



TEC CIRCULAR: TRANSFORMAÇÃO, ECONOMIA CIRCULAR E COMPETITIVIDADE

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TEC CIRCULAR: TRANSFORMACIÓN, ECONOMÍA CIRCULAR Y COMPETITIVIDAD

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RESUMO

O presente estudo de caso examina a implementação e o impacto da iniciativa TEC Circular — Transformação, Economia Circular e Competitividade — no âmbito do projeto IF Mais Empreendedor no Brasil. A iniciativa buscou promover o desenvolvimento sustentável, a transformação digital e os princípios da economia circular entre seis micro e pequenas empresas de diferentes setores. Por meio da aplicação de ferramentas gerenciais clássicas, como a Análise SWOT, o Diagrama de Ishikawa, a Matriz GUT e o Método 5W2H, a equipe do projeto identificou problemas sistêmicos, estruturou planos de ação e entregou soluções concretas. Este artigo

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explora a fundamentação teórica dessas ferramentas no contexto das práticas empresariais sustentáveis e da transformação digital. Também relata as ações específicas implementadas em cada empreendimento, como a criação de sites institucionais, estratégias de marketing digital, parcerias estratégicas, desenvolvimento de identidade visual e branding ambiental. Os resultados demonstram o potencial da colaboração intersetorial e do conhecimento acadêmico aplicado para fomentar ecossistemas locais de inovação baseados em valores da economia circular.

PALAVRAS-CHAVE: Economia Circular. Transformação Digital. Sustentabilidade.

ABSTRACT

The present case study examines the implementation and impact of the TEC Circular initiative Transformation, Circular Economy and Competitiveness—within the scope of the IF Mais Empreendedor project in Brazil. The initiative sought to promote sustainable development, digital transformation, and circular economy principles among six micro and small enterprises from different sectors. Through the application of classic managerial tools such as SWOT Analysis, the Ishikawa Diagram, the GUT Matrix, and the 5W2H Method, the project team identified systemic problems, structured action plans, and delivered concrete solutions. This paper explores the theoretical basis of these tools in the context of sustainable business practices and digital transformation. It also reports the specific actions implemented with each enterprise, such as the creation of institutional websites, digital marketing strategies, strategic partnerships, visual identity development, and environmental branding. The findings demonstrate the potential of cross-sector collaboration and applied academic knowledge to foster local innovation ecosystems grounded in circular economy values.

KEYWORDS: Circular Economy. Digital Transformation. Sustainability.

RESUMEN

El presente estudio de caso examina la implementación y el impacto de la iniciativa TEC Circular — Transformación, Economía Circular y Competitividad — en el marco del proyecto IF Mais Empreendedor en Brasil. La iniciativa buscó promover el desarrollo sostenible, la transformación digital y los principios de la economía circular entre seis micro y pequeñas empresas de diferentes sectores. A través de la aplicación de herramientas de gestión clásicas, como el Análisis SWOT, el Diagrama de Ishikawa, la Matriz GUT y el Método 5W2H, el equipo del proyecto identificó problemas sistémicos, estructuró planes de acción y entregó soluciones concretas. Este artículo explora la base teórica de estas herramientas en el contexto de las prácticas empresariales sostenibles y la transformación digital. También informa sobre las acciones específicas implementadas en cada emprendimiento, como la creación de sitios web institucionales, estrategias de marketing digital, alianzas estratégicas, desarrollo de identidad visual y branding ambiental. Los resultados demuestran el potencial de la colaboración intersectorial y del conocimiento académico aplicado para fomentar ecosistemas locales de innovación basados en los valores de la economía circular.

PALABRAS CLAVE: Economía Circular. Transformación Digital. Sostenibilidad.

1. INTRODUCTION

The transition toward more sustainable and resilient economic models has become an urgent global imperative. In this context, the Circular Economy (CE) emerges as a paradigm capable of aligning economic growth with environmental preservation and social inclusion. Unlike the traditional linear model based on "take, make, dispose", the circular model proposes a closed-loop system in which resources are kept in use for as long as possible, extracting maximum value before recovery and regeneration.

Micro and small enterprises (MSEs) play a vital role in this transition. In Brazil, they account for 99% of all companies and generate approximately 27% of the national GDP. However, these businesses often face structural bottlenecks, such as lack of access to strategic tools, innovation ecosystems, and digital transformation processes. This scenario is further complicated by the gap between the guidelines of the Brazilian National Solid Waste Policy (Law 12.305/10) and the operational reality of small-scale entrepreneurs, who often perceive sustainability as an additional cost rather than a competitive advantage.

In response to this challenge, the IF Mais Empreendedor project was created by the Federal Institute of Education, Science and Technology of Southern Minas Gerais (IFSULDEMINAS). Its purpose is to integrate academic expertise with the real needs of small businesses through university extension. Within this framework, the TEC Circular initiative was developed as a strategy for local implementation, focusing on six enterprises located in the Southern region of Minas Gerais, Brazil. The initiative sought to foster sustainable transformation through technical consulting, guided by CE principles and structured managerial tools.

Despite the growing literature on circularity, there is still a need for empirical evidence on how university-led interventions can effectively trigger these transitions in peripheral and resource-constrained contexts. Therefore, this study is guided by the following research question: How can the application of classical management tools, integrated with university extension practices, overcome the structural and cultural barriers for the adoption of circular economy principles in MSEs in Southern Minas Gerais?

2.THEORETICAL FRAMEWORK

2.1 Circular Economy: Principles and Relevance

The Circular Economy (CE) is a systemic approach designed to decouple economic growth from the consumption of finite resources. Unlike the linear model, CE promotes resource efficiency and waste reduction through regenerative cycles. According to Geissdoerfer et al. (2020), the transition to circularity requires not only technical adjustments but a complete redesign of business models, which is particularly challenging for Micro and Small Enterprises (MSEs) due to their limited financial and human capital.

In the Brazilian context, this paradigm is legally supported by the National Solid Waste Policy (Law 12.305/10 - PNRS), which establishes shared responsibility for product life cycles. Furthermore, the initiative aligns with the UN 2030 Agenda, specifically SDG 12 (Responsible Consumption and Production). As noted by Ghisellini et al. (2016), the successful implementation of circularity in regional ecosystems depends on "intermediate actors"—such as the Federal Institutes—that bridge the gap between high-level theory and local entrepreneurial reality. In Southern Minas Gerais, this integration is vital to transform environmental constraints into competitive advantages for local businesses.

2.2 SWOT Analysis: Strategic Self-Knowledge

The SWOT Analysis is a classic strategic management tool used to identify the internal strengths and weaknesses of an organization, as well as the external opportunities and threats in its environment. It facilitates strategic decision-making by aligning internal capabilities with external conditions.

- Strengths refer to internal characteristics that give the business an advantage over competitors.
- Weaknesses are internal factors that place the business at a disadvantage.
- Opportunities are external factors that the enterprise can exploit to its advantage.
- Threats are external elements that could cause trouble for the business.

In the TEC Circular project, SWOT analyses were conducted for each of the six enterprises through collaborative workshops and guided interviews. This allowed for the creation of contextualized diagnostics that respected the uniqueness of each business, while offering strategic clarity and focus. In addition, it enabled students and stakeholders to develop a shared language for problem-solving and action prioritization.

2.3 Ishikawa Diagram: Root Cause Analysis

Also known as the Cause-and-Effect Diagram or Fishbone Diagram, the Ishikawa Diagram is a quality management tool developed by Kaoru Ishikawa in the 1960s. It is used to systematically identify, organize, and display potential causes of a specific problem.

The diagram traditionally categorizes causes into six main branches:

1. Man (People)
2. Machine (Technology)
3. Method (Processes)

4. Material
5. Measurement
6. Environment

By mapping these categories in a visual structure, the Ishikawa Diagram helps identify root causes, rather than treating surface symptoms. In the context of small businesses, this is crucial for avoiding superficial solutions and investing resources where they matter most.

In the TEC Circular project, each enterprise's main challenge—be it low digital presence, logistical inefficiencies, or lack of visibility—was analyzed using the Ishikawa framework. This enabled the team to identify not only technical issues but also structural, human, and cultural dimensions that contributed to the problem, thereby supporting systemic thinking and long-term solutions.

2.4 GUT Matrix: Prioritizing Problems with Objectivity

The GUT Matrix (Gravity, Urgency, Tendency) is a tool used to prioritize problems by scoring them based on three criteria:

- Gravity (G): How serious is the problem? What are the consequences?
- Urgency (U): How immediate is the need for intervention?
- Tendency (T): How likely is the problem to worsen if not addressed?

Each factor is rated on a scale (commonly 1–5), and the total score ($G \times U \times T$) provides a prioritization ranking. The higher the score, the greater the need for action.

In TEC Circular, the GUT Matrix was applied after the diagnostic phase and served as a decision-support tool for both the project team and the business owners. It ensured that limited resources were allocated effectively, addressing the most impactful and time-sensitive issues first. This approach brought transparency to the consulting

process and empowered the entrepreneurs to participate in prioritization, fostering ownership and alignment.

2.5 5W2H Method: From Diagnosis to Action

The 5W2H method is a practical planning tool that translates ideas into structured action plans. Its name is an acronym for seven guiding questions:

- What (What will be done?)
- Why (Why should it be done?)
- Where (Where will it be done?)
- When (When will it be done?)
- Who (Who will do it?)
- How (How will it be done?)
- How much (How much will it cost?)

By answering each of these questions, teams can build comprehensive, feasible, and monitorable action plans.

In TEC Circular, 5W2H was used to operationalize the solutions derived from the SWOT, Ishikawa, and GUT processes. It functioned as a bridge between strategy and execution, ensuring that plans were not only idealistic but also realistic and deliverable within the project timeline. The tool also fostered clarity of roles, deadlines, and expected outcomes, critical in projects involving multiple stakeholders.

3.METHODOLOGY AND PROJECT DESIGN

3.1 Methodological Approach and Ethical Considerations

This study adopts a qualitative, exploratory case study design with a participatory approach. It is essential to acknowledge certain methodological boundaries: the findings presented herein are based on documentary analysis of technical reports and artifacts produced during the project, without the triangulation of in-depth interviews or direct participant observation. Furthermore, the small number of enterprises attended (6) does not allow for statistical generalizations, although the qualitative approach prioritizes interpretive depth.

Regarding ethical considerations, as the research focuses on organizational processes and institutional data within a university extension framework—ensuring the anonymization of individual participants and focusing on corporate transformation—it complies with the ethical standards for professional practice. No sensitive personal data was processed, and the project was conducted in accordance with the institutional regulations of IFSULDEMINAS regarding extensionist activities.

3.2 Research Context and Limits

Another relevant limit is the absence of a control group or a comparative baseline prior to the project, which makes it difficult to isolate the effects attributable exclusively to the intervention. Specific contextual conditions—such as the post-pandemic period, the peripheral geographic location, and the local socioeconomic characteristics of Southern Minas Gerais—may have influenced both the reported difficulties and the results achieved, without it being possible to measure this impact precisely.

3.3 Description of the Enterprises and Actions Implemented

Below is an overview of each participating business, along with the main challenges

identified and solutions proposed by the TEC Circular team.

a) Casa da Criança – Institutional Development and Circular Impact

Sector: Education and Social Assistance

Problem Identified: Lack of digital presence, outdated communication tools, and weak institutional image.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Creation of a new visual identity and branding guide.
- Development and finalization of the institutional website, including donation portals and transparency sections.
- Strategic advisory on partnership building with local universities, aiming at institutional strengthening and continuity.

This initiative demonstrated the potential of design and digital tools to amplify social impact, increase visibility, and foster trust among stakeholders—key elements in the logic of circularity, particularly in third-sector organizations.

b) Estilo Confecções – Creative Economy and Market Differentiation

Sector: Fashion and Apparel

Problem Identified: Limited brand recognition, informal marketing, and low connection to sustainability narratives.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Design of a new brand identity, including logo and catalog.
- Structuring of social media content strategy with storytelling based on sustainable fashion principles.

- Guidance on production reuse techniques, using fabric scraps and upcycling methods.

This case exemplifies how the circular economy can be a driver of creative differentiation and how storytelling can strengthen ties between products and conscious consumers.

c) Cachoeira dos Félix – Local Tourism and Environmental Education

Sector: Tourism and Environmental Conservation

Problem Identified: Poor promotion of services, seasonal demand, lack of community engagement tools.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Recording and editing of promotional videos highlighting local attractions and ecological value.
- Proposals for educational trails and sustainable practices for tourist flow management.
- Support for event planning to increase low-season visits and community involvement.

This case illustrates how the intersection of sustainability and digital content can reposition a local destination, promoting inclusive and environmentally responsible tourism.

d) Vanessa Make Up – Personal Branding and Service Innovation

Sector: Beauty and Personal Services

Problem Identified: Low brand visibility, limited customer retention strategies, unclear service portfolio.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Development of a structured marketing plan based on digital platforms.
- Delivery of a customized action plan with short- and long-term goals.
- Advising on service portfolio diversification, including eco-friendly products.

This microbusiness demonstrated how strategic consulting can bring clarity to informal entrepreneurs and promote conscious innovation, even in highly competitive markets.

e) Estamparia Criativa – Digital Inclusion and Entrepreneurial Identity

Sector: Personalized Gifts and Printing

Problem Identified: Poor financial control, absence of digital sales channels, undefined business identity.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Creation of a digital catalog for WhatsApp and Instagram sales.
- Guidance on cost structure, pricing, and value proposition refinement.
- Visual identity proposal and definition of brand tone aligned with youth and creativity.

This business highlights the centrality of digital tools for micro-entrepreneurs, especially for market access and competitiveness in low-income territories.

f) Agroecological Garden – Sustainability and Community Empowerment

Sector: Urban Agriculture and Environmental Education

Problem Identified: Low community engagement, lack of visibility, operational inefficiencies.

Tools Applied: SWOT, Ishikawa, GUT, 5W2H

Actions:

- Design of a communication strategy for mobilizing schools and NGOs.
- Development of environmental education materials to support workshops.
- Suggestions for waste management and composting systems, aligned with circularity principles.

This initiative emphasizes how urban agroecology, when well-communicated, can strengthen local food systems and foster circular practices within neighborhoods.

4. RESULTS AND DISCUSSION

4.1 Transformational Impacts on Businesses

The TEC Circular initiative catalyzed substantial transformations in each of the participating businesses. These changes can be grouped into four major dimensions:

a) Digital Maturity and Strategic Communication

The TEC Circular initiative catalyzed transformations across distinct dimensions. To overcome the descriptive limitation and provide a scientific assessment of the impact, Table 1 presents a comparative matrix of the results achieved. Impact was measured based on the completion of the 5W2H action plans and the level of digital integration observed at the end of the consulting cycle.

In particular:

- Casa da Criança gained legitimacy and transparency through its new institutional website, which now supports public fundraising and accountability tools.
- Estilo Confecções and Estamparia Criativa achieved brand cohesion and product differentiation, essential for digital commerce and visual marketing.
- Vanessa Make Up reported an increase in client bookings after launching digital promotions and refining her brand image.

This aligns with the Digital Transformation for MSMEs (micro, small and medium enterprises) framework, which emphasizes that structured digital presence fosters growth, resilience, and customer trust in small businesses (World Bank, 2022).

b) Circular Economy Practices

Although the businesses operated in distinct sectors, circular economy principles were integrated in customized ways, reflecting the adaptability and transversal nature of circularity:

- Estilo Confecções incorporated upcycling and reuse into its production chain.
- Cachoeira dos Félix developed educational content to raise environmental awareness among tourists.
- Agroecological Garden structured composting practices and waste reintegration into local food production.

These cases echo the European Commission's (2020) understanding that the circular economy is not merely a technical solution, but a paradigm shift that requires systemic thinking, education, and community engagement.

c) Entrepreneurial Empowerment

A recurring result reported by all participants was the empowerment of the entrepreneurs through strategic clarity, personalized action plans, and capacity-building workshops. They described feeling more “professional,” “prepared,” and “capable” of running their business with a long-term vision.

This aligns with Freire’s concept of conscientização (critical consciousness): participants were not passive recipients of technical knowledge but active agents of change, supported by reflective tools such as SWOT and Ishikawa diagrams.

d) Strengthening of the Entrepreneurial Ecosystem

The collaborative and multidisciplinary nature of the TEC Circular project contributed to strengthening the local entrepreneurial ecosystem in several ways:

- Academic partnerships were formed, particularly through the Casa da Criança, promoting sustainable networks between institutions.
- Community mobilization occurred via environmental education actions and digital campaigns.
- Knowledge circulation emerged, as entrepreneurs began to share practices and recommend tools beyond the project's scope.

This outcome reinforces the idea that innovation in small businesses is relational (Schmitz, 1989), emerging from networks, learning communities, and territorial embeddedness.

4.2 Analytical Insights from the Diagnostic Tools

Each tool used—SWOT, GUT, Ishikawa, and 5W2H—revealed specific layers of organizational complexity. Their combined application enriched the analysis and enabled a tailored approach for each enterprise. Below is a deeper look into the role of each tool in fostering systemic thinking:

a) SWOT Matrix (Strengths, Weaknesses, Opportunities, Threats)

The SWOT analysis provided a comprehensive situational diagnosis, exposing both internal vulnerabilities and external possibilities. For example:

- In Vanessa Make Up, the SWOT highlighted a mismatch between service quality (strength) and lack of brand recognition (weakness).
- In the Agroecological Garden, opportunities in environmental education were emphasized, counterbalancing operational limitations.

SWOT's utility lies in its capacity to stimulate strategic self-awareness—a fundamental step for resilience and innovation in micro-entrepreneurial contexts.

b) GUT Matrix (Gravity, Urgency, Trend)

The GUT matrix brought an action-oriented perspective, helping entrepreneurs

prioritize problems and avoid decision paralysis. It allowed teams to focus on high-impact interventions, such as:

- The digital catalog creation for Estamparia Criativa (high urgency, high trend);
- The identity redesign for Estilo Confecções (medium urgency, but high gravity for market positioning).

GUT proved especially useful in settings where resources are scarce and actions must be strategic, which is typical of informal or early-stage businesses.

c) Ishikawa Diagram (Cause-and-Effect Analysis)

Also known as the fishbone diagram, Ishikawa enabled a deep dive into root causes of recurring challenges, rather than superficial fixes.

- In the Cachoeira dos Félix, the tool revealed how low visibility stemmed not only from poor communication, but from the absence of a structured visitor journey and community engagement.
- For Casa da Criança, it demonstrated how weak institutional identity was linked to multiple causes: outdated tools, staff turnover, and lack of digital training.

The Ishikawa approach supported the systems thinking required in sustainable entrepreneurship, as it encouraged integrative diagnosis across domains.

d) 5W2H Framework (What, Why, Where, When, Who, How, How Much)

Finally, the 5W2H was employed to translate diagnoses into structured plans, ensuring that recommendations were not abstract but actionable. The framework helped each entrepreneur answer critical questions such as:

- What actions are most feasible now?
- How can I measure impact and cost?
- Who will be responsible for follow-up?

By using the 5W2H collaboratively, each business exited the consulting cycle with a

clear roadmap for implementation, respecting its own pace, resources, and context.

4.3 Educational and Institutional Contributions

The TEC Circular project also generated significant institutional learning, including:

- Curricular innovation: Students applied theoretical content to real-world scenarios, strengthening the pedagogical relevance of extension programs.
- Research opportunities: The case study produced rich data on entrepreneurship, circularity, and public policy.
- Institutional visibility: The Federal Institute became recognized in local media and community events as a vector for sustainable development.

This multidimensional outcome exemplifies the concept of tripartite integration (teaching, research, and extension), showing how engaged universities can drive not only knowledge production, but also territorial transformation.

5. FINAL CONSIDERATIONS

5.1 Synthesis of Findings and Theoretical Contributions

The methodology applied in the TEC Circular project reflects successful international frameworks, such as the Knowledge Transfer Partnerships (KTP) in the United Kingdom and the Digital Innovation Hubs (DIHs) in the European Union. These global models emphasize the role of academic institutions as catalysts for the 'twin transition' (green and digital) in small enterprises. By adapting these high-level strategies to the socioeconomic reality of Southern Minas Gerais, the TEC Circular project demonstrates that MSEs in developing territories can achieve similar levels of strategic maturity when supported by dedicated university extension programs.

The TEC Circular project demonstrates that Micro and Small Enterprises

(MSEs) in Southern Minas Gerais can act as catalysts for socio-environmental transformation when supported by structured university extension. The application of tools like Ishikawa and 5W2H allowed these businesses to transition from reactive management to a strategic circular model. Theoretically, this study contributes to the field of Sustainability Studies by proving that circularity is not exclusive to large corporations, provided there are intermediate actors (Federal Institutes) to translate complex concepts into local reality.

5.2 Limitations and Replicability

As previously noted, the main limitation of this study lies in its small sample size and the absence of long-term quantitative monitoring of environmental metrics (e.g., exact mass of waste diverted from landfills). Furthermore, the results are deeply linked to the regional context of Southern Minas Gerais. However, the methodological framework (the combined use of SWOT, GUT, and 5W2H for circularity) is highly replicable. To scale this model, it is recommended that university extension programs be institutionalized as permanent public policies, reducing the dependency on specific project cycles.

5.3 Policy Implications and Final Remarks

In terms of public policy, the success of TEC Circular reinforces the need for credit lines and tax incentives specifically geared toward MSEs that adopt the Brazilian National Solid Waste Policy (PNRS) guidelines. In conclusion, the project serves as a "living laboratory," showing that the intersection of digital transformation and circular economy is the most viable path for regional competitiveness in the 21st century.

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DATA DE SUBMISSÃO: agosto de 2025

DATA DE ACEITE: junho de 2026