating new contextual triggers for future pedagogical innovation.

Conversely, weak institutional support constrains this recursive process. In the absence of formal policies and organizational coordination, material conditions remain fragmented and inconsistent, limiting the continuity of resource-based learning. As a result, innovation becomes episodic and dependent on individual initiative rather than systemically sustained.

This feedback mechanism demonstrates that sustainability education operates as a self-reinforcing or self-limiting cycle, depending on the strength of institutional engagement. Institutional moderation, therefore, does not merely sustain existing practices but actively co-produces the evolving ecological and pedagogical context in which new learning cycles emerge. This perspective reinforces the circular nature of the model, where institutional dynamics continuously influence and reconfigure the foundational conditions of sustainability-oriented pedagogy.

## DISCUSSION

This study advances the understanding of Sustainability Teaching in rural island schools by demonstrating how contextual constraints, teacher agency, and institutional capacity interact to shape pedagogical transformation. Moving beyond descriptive accounts of recycled-based learning, the findings provide a theoretically grounded explanation of how sustainability-oriented practices emerge, stabilize, and remain vulnerable within marginalized educational settings. To further clarify the integrative contribution of this study, a comparative analysis with existing models is presented in Table 5.

**Table 5.** Comparative Analysis of Sustainability Pedagogy Models

Dimension	Existing Models	Limitations	Transformative Circular Pedagogy Model
Material Context	Focus on resource availability (often assumed sufficient)	Limited attention to scarcity contexts	Positions material scarcity as a trigger for innovation
Teacher Role	Teacher as facilitator or implementer	Under-theorized agency in constrained settings	Emphasizes adaptive teacher agency as central mediator
Learning Process	Experiential or project-based learning	Often isolated from context and system	Integrates experiential learning with contextual realities
Institutional Dimension	Policy or system-level focus	Weak linkage with classroom practice	Connects institutional structures with pedagogical processes
System Integration	Fragmented (partial focus)	Lack of holistic framework	Integrates all dimensions into a circular, dynamic system

### Waste as Epistemic Resource

The first major contribution of this study lies in identifying waste reframing as an epistemic transformation rather than a merely operational shift. Teachers' transition from perceiving waste as a sanitation issue to conceptualizing it as a pedagogical resource reflects a deeper cognitive and cultural change within school communities.

This process aligns with Sterling's notion of transformative learning, which emphasizes paradigm shifts from linear to systemic thinking in sustainability education. Rather than simply incorporating environmental topics into existing curricula, participating teachers reconstructed everyday material realities into learning contexts (Sterling, 2010). This finding extends Sterling's framework by demonstrating how such epistemic shifts can occur in resource-constrained rural environments through localized material engagement.

International studies conducted in technologically advanced contexts have similarly emphasized material-based sustainability learning (Deng et al., 2021; Escala et al., 2025). However, these studies typically rely on institutional infrastructure and external funding. In contrast, the present research illustrates that epistemic transformation can emerge organically from material scarcity. This suggests that constraint itself may function as a catalyst for pedagogical innovation, challenging deficit-based narratives surrounding rural education.

### Teacher Agency as Pedagogical Driver

The second key finding positions teacher agency as the primary mediating mechanism between environmental context and learning outcomes. Consistent with Vygotskian sociocultural theory, teachers operated as mediators who transformed physical materials into symbolic learning resources through guided interaction and scaffolding (Fadeev, 2019).

This finding resonates with Brown et al., (2023) conception of teachers as change agents, emphasizing bottom-up reform processes. However, while Fullan's work focuses largely on systemic reform in developed education systems, this study extends the concept to marginalized island contexts, where institutional support is limited and professional autonomy becomes the main driver of innovation.

Comparatively, studies in European and East Asian contexts often report policy-driven sustainability integration (Hemmer et al., 2022; Meng & Wang, 2025; Zhao & Omran, 2025). In such systems, innovation is embedded within formal curricula. By contrast, the present findings reveal a form of "adaptive professionalism," whereby teachers compensate for structural deficiencies through creative improvisation. This suggests that agency in low-resource settings is not merely an individual trait but a survival-oriented professional strategy.

This finding can be further understood through the lens of frugal innovation and necessity-driven innovation, which emphasize how constraints and resource scarcity can act as catalysts for creative problem-solving and adaptive practices. In contrast to conventional innovation models that rely on resource abundance, frugal innovation literature highlights the capacity of individuals and organizations to develop effective, low-cost, and contextually relevant solutions under conditions of limitation.

Similarly, necessity-driven innovation underscores that innovation often emerges not from opportunity-seeking conduct, but from the urgent need to respond to structural constraints. In this study, teachers' pedagogical creativity reflects a form of necessity-based innovation, where limited infrastructure, lack of formal support, and material scarcity stimulate the development of context-sensitive learning strategies. This perspective strengthens the argument that resource constraints should not be viewed merely as barriers, but as productive conditions that can foster transformative pedagogical practices, particularly in marginalized educational settings.

### Experiential Learning and Student Transformation

The observed student outcomes support Kolb's experiential learning theory, particularly the cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation (Morris, 2020). Students' engagement in recycled-based projects enabled them to internalize sustainability values through embodied practice rather than abstract instruction.

This mechanism aligns with global research emphasizing experiential sustainability education (Davidson et al., 2021; Friman et al., 2024). However, unlike many studies that focus on short-term interventions, the present research demonstrates that sustained experiential engagement can foster durable behavioral change, especially when embedded within daily school routines. Moreover, the findings contribute to the growing literature on affective and behavioral dimensions of sustainability learning. While previous research often privileges cognitive outcomes, this study highlights the interdependence of cognitive, emotional, and moral development. This supports recent calls for holistic sustainability pedagogy that integrates knowledge, values, and action.

### Institutional Fragility and Innovation Limits

Despite strong pedagogical practices, this study reveals persistent institutional fragility as a major constraint on sustainability. The dependence on individual teachers reflects what organizational theorists describe as "person-dependent innovation," characterized by high creativity but low durability.

From an institutional change perspective, these findings corroborate (Keyser et al., 2021) argument that innovation becomes sustainable only when embedded in formal governance structures. Similarly, emphasizes that Education for Sustainable Development requires policy alignment, leadership commitment, and systemic monitoring mechanisms (Alhazemi, 2024).

Compared to studies in centralized education systems, where sustainability initiatives are mandated through national frameworks, rural Indonesian schools operate within decentralized and resource-limited governance environments (Salim et al., 2024; Anggara, 2025; Nurhasanah & Suyatman, 2025). Consequently, sustainability practices remain vulnerable to staff turnover and leadership change. This highlights a structural paradox: pedagogical innovation thrives at the micro level while remaining fragile at the macro-organizational level.

### **A Context-Sensitive Circular Pedagogy Model**

Integrating the four major themes, this study proposes a context-sensitive model of Transformative Circular Pedagogy (as shown at Figure 4.). The model conceptualizes sustainability education as a cyclical process involving contextual triggers, pedagogical mediation, experiential transformation, and institutional moderation.

This framework extends existing circular economy education models by incorporating sociocultural and organizational dimensions. Whereas most circular pedagogy models emphasize material flows and technical competencies, the present model foregrounds human agency, cultural meaning-making, and governance structures.

In global terms, this model contributes to comparative sustainability education by offering an analytical lens applicable to marginalized contexts. It demonstrates that effective sustainability education does not require advanced infrastructure but depends on the alignment of material realities, professional capacity, and institutional commitment.

### **Integrated Contributions, Implications, and Recommendations**

This study advances sustainability education research through three interrelated theoretical contributions while simultaneously generating practice- and policy-relevant insights. First, it reconceptualizes waste as an epistemic resource rather than merely a pedagogical tool, emphasizing its role in triggering cognitive and cultural transformation within resource-constrained learning environments. Second, it extends the notion of teacher agency by introducing the concept of adaptive professionalism, demonstrating how educators in marginalized contexts construct innovation through constraint-driven practices. Third, it integrates experiential learning and institutional change perspectives into a multi-level framework, offering a dynamic explanation of how sustainability pedagogy emerges through the interaction of material conditions, pedagogical mediation, and organizational structures.

These contributions have direct implications for educational policy and professional practice. Empirically grounded findings indicate that sustainability initiatives are more likely to emerge and persist when supported by teacher agency, collaborative practices, and minimum institutional alignment. In this regard, recommendations directly supported by the findings include the need to strengthen school-level governance through the development of internal guidelines, structured program coordination, and leadership engagement. The findings also support the integration of recycled-based learning into classroom practices through experiential and project-based approaches, as well as the strengthening of professional learning communities to reduce dependency on individual teacher initiative and enhance continuity.

At the same time, several forward-looking or extrapolative recommendations can be proposed to enhance scalability and systemic impact. These include the development of formal policy frameworks at regional or national levels, the allocation of dedicated funding for sustainability-oriented learning infrastructure, and the integration of sustainability competencies into curriculum and assessment systems. Additionally, the establishment of comprehensive monitoring and evaluation mechanisms, including longitudinal tracking of student outcomes, may support evidence-based policy refinement. Expanding partnerships with community organizations and promoting place-based sustainability education are also recommended to embed learning within broader socio-ecological systems.

While these recommendations extend beyond the immediate empirical scope, they are logically derived from the identified patterns and highlight pathways for institutionalizing and scaling sustainability education. Future research should further examine these propositions through longitudinal and comparative designs, while also incorporating student agency, community participation, and emerging digital tools to better capture the evolving ecosystem of sustainability learning.

## **CONCLUSION**

This study demonstrates that sustainability-oriented pedagogical practices in rural island schools are shaped by the interaction between material conditions, teacher agency, experiential learning processes, and institutional contexts. In response to the first research question, the findings show that the availability of waste materials functions as a contextual trigger that initiates pedagogical innovation. Addressing the second question, teacher agency emerges as the central mediating mechanism, where educators transform material constraints into meaningful instructional practices through adaptive and creative strategies. Regarding the third question, experiential and project-based learning fosters not only cognitive understanding but also affective engagement and behavioural change, reflected in students' environmental awareness, creativity, and collaboration. Finally, in relation to the fourth question, institutional factors particularly leadership support, policy frameworks, and resource allocation significantly influence the continuity and sustainability of these practices.

The study contributes theoretically by advancing a Transformative Circular Pedagogy model that integrates material, pedagogical, and institutional dimensions within a dynamic framework. It reconceptualises waste as an epistemic resource and positions adaptive teacher agency as a key driver of sustainability learning in resource-

constrained contexts. Practically, the findings highlight that low-cost, contextually grounded pedagogies can generate meaningful educational outcomes. However, their long-term impact depends on institutional alignment, governance support, and the integration of sustainability into formal organizational structures.

This study is limited by its focus on a specific rural island context and a relatively small sample, which may constrain transferability. As a qualitative inquiry, it prioritizes depth over generalization, and although reflexive strategies were employed, interpretive bias cannot be fully eliminated. Future research should extend this work through longitudinal and mixed-method designs to examine how teacher agency, institutional support, and organizational capacity interact over time, as well as to explore the applicability of the proposed model across diverse socio-cultural settings.

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## AUTHOR CONTRIBUTION STATEMENT

MD conceived the research idea and designed the study. MD conducted data collection, performed the qualitative analysis, and developed the conceptual framework. MD prepared the original manuscript draft. NA and LI supervised the research process, provided methodological guidance, critically reviewed the manuscript, and contributed to the refinement of the theoretical discussion. All authors reviewed and approved the final version of the manuscript.

## AI DISCLOSURE STATEMENT

The author used ChatGPT during the preparation of this work for language editing and improving the clarity of academic writing. After using the tool, the author carefully reviewed and revised the content and takes full responsibility for the final manuscript.

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