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INNOVATION AND CIRCULAR ECONOMY IN THE PRISON SYSTEM: AN ANALYSIS OF THE 10R'S

Inovação e economia circular no sistema prisional: uma análise dos 10r's

Innovación y economía circular en el sistema penitenciario: un análisis de los 10R's

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ABSTRACT

This study investigates the application of the 10R strategies as an innovation-driven alternative for advancing the circular economy in Santa Catarina state prisons. A qualitative single case study design was adopted, triangulating data from a systematic literature review, 16 semi-structured interviews with prison managers, and direct observation. Results show that despite some isolated sustainable practices, there is a lack of institutional coordination, stakeholder awareness, and technical training. Technological innovation, digital tools, and organizational routine redesign were identified as enablers of circularity. It is concluded that circular economy implementation requires a systemic approach with technological infrastructure and continuous engagement.

RESUMO

Este estudo investiga a aplicação das estratégias dos 10R como alternativa impulsionada por inovação para o avanço da economia circular em penitenciárias estaduais de Santa Catarina. Adota-se um estudo de caso único e qualitativo, triangulando dados de revisão sistemática da literatura, 16 entrevistas semiestruturadas com gestores prisionais e observações diretas. Os resultados indicam que, embora existam práticas sustentáveis isoladas, há carência de coordenação institucional, sensibilização de stakeholders e capacitação técnica. A inovação tecnológica, ferramentas digitais e a reorganização de rotinas organizacionais são identificadas como facilitadores da circularidade. Conclui-se que a transição para a economia circular requer abordagem sistêmica com infraestrutura tecnológica e engajamento contínuo.

RESUMEN

Este estudio investiga la aplicación de las estrategias de los 10R como alternativa impulsada por la innovación para avanzar en la economía circular en las prisiones del estado de Santa Catarina. Se adoptó un estudio de caso único cualitativo, triangulando datos de revisión sistemática de la literatura, 16 entrevistas semiestructuradas con administradores penitenciarios y observaciones directas. Los resultados muestran que, a pesar de algunas prácticas sostenibles aisladas, existe una falta de coordinación institucional, conciencia de las partes interesadas y capacitación técnica. Se identificaron la innovación tecnológica, las herramientas digitales y la reorganización de las rutinas organizacionales como facilitadores de la circularidad.

INTRODUCTION

The growing concern with environmental degradation has driven global discussions about how to transition from a linear model of production and consumption to a circular and regenerative approach. Since the early 20th century, concepts such as eco-efficiency, popularized through industrial practices like those of Henry Ford, demonstrated that it was possible to reduce material consumption while increasing profitability through reuse and recycling (Braungart & McDonough, 1998). However, these early practices, although economically effective, did not fully address environmental limits and intergenerational equity.

The notion of sustainable development**,** formally introduced in the Brundtland Report (1987), established a new paradigm by emphasizing that development should “meet the needs of the present without compromising the ability of future generations to meet their own needs” (p. 43). This concept advanced the need for systemic thinking and multi-stakeholder collaboration to achieve environmental, social, and economic balance (Goodman et al., 2017).

In this context, the Circular Economy (CE) emerges as a strategic and operational model that proposes a systemic shift from the traditional "take-make-dispose" approach to one that regenerates natural systems, retains the value of products and materials, and minimizes waste (Ellen MacArthur Foundation, 2015; Geissdoerfer et al., 2017). CE is not only a technical solution but a socio-institutional transformation that challenges current consumption and production patterns (Kirchherr et al., 2018), and requires new values, behaviors, and governance mechanisms (Ghisellini et al., 2016; Kruglianskas et al., 2018).

Among the strategic approaches to operationalizing CE are the so-called 10R strategies, which offer a hierarchy for action: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover (Reike et al., 2018). These strategies offer not only environmental gains but also economic and social benefits, especially when adapted to complex institutional environments.

Despite the growing academic interest in CE, studies tend to focus on industrial, urban, or agricultural contexts, while institutionally marginalized environments, such as prison systems, remain largely unexplored (Mies & Gold, 2021). Correctional facilities, with their rigid structures and specific governance challenges, can paradoxically offer fertile ground for sustainability innovations, especially given the potential for resource reuse, professional training of inmates, and localized circular systems.

This study addresses this gap by investigating how the 10R strategies can be integrated as innovation-driven alternatives for the transition to a circular economy in state penitentiaries in Santa Catarina, Brazil. Using a qualitative single-case study approach, including a systematic literature review, 20 semi-structured interviews with prison administrators, and direct observation, the research explores both existing practices and institutional barriers.

While some units present promising initiatives, such as digital document management, selective waste collection, and rainwater harvesting, there is still limited institutional coordination, low stakeholder awareness, and scarce training in CE principles. These gaps highlight the importance of integrating organizational and technological innovations to support systemic adoption of the 10R framework in penitentiary environments.

By expanding CE research into overlooked public-sector domains, this study contributes to theory by refining the applicability of circular principles in constrained institutional settings, and to practice by identifying replicable strategies for prison management focused on sustainability, efficiency, and socio-environmental responsibility.

THEORETICAL FRAMEWORK

The 10R Strategies and the Circular Economy

The concept of Circular Economy (CE) encompasses diverse principles and frameworks, emerging from a multidisciplinary foundation that includes ecological, industrial, and environmental economics (Ghisellini et al., 2016; Merli et al., 2018). As an alternative to the traditional linear model of "take-make-dispose," the CE aims to redesign industrial systems to be regenerative by design, reducing the use of virgin resources, minimizing waste, and extending the life cycle of materials (EMF, 2013).

Prominent models such as Cradle to Cradle, the Blue Economy, Biomimicry, and Regenerative Design contribute to this vision by emphasizing restorative practices, clean energy use, and the separation of biological and technical cycles (Ellen MacArthur Foundation, 2015). Circular practices are increasingly viewed as strategic tools for aligning environmental protection with economic development (Geissdoerfer et al., 2018).

Within this context, the 10R framework proposed by Reike et al. (2018) provides a structured hierarchy for circular strategies. These range from the most radical, R0 (Refuse) and R1 (Reduce), to downstream approaches such as R7 (Recycle), R8 (Energy Recovery), and R9 (Re-extraction of Resources). The complete list includes "Refuse", "Reduce", "Reuse", "Repair", "Refurbish", "Remanufacture", "Repurpose", "Recycle", "Recover" (energy), and "Re-extract" (resources). This hierarchy supports waste reduction while fostering innovation, ethical awareness, and institutional adaptation.

Several scholars have contributed to the conceptual refinement of the 10Rs. Allwood et al. (2011) emphasize refusal as a means of reducing overconsumption, while Francis (2003) highlights the environmental and financial gains of reduction. Reuse and repair are linked to innovation and corporate social responsibility (Yan & Feng, 2014; Hultman & Corvellec, 2012). Refurbishment and remanufacturing support technological renewal and emissions reduction (Blackburn, 2004; Lieder & Rashid, 2015). At later stages, recycling and resource recovery contribute to sustainability where prevention is no longer viable (Ghisellini et al., 2014; Cossu & Williams, 2015).

Despite these potentialities, the implementation of the 10Rs poses institutional and managerial challenges. Mies and Gold (2021) point out that the social dimension of the CE remains underdeveloped, lacking ethical frameworks and collaborative strategies. Similarly, Murray et al. (2017) stress the need for a more inclusive discourse in CE theory and practice.

Roper et al. (2018), analyzing Ricoh's case, argue that circular models are dynamic and require continual adaptation to innovation cycles and shifting organizational priorities. Effective implementation of the 10Rs depends on committed leadership and the ability to coordinate forward and reverse flows across the system.

Finally, Valencia et al. (2023) propose "rethinking the 10Rs" by addressing not only technical practices but also business models, governance mechanisms, and institutional discourses. Their findings emphasize that circularity must be embedded in innovation strategies, value chains, and localized systems to create sustainable transformations across sectors.

Building on this discussion, the present study explicitly adopts the hierarchy of the 10R framework proposed by Reike et al. (2018), which encompasses the following strategies: R0 (Refuse), R1 (Rethink/Reduce), R2 (Reuse), R3 (Repair), R4 (Refurbish), R5 (Remanufacture), R6 (Repurpose), R7 (Recycle), R8 (Recover – energy), and R9 (Re-extract – resources). These categories were not only considered as conceptual references, but also operationalized as analytical dimensions to guide data collection and interpretation. In practical terms, the interview protocol, the analysis of documentary evidence, and the field observations were structured around these strategies, enabling the identification of practices, opportunities, and innovations related to each "R". Furthermore, the same framework was employed in the triangulation stage (Table 7), ensuring consistency between theoretical grounding, methodological design, and empirical results.

METHODOLOGY

This research follows a qualitative and constructivist approach, supported by Vygotsky's perspective of the human being as a social and historical actor (Vygotsky, 2001). It is descriptive in nature and aims to understand the organizational reality of the penitentiary system in Santa Catarina through multiple units of analysis, using a case study strategy (Yin, 2015).

Data collection employed triangulation, combining semi-structured interviews, documentary analysis, and on-site observation. The central instrument was the set of semi-structured interviews, conducted between August and November 2023 with prison managers. A total of 20 professionals were invited (12 prison directors and 8 regional superintendents), of which 16 agreed to participate, representing over 75% of the target group. Interviews were carried out via Zoom, recorded with the participants' consent, and followed a script based on the 10R framework (Refuse, Rethink/Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover, and Re-extract). Questions explored current practices, institutional challenges, and opportunities for innovation. In addition, participants' profiles (age, education, years of service, and role) were collected to contextualize the findings.

The penitentiary units of Santa Catarina (12 establishments) and their eight regional administrations composed the unit of analysis. The combination of directors and regional managers ensured that the study encompassed the entire state system. Alongside the interviews, institutional documents (legislation, reports, and strategic plans) were analyzed and coded according to the 10R categories. On-site visits were conducted in all 12 prison units following a structured protocol, focused on practices such as reuse, repair, recycling, recovery, and rainwater harvesting.

All interviews were fully transcribed and analyzed through content analysis (Bardin, 2011), allowing the classification and grouping of responses by thematic relevance. The methodological design thus ensured consistency between the theoretical framework, data collection procedures, and empirical analysis.

The research project was approved by the Research Ethics Committee of Universidade do Sul de Santa Catarina – UNISUL, under the procedures of CONEP/Plataforma Brasil (Opinion nº 6.321.514, CAAE 73902223.8.0000.0261). All participants signed an Informed Consent Form, guaranteeing confidentiality, voluntary participation, and compliance with Brazilian regulations on human subject's research.

Table 1 summarizes the methodological design, including objectives, data collection techniques, and analytical procedures, within an interpretivist paradigm.

Table 1. Methodological steps of the research

Specific objective	Variables/Dimensions mobilized	Procedures/Methods	Analysis strategy
Identify organizational practices related to circular economy in prison units	10R strategies (Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, Recover/Re-extract)	Semi-structured interviews with 20 prison managers; direct observation in 12 units	Content analysis (Bardin, 2011)
Verify barriers and opportunities for implementing the 10Rs	Managers' perceptions; institutional conditions; technological infrastructure	Interviews + documentary analysis (plans, reports, legislation)	Data triangulation (Yin, 2015)
Map innovations that contribute to socio-institutional changes toward circularity	Use of digital technologies, management practices, staff training	Field observations + institutional documents	Comparative thematic analysis
Consolidate evidence and integrate results from different data sources	Synthesis of collected data; convergence and divergence among sources	Triangulation between interviews, observations, and documents	Data triangulation framework (Table 7)

Source: Author's elaboration based on research data (2025).

Table 1 presents the methodological design of the study, linking specific objectives, analytical variables/dimensions, data collection methods, and analytical strategies. The adoption of a single case study with multiple units of observation aimed to ensure depth and interpretative richness (Yin, 2015). The variables mobilized were operationalized through the 10R framework (Reike et al., 2018), which guided both the interview protocol and the categorization of documentary and observational data. Methodological triangulation strengthened the consistency and validity of the findings by cross-checking evidence from different sources.

Data Triangulation

To ensure the reliability and comprehensiveness of the findings, this study employed **data** triangulation, integrating multiple sources of evidence to address the research objectives. Specifically, triangulation was used to: Identify organizational practices and routines that converge towards the adoption of the 10R's; Map opportunities for advancing the implementation of the 10R's; Examine the types of innovation that contribute to socio-institutional change, involving the revision of rules, customs, and beliefs toward a circular economy. The triangulation incorporated three types of evidence:

- Primary data: Semi-structured interviews with managers, operational staff, and other stakeholders across 12 penitentiary units and additional administrative or departmental units.
- Observational data: On-site visits to the units, documenting practices related to material use, waste management, energy recovery, and other sustainability initiatives.
- Secondary data: Official documents, including operational manuals, sustainability plans, annual reports, and regional directives issued by the Department of Penitentiary Administration.

By combining these sources, the study was able to cross-verify information and gain a more robust understanding of how the 10R's are implemented and can be advanced in state penitentiaries in Santa Catarina. The synthesis of these data is summarized in Table 7.

RESULTS AND DISCUSSION

Characterization of the Prison Units Researched

The penitentiary units that were the subject of this research have very individual peculiarities and characteristics. Industrial prisons none of them have similarity in the activities carried out, some develop textile lines, other technologies, others furniture. Agricultural penitentiaries, depending on their location, climate and relief, characterize their crops, some to support the penitentiary itself, others to supply the complex that is located with other prison units and others that have a harvest demand that supplies the units and it is still possible to sell a demand providing funds for that penitentiary, some even industrialize products from their harvests, such as fruit and vegetable jams, which are sold. In general, it is possible to discuss the lack of waste and waste management through interviews, observations and documentary analysis. Servers are not encouraged to adopt the Circular Economy, nor are they encouraged to implement "Rs" strategies.

Profile of Interviewees

The research sought information from the superintendents, that is, the penitentiary system of the State of Santa Catarina and divided into 08 regions in which each region has a representative who has a career as a Criminal Police Officer where they work in the role of managing the prison units in their division. which may include prisons, penitentiaries, industrial penitentiaries, hostels, agricultural colonies, industrial agricultural colonies, female or male units, maximum security unit, custody hospital, each with its peculiarities and definitions of serving a sentence, as established by law.

The penitentiary units analyzed in this study present distinct characteristics. Industrial prisons differ in their productive activities: some develop textile lines, others focus on technology, while others manufacture furniture. Agricultural penitentiaries, depending on their location, climate, and soil conditions, cultivate different crops. In some cases, production is directed to internal consumption; in others, it supplies neighboring complexes or even generates surplus for sale, creating financial resources for the institution. Certain units also process their harvests, producing items such as fruit and vegetable jams for commercialization.

Despite these initiatives, interviews, observations, and document analysis revealed a general lack of structured waste management. Staff members are not systematically encouraged to adopt circular economy principles or to implement strategies based on the 10Rs framework.

A total of 20 prison managers were invited to participate in the study, including 12-unit directors and 8 regional superintendents. Despite repeated contact attempts, 4 invitees declined or were unavailable, resulting in 16 completed semi-structured interviews. This corresponds to a response rate of over 75%, ensuring broad coverage of the prison system

Table 2. Interviewee profile

Age	Education	Length of time in position	Time spent in the role	Office	Function
38 years	Law graduation	8 years	10 months	Criminal police	Superintendent
37 years	Graduated in law and postgraduate in public security	5 years	6 months	Criminal police	Director
50 years	Graduated in law and Postgraduate in seg. Pub.	21 years	7 months	Criminal police	Director
42 years	Graduated in administration	6 years	7 months	Criminal police	Superintendent
45 years	Graduated in law and Postgraduate mon. Public	16 years	3 years	Criminal police	Director
33 years	Graduated in law and Postgraduate mon. Public	9 years	1 year	Criminal police	Director
36 years	Graduated in law and postgraduate in public administration	9 years	1 year and 6 months	Criminal police	Director
37 years	Graduated in law	8 years	1 year	Criminal police	Superintendent
40 years	Graduated in law	20 years	1 year	Criminal police	Director
43 years	Graduated in law and Postgraduate mon. Public	14 years	2 years	Criminal police	Superintendent
36 years	Graduated in law and postgraduate in public administration	14 years	3 months	Criminal police	Director
45 years	Graduate in pedagogy postgraduate in public management	8 years	10 months	Criminal police	Superintendent
44 years	Graduated in accounting and postgraduate in management In prison units	8 years	10 months	Criminal police	Director
51 years	Graduated in law and Postgraduate mon. Public	13 years	2 years	Criminal police	Director
43 years	Graduated in law and postgraduate in public administration And public security	13 years	7 months	Criminal police	Superintendent
37 years	Law degree and postgraduate In public administration	15 years	3 years	Criminal police	Director
51 years	Graduated in law and Postgraduate mon. Public	13 years	2 years	Criminal police	Director
51 years	Graduated in law and postgraduate in public management	13 years	10 months	Criminal police	Superintendent
42 years	Graduated in law and Postgraduate mon. Public	20 years	10 months	Criminal police	Director
45 years	Graduated in law	9 years	1 month	Criminal police	Superintendent

Source: Author's elaboration based on research data (2025).

Of the 20 prison managers invited to participate in the study (12-unit directors and 8 regional superintendents), 16 completed the semi-structured interviews, corresponding to a response rate of over 75%. All respondents are career criminal police officers, gazette and active, having completed the three-year probationary period required by the Federal Constitution of Brazil (1988, art. 41). This condition demonstrates their professional stability, accumulated experience, and knowledge of the penitentiary system. With respect to the age group, the respondents are professionals with the maturity required to occupy leadership positions such as Unit Director or Regional Superintendent.

Organizational Practices and Routines Supporting the Adoption of the 10R's

In this study, data were collected from two types of units within the Santa Catarina penitentiary system:

1. **Penitentiary Units**: Twelve specific penitentiaries were included in the study, representing the main operational units where daily management and inmate activities occur.

2. **Administrative or Departmental Units**: These include other organizational structures, such as departments or directorates, which support the penitentiary system through administrative, educational, health, or operational functions. These units may encompass multiple penitentiaries within a regional scope (e.g., one regional department may include four to ten individual penitentiaries).

The data revealed a general lack of formalized organizational practices and routines aimed at implementing the 10R's. The most frequently observed practices were selective collection of materials for sale to specialized companies, reduction of consumption, and some initiatives to encourage refusal of unnecessary materials. Other practices were rarely observed or reflected only a stated intention to implement them.

It is important to note that the observed practices pertain to the units and regions included in the study. Observations, interviews, and document analysis indicated projects in progress or expressions of willingness to carry out sustainable practices, such as courses, events, and stakeholder training related to the 10R's. Therefore, the percentages presented do not fully reflect the actual implementation of these practices.

As shown in Table 3, the data correspond either to specific penitentiary units or to regional/departmental units, explaining the variation in the number and type of practices observed across different units.

Table 3. Organizational practices and routines that converge towards the adoption of the 10R's

Units	Organizational practices and routines
Social unit	Refuse, Reduce, Reuse, Repair, Renew, Remanufacture, Reuse, Recycle, Energy recovery and Resource re-extraction.
Penal unit	Refuse, Reduce, Reuse, Repair, Renew, Remanufacture, Reuse, Recycle, Energy recovery and Resource re-extraction.
Administrative unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle and Re-extraction of resources (artesian well).
Education unit	Refuse, reduce, repair.
Remission unit	Refuse, Reduce, Repair, Recycle, Re-extraction of resources (rainwater capture).
Screening unit	Refuse, reduce, reuse, repair, renew, remanufacture, reuse, recycle.
Parliamentary unit	Refuse, reduce, reuse, repair, recycle.
Reception unit	Reduce, reuse, repair, recycle, renew, reuse, recycle.
Intelligence unit	Refuse, reduce, reuse, repair, renew, remanufacture, reuse, recycle.
Health unit	Refuse, reduce, reuse, repair, renew, remanufacture, reuse, recycle.
Warehouse unit	Refuse, reduce, reuse, repair, renew, remanufacture, reuse, recycle.
Peculium unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle, Energy recovery (boiler) and Resource re-extraction (artesian well).
Human resources unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle, Energy recovery (boiler) and Resource re-extraction (artesian well).
Management unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle and Re-extraction of resources (artesian well).
Coordination unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle, Energy recovery (boiler) and Resource re-extraction (artesian well).
Duty unit	Refuse, reduce, reuse, repair, renew, reuse, recycle
Chief security unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle, Energy recovery (boiler) and Resource re-extraction (artesian well).
Armament unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle and Re-extraction of resources (artesian well).
Fleet prison unit	Refuse, Reduce, Reuse, Repair, Renew, Reuse, Recycle and Re-extraction of resources (artesian well).
Prison monitoring unit	Refuse, reduce, reuse, repair, renew, reuse, recycle.

Source: Author's elaboration based on research data (2024).

The practices and routines shown in table 3 are carried out in most cases partially, there is a focus on sustainability on the part of management, however, it is possible to analyze in data collection the lack of individual knowledge of stakeholders in misalignment with the government incentive and effectively commitment to these practices.

Secondary sources were consulted to complement the observations and interviews. These sources included official documents from the penitentiary units, such as annual reports, operational manuals, sustainability or environmental action plans, and internal memos, as well as regional guidelines issued by the Department of Penitentiary Administration

Table 4 maps some observed aspects and data from secondary sources alluding to the practices of the 10R's of sustainability, which demonstrates the desire to refuse materials and reduce the consumption of certain items, highlighting the recycling of materials, which in most units are sold, which generates value for the unit, resulting in benefits for stakeholders.

Table 4. Aspects observed and mapped in secondary sources relating to the 10R'z

Prison units	Aspects observed	Relevant secondary data
Social unit	Some of the regional units no longer use A4 sheets and do not use printing, they use digital technology, they encourage servers to have their own glasses, cups and other utensils, avoiding the use of disposable materials, Reusing all types of materials , for example: walls that were demolished, to be used to prepare sidewalks in the unit, Repair uniforms used by inmates, giving the possibility of reuse, Renew rubber materials that were already “unused”, manufacturing slippers, Remanufacture irons and demolition bars for a new area or to another unit that needs it, Reuse of food waste for composting and use in vegetable gardens, Recycling materials such as paper and plastic, selling and generating income. Energy recovery, there is a project to implement photovoltaic panels and re-extract resources such as rainwater capture.	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Penal unit	The unit no longer uses A4 sheets and does not use printing, it uses digital technology, it encourages servers to have their own glasses, cups and other utensils, avoiding the use of disposable materials, Reusing all types of materials, for example : walls that have been demolished, to be used to prepare sidewalks in the unit, Repair uniforms used by inmates, giving the possibility of reuse, Renew rubber materials that are already “unused”, manufacturing slippers, Remanufacture irons and demolition bars for a new area or for another unit that is necessary, Reuse of food waste for composting and use in vegetable gardens, Recycling materials such as paper and plastic, selling and generating income. Energy recovery, there is a project to implement photovoltaic panels and re-extract resources such as rainwater capture.	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Administrative unit	The unit recycles materials such as plastics and paper, which are sold to a company that collects them, and thus ends up making a certain amount of money for the unit. Makes repairs whenever necessary to equipment, vehicles and structures.	It has sewage treatment. 50% use of LED lamps; Separation of recycled materials is carried out.
Education unit	Recycling of materials that are sold to a company that collects income for the unit, Refusal to use disposable cups, the outsourced food company itself carries out a campaign to encourage servers to use their own cups and cups, avoiding the disposable.	It has sewage treatment. 75% use of LED lamps. Separation of recycled materials is carried out.
Remission unit	Rainwater capture.	Sale of recycled material to generate resources for the benefit of the unit and servers. It has sewage treatment. 40% use of LED lamps; Separation of recycled materials is carried out.

Screening unit	Stakeholders separate the material, and recycling is done through a company.	30% use of LED lamps. It has sewage treatment. Separates recycled materials.
Parliamentary unit	Stakeholders separate the material, and recycling is done through a company. Income generation. Refusal to use a sheet of paper ("as far as communication is concerned, it is no longer made of paper. It is all by SGPE. Today in our unit I will not tell you that it is 100% but 90% is no longer used with paper") SGPE - Management System Electronic Processes.	100% use of LED lamps. Use of brackish water to flush toilets. It has sewage treatment. Separation of recycled materials is carried out.
Reception unit	Recycling materials. ("And this issue of solar panels also doesn't have any possibility. It doesn't, but I want to mention it").	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Intelligence unit	Repair of walls and paintings. Separation of recycled material.	30% use of LED lamps. It has sewage treatment. Separates recycled materials.
Health unit	Refusal of materials. Separation of recycled materials.	30% use of LED lamps. It has sewage treatment. Separates recycled materials.
Peculium unit	Refuses the use of materials, such as plastic cups and paper sheets. Stakeholders separate the material, and recycling is done through an income generation company.	30% use of LED lamps. It has sewage treatment. Separates recycled materials.
Warehouse unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repairs to your unit, such as walls and paintings, vehicles. Recycled materials are collected, and income is generated. Performs energy recovery through a boiler and re-extraction of resources through an artesian well.	It has sewage treatment. 80% use of LED lamps; Separation of recycled materials is carried out.
Human resources	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repairs to your unit, such as walls and paintings, vehicles. Recycled materials are collected, generating income. Performs energy recovery through a boiler and re-extraction of resources through an artesian well.	It has sewage treatment. 45% use of LED lamps; Separation of recycled materials is carried out.
Management unit	Re-extraction of natural resources such as rainwater capture; Energy recovery through solar panels for heating and photovoltaic panels	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Coordination unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, generating income. Performs energy recovery through a boiler and re-extraction of resources through an artesian well.	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Duty unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, generating income for the unit	It has sewage treatment. 100% use of LED lamps; Separation of recycled materials is carried out.
Chief security unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, generating income for the unit. Energy recovery (boiler) and resource re-extraction (artesian well).	It has a boiler for water heating, artesian well and sewage treatment, 50% of the lamps used are LED.
Armament unit	Refuses the use of materials, such as plastic cups and paper sheets. The outsourced company itself collects and disposes of organic waste. Recycled materials are collected, and income is generated. Provides incentives to servers for selective collection. Re-extraction of resources (artesian well). Possibility of implementing an organic vegetable garden.	It has an artesian well. It has sewage treatment.

Fleet unit	Refuses the use of materials, such as plastic cups and paper sheets. The outsourced company itself collects and disposes of organic waste. Recycled materials are collected, and income is generated. Provides incentives to servers for selective collection. Re-extraction of resources (artesian well).	It has an artesian well and sewage treatment. It seeks to implement the motto of the State of Santa Catarina "Paperless Government".
Monitoring unit	Refuses the use of materials, such as plastic cups and paper sheets. Reuse of materials, in relation to vehicles and the physical structure of the unit with repair and painting.	It has sewage treatment.

Source: Author's elaboration based on research data (2025).

In table 4 it is possible to verify that the most representative elements are on the verge of starting the refusal of materials and recycling, the respondents demonstrate willingness or some implementation in the refusal of materials, presentation of motivation to start new projects, and it is possible to observe through documents that Some prison units already have projects under development for the circular economy, such as implementing voltaic panels and rainwater capture projects.

One of the respondents stated that he has a project under development, called "Zero Waste", created by himself in the "penal unit": "we implemented zero waste here about three months ago, in the unit the separation of waste, it is done by inmates and we sell this garbage, this money goes back to the revolving fund, around three to four thousand reais per month". In the interview, he highlighted the professional training he carries out with the employees of that unit, to raise awareness and the environmental importance of recycling.

In the "administrative" unit, he was asked about organic waste, disposal and composting and the answer was that in that unit and 90% of the units interviewed were the same: "it is the responsibility of the outsourced company", which has a contract with the State's prison units. of Santa Catarina, to provide food and the consequent obligation to dispose of organic waste, as established in the contract.

Regarding courses, events and training of professionals in basic education on recycling, R's strategies and Circular Economy, the respondent from the "education unit" responded: "I didn't see any campaign, no campaign was carried out. It was even good to talk about it, so that it can be charged, I think that with recycling we can be earning some money to maintain the unit". The interviews motivate respondents to reflect on the themes, the environmental relevance and the opportunities that the penitentiary system has to develop within the scope of the Circular Economy.

Regarding reuse, the respondent from the "remission unit" responded that: "there is an intern who understands electronics, so he tidies up every LED lamp and returns it to be reused". The units that participated in the interviews and after what was observed in the researched units and in the documentation, the reuse of LED lamps is carried out only in the "remission unit".

The "sorting unit" is part of the 10% of the units interviewed that carry out the practice of rainwater capture: "we store rainwater, to be reused exclusively for irrigation of the garden", it is possible to observe the lack of information in the possibilities of use that rainwater can be enjoyed within a prison unit, such as washing vehicles, flushing toilets and even in the future with the installation of photovoltaic panels and their own maintenance.

Of the units surveyed that participated in the interviews, 95% had the same response regarding the remanufacturing of printer ink cartridges: “in that regard, the printers are rented, they come and install and collect the used one, the used one they take doesn’t stay here” . The outsourced company that rents the printers to the prison system carries out the maintenance and disposal of the cartridges. Currently, only one unit in the State, does not use a printer, makes 100% use of digital technology tools offered by the secretary of prison administration and honoring the state motto: “Government without paper”.

Respondents were unanimous in their response, when asked about biological processes in their respective units: “We do not have biological processes”. Regarding water discharges in toilets, the Parlatore unit responded: “the discharges from the cells are brackish water, the water is not drinking water”. Sewage treatment in the units was not carried out by 90% of the respondents, the reception unit was one of the two units that carry out the treatment, which responded: “we are actually the ones who go to buy some equipment there that is damaged in the our treatment plant and it seems to me that it will be the first tender in the State”.

Regarding the refusal of materials, for example, the refusal to print sheets, replaced by digital technology, during the interviews, it was said that two State units do not use printing, one does not use it in 100%, the other in 95% of cases. In the refusal of plastic cups, something more complex to implement in the units, due to the fact that it depends on the culture and customs of each employee, it was possible to verify that only one unit no longer uses recycled cups, the others refuse partially, the responses in general they are in the same sense as the respondent from the intelligence unit:

> “Each server had their own cup with a name on it, I don't know if it's us, I don't know if it's the lack of culture, I don't know if it's a lack of knowledge, but that's kind of that was lost, we tried to implement it, but it is difficult”.

The lack of campaigns, events and training of employees becomes essential for the development of R's strategies and the implementation of the Circular Economy. On the other hand, the importance on the part of governance in organizing and reorganizing some methods and logistics, regarding linen, only one unit has a laundry room and a sewing area with machines, for repairing inmates' uniforms. Being a relevant topic in the penitentiary system, as confirmed in the speech of the respondent from the “warehouse” unit:

> [...] But we have a lot of clothing waste today, why? Because we don't have a laundry there today, which is something we are fighting about, and what happens with this laundry? As they end up washing it in the cell, this ends up with the uniform itself, it doesn't dry well, it's not that good, it doesn't last well, so it could be better used, because well-washed, well-dried clothes last longer, right? Implement it in all units so that there would be an economy and sustainability and there would be an issue of recycling, in short, I think it would be possible to do a very good job on that[...].

In the 53 active units in the State of Santa Catarina, that is, 53 units do not have a laundry system for inmates' clothes, which causes waste, damage to the environment and expenses for the state government. The “health and savings” units, when asked about the implementation of photovoltaic panels, had answers very similar to the other units interviewed, with the exception of only one unit that has the implementation of photovoltaic panels and is able to partially redistribute what is needed for that unit. The units generally responded:

> [...] I will tell you that we did a project, a very audacious project, the investment was two million and I was scared, and I ended up backtracking. Why did I go back and why are we now moving more slowly? At the time when we did the project we went there and presented a very beautiful thing to the secretariat, it will be the first to have it, it will be top notch. But at the time we were presenting the project to people, it was in the bidding phase for the generator. We bought this generator, it was put to tender, it was delivered, a very good generator, but we ran into a problem, the unit was very old, the issue of guidance, the issue of all this technical issue It started to cause problems. And then the generator started to have problems and we only had a hard time like that for about six months, a lot. So, at the time, I even spoke to the prosecutor's office and the judiciary and I was very scared of doing something like that, we're going to invest two million, then it starts to explode and cause problems in the unit, then it catches on fire and instead of being a business What would be cool is going to be a business that will become a problem [...].

Most active units in the State of Santa Catarina are old, and even the youngest ones, which are a minority, are currently more than 15 years old, that is, in general they are from a generation without prospecting or projects for the implementation of photovoltaic panels, which today reflects the lack of structural condition.

Opportunities to advance the implementation of the 10R's

The opportunities to advance the implementation of the 10R’s in penitentiary units in the State of Santa Catarina deserve careful consideration. Based on the data collected in this study, several possibilities emerge, particularly in areas such as rainwater capture and solar energy recovery through the installation of photovoltaic panels; the implementation of artesian wells; effective selective collection and sale of recyclable materials to generate resources for the units; and the management of organic waste, including composting and subsequent use in vegetable gardens for unit consumption.

Although penitentiary units generally have limited space for cultivation, some even lacking sufficient parking within the walls, proper disposal of organic waste and small-scale food production remain important. Even partial implementation can contribute to cost savings for the state government. Additionally, this study highlights that inmates themselves perform much of the labor involved in these activities, providing them with practical knowledge, supporting their rehabilitation, and reducing idle time within the units.

Table 5 presents the opportunities observed for advancing the implementation of the 10R’s. Some units have the potential to implement all ten principles, given the availability of space for photovoltaic panels and vegetable gardens, among other initiatives.

The opportunities listed in Table 5 were identified through interviews with unit managers and stakeholders, complemented by observations and the analysis of secondary sources, including internal reports, operational manuals, and sustainability plans of the penitentiary units. These opportunities reflect practices that units either already implement or have the potential to implement, all related to the 10R’s of sustainability (Refuse, Reduce, Reuse, Repair, Renew, Remanufacture, Recycle, Energy Recovery, Resource Re-extraction).

The table organizes the results by unit, highlighting the specific initiatives or practices that can advance the implementation of the 10R’s. For example, practices such as composting, installation of photovoltaic panels, rainwater capture, and creation of organic or hydroponic gardens were frequently mentioned in interviews and confirmed through documents, indicating both existing actions and potential areas for improvement.

Table 5. Opportunities to advance the implementation of the 10R's

Units	Mapped opportunities
Social unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Penal unit	-
Administrative unit	Re-extraction of resources (photovoltaic panels), rainwater capture
Education unit	Refusal of paper sheets, rainwater capture, composting, energy recovery and resource re-extraction.
Remission unit	Refusal of paper sheets, rainwater capture, composting, energy recovery and resource re-extraction.
Screening unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Parliamentary unit	Composting, energy recovery and resource re-extraction.
Reception unit	Composting, energy recovery, rainwater harvesting.
Intelligence unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Health unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Warehouse unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Peculium unit	Composting. Garden for own consumption and for sale. Artesian well. Use throughout the structure of led lamps.
Human resources unit	Refusal of sheets of paper. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.
Management unit	Composting. Garden for own consumption and for sale. Artesian well. Use throughout the structure of led lamps.
Coordination unit	Refusal of sheets of paper, plastic cups. Composting, energy recovery and resource re-extraction. Artesian well. Organic/community garden
Duty unit	Refusal of sheets of paper, plastic cups. Composting, energy recovery and resource re-extraction. Artesian well. Organic/community garden
Chief security unit	Refusal of sheets of paper, plastic cups. Composting, energy recovery and resource re-extraction. Artesian well. Organic/community garden
Armament unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden.
Fleet unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden.
Monitoring unit	Refusal of sheets of paper, plastic cups. Composting. Energy recovery and resource re-extraction. Possibility of implementing an organic, hydroponic and community garden. Artesian well. Use throughout the structure of led lamps.

Source: Author's elaboration based on research data (2025)

Types of innovation that contribute to socio-institutional change that involves the review of rules, customs and beliefs towards the circular economy

The present study points out as the main contributor to the socio-institutional change that involves the review of rules, customs and beliefs towards the circular economy, such as knowledge, specifically in human behavior, through awareness and in a second moment the use of digital technologies, internet of things. In this way, it allows innovation towards the circular economy with technological tools that converge with the 10R's of sustainability, according to the following table:

Table 6. Innovations towards the circular economy

Units	Aspects observed	Relevant secondary data
Social unit	The region has some implementations of the 10R of sustainability, the units are moving towards the circular economy.	The regional department trains its employees to raise awareness of the implementation and permanence of the circular economy.
Pe na	The unit has wide implementation of the 10R of sustainability, the unit maintains a circular economy.	The unit trains its employees to raise awareness of the implementation and permanence of the circular economy.
Administrative unit	Separation of material for recycling collection. Motivation to refuse materials such as recycled cups and paper sheets.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaign to raise sustainable stakeholder awareness, focused on the circular economy
Education unit	The unit encourages servers to avoid using disposable cups and paper sheets. Encourages the recycling of materials, selling them to a specialized company, generating income for the unit.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Remission unit	The unit encourages servers to avoid using disposable cups and paper sheets. Encourages the recycling of materials.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy.
Screening unit	The unit has full capacity for sustainable deployment.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Parliamentary unit	50% of the unit uses LED lamps. The unit has an ongoing project to implement photovoltaic panels. It has separation of recycled and organic material.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Reception unit	The unit has a project to implement photovoltaic panels and capture rainwater. 100% use of LED lamp. Separates recycled material.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Intelligence unit	Unit has the capacity to become sustainable.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Health unit	Unit has the capacity to become sustainable.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy

Warehouse unit	The unit has a project to implement photovoltaic panels, composting and an artesian well.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Peculium unit	The unit has a project to implement photovoltaic panels. Composting. Garden for own consumption and for sale. Artesian well. Use throughout the structure of LED lamps. 100% use of LED lamp	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Human resources unit	The unit has a project to implement photovoltaic panels. Composting. Garden for own consumption and for sale. Artesian well. Use throughout the structure of LED lamps. 100% use of LED lamp	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Management unit	The unit has an ongoing project to train employees to be more sustainable in terms of refusing materials, reusing and recycling. Re-extraction of natural resources such as rainwater capture; Energy recovery through solar panels for heating and photovoltaic panels,	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Coordination unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, and income is generated. Performs energy recovery through a boiler and re-extraction of resources through an artesian well. 70% of the unit uses LED lamps. Sale of organic and industrialized products, generating income.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Duty unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, and income is generated. 70% of the unit uses LED lamps. Selling organic products at municipal fairs, generating income.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Chief security unit	Refuses the use of materials, such as plastic cups and paper sheets. Everything possible is repaired in your unit, such as walls and paintings, vehicles. Recycled materials are collected, and income is generated. Performs energy recovery through a boiler and re-extraction of resources through an artesian well. 70% of the unit uses LED lamps. Sale of industrialized products, generating income.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy
Armament prison unit	The unit has a project to implement photovoltaic panels and capture rainwater. The unit encourages servers to avoid using disposable cups and paper sheets. Encourages the recycling of materials, selling them to a specialized company, generating income for the unit. It has an organic vegetable garden for your own consumption. It has composting. 60% use of LED lamps. The unit recycles materials that are sold to a company that collects income for the unit. Refusal to use disposable cups, the outsourced food company itself carries out a campaign to encourage servers to use their own disposable cups. and cups, avoiding disposable ones.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy

Fleet prison unit	The unit has a project to implement photovoltaic panels and capture rainwater. The unit encourages servers to avoid using disposable cups and paper sheets. Encourages the recycling of materials, sells them to a specialized company, generating income for the unit. It has an organic vegetable garden for your own consumption. It has composting. 100% use of LED lamp. The unit recycles materials that are sold to a company that collects income for the unit. Refusal to use disposable cups, the outsourced food company itself carries out a campaign to encourage servers to use their own disposable cups. and cups, avoiding disposable ones.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable stakeholder awareness, focused on the circular economy
Prison monitoring unit	The unit has a small sampling of rainwater collection, for use in toilets. It has vegetable gardens for its own consumption. It has selective separation of materials and collection carried out by a specialized company. It seeks to encourage stakeholders to refuse to use materials, such as plastic cups and paper sheets. 50% use of LED lamp. The unit recycles materials; the outsourced food company itself collects some of the materials and disposes of them appropriately.	The unit has a record of its cargo material: telephone extensions, radio communicators, computers, tablets, cell phones, digital technology tools such as I-pen, SGPE, GVE. Webcam devices (conducting video conferences, for virtual visits and court hearings). Motivational campaigns to raise sustainable awareness among stakeholders, focused on the circular economy

Source: Author's elaboration based on research data (2025).

Recycling is evident in the responses, a practice that is beginning to take shape, through financial incentives, the notorious lack of awareness among stakeholders in a comprehensive process of the 10R's towards the circular economy, that is, the penitentiary system in the State of Santa Catarina lacks development and breaking paradigms, to have socio-institutional evolution, supported by governance.

Data Triangulation

The triangulation of data carried out in this research seeks to answer the objectives related to organizational practices and routines that converge towards the adoption of the 10R's, the opportunities for advancing the implementation of the 10R's and the types of innovation that contribute to the socio-institutional change that involves the review of rules, customs and beliefs towards the circular economy. In which it verifies the 10R's as an alternative supported by innovation for the transition to the circular economy in state penitentiaries in Santa Catarina, as shown in Table 7.

Table 7. Data triangulation

Goals	Evidence from interviews	Evidence from observations	Documentary evidence
It analyzed the organizational practices and routines that converge towards the adoption of the 10R's.	The main finding was some practice of selecting materials for selective collection of recycled materials. Transition to using LED lamps. Transition to refusal to use materials. Motivation for projects to implement photovoltaic panels and rainwater harvesting.	Lack of incentive or motivation from stakeholders towards sustainable awareness, in taking advantage of Artificial Intelligence tools or Digital Technologies.	Evidence of digital technology materials available to stakeholders, avoiding the use of sheets even for vehicular transport.
Verified opportunities to advance the implementation of the 10R's.	Raising stakeholder awareness of sustainability and use of digital technologies.	Lack of incentive or motivation from stakeholders towards sustainable awareness, individual and governance issues.	Existence of facilitating tools to provide opportunities to advance the implementation of the 10'R
It listed the types of innovation that contribute to socio-institutional change that involves the review of rules, customs and beliefs towards the circular economy.	Training, courses and events to raise awareness using the government as a starting point, to break customs and beliefs.	The socio-institutional change that involves the review of rules, customs and beliefs, to align individuals and government towards the circular economy.	Digital technology and artificial intelligence available to stakeholders

Verified the 10R's as an alternative supported by innovation for the transition to the circular economy in state penitentiaries in Santa Catarina.	It has full transition capacity.	It has full transition capacity.	It has full transition capacity.

Source: Author's elaboration based on research data (2025).

The main evidence in data triangulation is represented by the individual, that is, in the change of beliefs and customs, followed by the lack of motivation and professional training by the state government, seeking to raise awareness among its employees through the Circular Economy bias, showing the benefits it brings. for the penitentiary system, the environment, the prison community and society.

FINAL CONSIDERATIONS

This study identified that penitentiary units in the State of Santa Catarina are still at an early stage in the implementation of the 10R strategies of sustainability. Although there is recognition of some R-based practices, such as reuse, recycling, and reduction, there remains a significant gap in understanding the broader principles of the circular economy and a lack of state-level initiatives aimed at professional training, technological integration, and structured planning.

The findings demonstrate that the transition to a circular economy within the prison system depends not only on isolated good practices but on a systemic approach supported by technological innovation, stakeholder engagement, and institutional coordination. Engagement of key actors—including employees, management, suppliers, and society, emerges as a critical factor for advancing sustainability practices across the prison environment.

Digital technologies and automation have the potential to significantly improve resource management within penitentiaries. The integration of tools such as document digitization, photovoltaic energy systems, reuse and repair of equipment, selective waste collection, and rainwater harvesting contributes to greater operational efficiency and reduced environmental impact. Moreover, these innovations can foster collaboration between government and prison staff, while promoting environmental awareness and sustainable behavior.

From a strategic standpoint, the 10R framework offers a clear path toward environmental and economic benefits. Refusal, reuse, repair, and recycling not only reduce waste and operational costs but also open opportunities for revenue generation, training of inmates, and community engagement. The implementation of circular practices can thus enhance both the sustainability of the prison system and its capacity to contribute positively to broader social and environmental goals.

This research reinforces the importance of adopting circular strategies in institutional environments often neglected by public policy and academic debate. Despite infrastructural and cultural challenges, the study shows that there is both potential and willingness within some units to move toward a more circular model, provided that adequate governance, investment, and training are offered.

Among the limitations of the study is the restricted focus on 12 penitentiary units in Santa Catarina, which may affect the generalizability of the findings. In addition, the rapid evolution of technologies and sustainability practices requires ongoing monitoring and adaptation. Challenges such as resistance to change, lack of infrastructure, and gaps in professional qualification also demand attention to ensure the effectiveness of future implementations.

In conclusion, the research highlights that the circular economy, when supported by innovation and strategic commitment, can play a transformative role in public institutions. In the prison context, it represents not only a path toward environmental responsibility but also an opportunity to generate value, optimize resources, and promote dignified and inclusive management.

REFERENCES

Allwood, J. M., Ashby, M. F., Gutowski, T. G., & Worrell, E. (2011). Material efficiency: a white paper. *Resources, Conservation and Recycling, 55*(3), 362-381. https://doi.org/10.1016/j.resconrec.2010.11.002

Bardin, L. (2011). *Análise de conteúdo*. São Paulo, SP: Edições 70.

Blackburn, R. (2004). Remanufacturing in the UK: A significant contributor to sustainable development? *Journal of Cleaner Production, 12*(8–10), 1129–1140. https://doi.org/10.1016/j.jclepro.2004.02.020

Braungart, M., & McDonough, W. (1998). The next industrial revolution. *The Atlantic Monthly, 282*(4), 82–92.

Brasil. (1984). *Lei nº 7.210, de 11 de julho de 1984 (Lei de Execução Penal)*. Dispõe sobre a execução penal. Recuperado de https://www.planalto.gov.br/ccivil_03/leis/l7210.htm

Brasil. (1940). *Decreto-Lei nº 2.848, de 7 de dezembro de 1940 (Código Penal Brasileiro)*. Recuperado de https://www.planalto.gov.br/ccivil_03/decreto-lei/del2848compilado.htm

Brasil. (2005). *Resolução nº 3, de 23 de setembro de 2005*. Diretrizes básicas para arquitetura penal. Recuperado de https://www.gov.br/depen/pt-br/composicao/cnpcp/resolucoes/2011/diretrizes-basicas-para-arquitetura-penal.pdf

Brundtland, G. H. (1987). *Our common future: Report of the World Commission on Environment and Development*. Oxford: Oxford University Press.

Cossu, R., & Williams, I. D. (2015). Urban mining: Concepts, terminology, challenges. *Waste Management & Research, 33*(6), 478–479. https://doi.org/10.1177/0734242X15588305

Ellen MacArthur Foundation. (2013). *Towards the circular economy: Opportunities for the consumer goods sector*. https://www.ellenmacarthurfoundation.org

Ellen MacArthur Foundation. (2015). *Towards the circular economy: The business rationale to accelerate the transition*. https://www.ellenmacarthurfoundation.org

Francis, C. A., Lieblein, G., Gliessman, S. R., Breland, T. A., Creamer, N. G., Harwood, R. R., ... & Wiedenhoeft, M. H. (2003). Agroecology: The ecology of food systems. *Journal of Sustainable Agriculture, 22*(3), 99–118. https://doi.org/10.1300/J064v22n03_10

Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interaction of environmental and economic systems. *Journal of Cleaner Production, 114*, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007

Ghisellini, P., Ripa, M., & Ulgiati, S. (2014). Sustainable waste management: A case study of Italy. *Journal of Cleaner Production, 33*, 58–66. https://doi.org/10.1016/j.jclepro.2012.09.013

Goodman, J., Korsunova, A., & Halme, M. (2017). Our collaborative future: Stakeholder roles and agendas in sustainability innovation. *Business Strategy and the Environment, 26*(6), 731–753. https://doi.org/10.1002/bse.1941

Hultman, J., & Corvellec, H. (2012). The European waste hierarchy: From the sociomateriality of waste to a politics of consumption. *Environment and Planning A, 44*(10), 2413–2427. https://doi.org/10.1068/a44668

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Kruglianskas, I., & Pinsky, V. (2018). Inovação tecnológica para a sustentabilidade: lições de sucessos e fracassos. *Estudos Avançados, 31*(90), 107–126. https://doi.org/10.1590/s0103-40142017.3190008

Lieder, M., & Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production, 115*, 36–51. https://doi.org/10.1016/j.jclepro.2015.12.042

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic review of the literature. *Journal of Cleaner Production, 178*, 703–722. https://doi.org/10.1016/j.jclepro.2017.12.112

Mies, A., & Gold, S. (2021). Mapping the social dimension of the circular economy. *Journal of Cleaner*

Production, 321, 128960. https://doi.org/10.1016/j.jclepro.2021.128960

Murray, A., Skene, K., & Haynes, K. (2017). The circular economy: An interdisciplinary exploration of the concept and application in a global context. *Journal of Business Ethics, 140*(3), 369–380. https://doi.org/10.1007/s10551-015-2693-2

Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or refurbished as CE 3.0? Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling, 135*, 246–264. https://doi.org/10.1016/j.resconrec.2017.08.027

Rodwell, M. K. (1994). *Social work constructivist research*. New York: Garland Publishing.

Roper, S., Hopkinson, P., Zils, M., & Hawkins, P. (2018). Managing a complex global circular economy business model: Opportunities and challenges. *California Management Review, 60*(3), 71–94. https://doi.org/10.1177/0008125618764692

Santa Catarina. (2019). *Lei Complementar nº 741, de 12 de junho de 2019*. Dispõe sobre a estrutura organizacional básica da Administração Pública Estadual. Recuperado de http://leis.alesc.sc.gov.br/html/2019/741_2019_lei_complementar.html

Santa Catarina. (2021). *Lei Complementar nº 774, de 27 de outubro de 2021*. Dispõe sobre o Estatuto da Polícia Penal do Estado de Santa Catarina. Recuperado de http://leis.alesc.sc.gov.br/html/2021/774_2021_lei_complementar.html

Santa Catarina. (2022). *Decreto nº 2.379, de 28 de dezembro de 2022*. Aprova o Regimento Interno da Secretaria de Estado da Administração Prisional e Socioeducativa. Recuperado de https://leisestaduais.com.br/sc/decreto-n-2379-2022-santa-catarina-aprova-o-regimento-interno-da-secretaria-de-estado-da-administracao-prisional-e-socio-educational

Santa Catarina. (2007). *Lei nº 14.003, de 3 de maio de 2007*. Dispõe sobre o Conselho Penitenciário Estadual. Recuperado de http://leis.alesc.sc.gov.br/html/2007/14003_2007_Lei.html

Secchim, A. B., Freitas, R. R., & Gonçalves, W. (2018). Mapeamento e análise bibliométrica da utilização da análise envoltória de dados (DEA) em estudos de engenharia de produção. *Brazilian Journal of Production Engineering*, 4(2), 87–108. https://doi.org/10.47456/bjpe.v4i2.24464

Valencia, M., Bocken, N. M. P., Loaiza, C., & Jaeger, S. (2023). The social contribution of the Circular Economy. *Journal of Cleaner Production, 408*, 137082. https://doi.org/10.1016/j.jclepro.2023.137082

Vygotsky, L. S. (2001). *A construção do pensamento e da linguagem*. São Paulo, SP: Martins Fontes.

Yan, J., & Feng, C. (2014). Sustainable design-oriented product modularity combined with the 6R concept: A rotor laboratory bench case study. *Clean Technologies and Environmental Policy, 16*(1), 89–101. https://doi.org/10.1007/s10098-013-0597-3

Yin, R. K. (2015). *Estudo de caso: Planejamento e métodos* (5ª ed.). Porto Alegre, RS: Bookman.