

The Circularity Risk Matrix in EU Projects – An Approach by the Financial Auditor in Assessing a Cleaner Environment

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Abstract. *The transition to a circular economy is one of the main strategic goals of the European Union. To support this, large amounts of money have been allocated to projects with environmental impact. In theory, these projects should show not only that the money was spent legally, but also that real sustainability results were achieved. In practice, things are different. Circular economy principles are often present only on paper, and financial auditors do not have clear tools to check whether they are actually followed. The academic literature mostly treats the circular economy as a public policy direction. The concrete risks that come with implementing it in publicly funded projects receive much less attention. Even less explored are the practical tools that would allow auditors to assess these risks in a systematic way.*

This paper starts from exactly this gap. This paper treats circularity as a distinct source of auditable risk and builds a circularity risk matrix adapted to financial audit practice. The research is qualitative and exploratory, I analyzed project documents, audit reports, and applied professional judgment to a set of anonymized case studies. The result is a typology of circularity risks and a matrix that helps assess their likelihood and impact. The main contribution of this paper is to make circularity an auditable concept and to show that the financial auditor can play a real role in promoting a cleaner economic environment.

Keywords: circular economy, circularity risk, European Union–funded projects, financial audit, risk matrix, sustainability.

Introduction

The circular economy is becoming more and more common in the economic and environmental policies of the European Union. The main idea behind this is that traditional growth models are no longer sustainable in the long run. European funds have become the main tool through which circular economy principles are applied in different sectors, from infrastructure and production, to waste management, energy and research. Projects funded through these programmes regularly use concepts like reducing material footprint, extending product life cycles, or recovering the economic value of resources.

However, there is a persistent gap between what projects promise and what can actually be checked. In practice, the success of EU-funded projects is mostly measured by how much money was absorbed and whether implementation procedures were followed. The real environmental impact is much harder to measure. This is not just a technical problem. Circular economy goals risk becoming commitments on paper rather than real operational targets.

This gap has a direct effect on the role of the financial auditor. Beyond the traditional checks of legality, regularity and eligibility of spending, auditors are now more often asked to evaluate whether reported performance results were actually achieved, including those related to circular economy outcomes. Claims about reduced resource consumption, higher reuse rates or waste recovery are, in fact, performance estimates. As such, they can be affected by measurement errors, subjective interpretations, and sometimes intentional overstatements.

This is where the concept of circularity risk becomes relevant. In this research, circularity risk is defined as the probability that an EU-funded project formally meets compliance requirements without generating real and sustainable contributions to its circular economy objectives. This risk can take different forms: circularity stated in project documents without operational support, performance indicators that are never validated, weak traceability of material flows, procurement practices not aligned with environmental goals, or simply the inability to show real impact on the ground.

The literature on circular economy, risk management and sustainability assurance has grown a lot in recent years. But these fields are mostly treated separately. There is no practical framework for financial auditors. Nothing that helps them identify and assess circularity risks in EU-funded projects. The environmental dimension is still treated as a compliance element. Not as a real risk category in audit planning.

This paper tries to fill this gap. The main research question is simple: how can the financial auditor identify, assess and manage circularity risks in EU-funded projects? The goal is to build and test a circularity risk matrix. It is based on qualitative analysis and adapted to the practical needs of financial audit work.

Research questions, objectives and hypotheses

Based on the identified research gap, this study addresses the following research questions:

RQ1: How can circularity be conceptualized as a distinct source of auditable risk in projects financed by European Union funds?

RQ2: What types of circularity-related risks emerge across different sectors and forms of EU-funded interventions?

RQ3: How can these risks be systematically assessed by the financial auditor using an operational tool?

To answer these questions, the research pursues the following objectives:

O1: To identify recurring typologies of circularity risk in projects financed by European Union funds.

O2: To develop a circularity risk matrix adapted to the professional judgment and procedures of financial audit.

O3: To test the applicability of the proposed matrix through multiple case studies.

Based on these objectives, the following research hypotheses are formulated:

H1: Circularity claims formulated in projects financed by European Union funds generate specific risks that are not adequately captured by compliance-oriented financial audits.

H2: ISRS 4400-type engagements provide sufficient evidence for the verification of expenditures, but are insufficient for validating circular performance and environmental impact.

Literature Review

The Circular Economy and the Challenges of Performance Assessment

According to European public policies and specialist literature, the circular economy is an alternative to the linear economic model. It promotes the retention of value in materials, products and resources, while limiting pressure on the natural environment through cyclical use. Within the European Union, these principles are embedded in strategies and funding programmes that encourage reuse, recycling and the optimization of resource flows. Progress is monitored through agreed sets of indicators at the macro level.

The literature also recognizes significant methodological diversity in how circularity is measured. Claudio-Quiroga and Poza (2024) analyzed the circular economy across Europe and found considerable differences in how Member States perform, depending on which indicators are used and how they are aggregated. The authors describe this as a "multi-speed" Europe in the transition to circularity. Without a standard set of agreed metrics, results depend heavily on methodological choices, which limits comparability.

For publicly funded projects, this matters a lot. Circular economy indicators are used not only to monitor progress, but also to justify resource allocation and evaluate performance.

Circularity Indicators and the Risk of Overstating Performance

A large part of recent literature points out the limitations of widely used circularity indicators. One of them is the Material Circularity Indicator, or MCI. It is often used to assess performance at product and project level. The main criticism is that it relies too much on mass flows. It also assumes that the value of recovered materials does not drop significantly over time.

Jiang et al. (2022) show that using mass as the main unit of measurement can lead to wrong circularity assessments. This is especially true for materials that are light but have high economic value. The authors argue that the MCI tends to overestimate circular performance. The reason is that it ignores how residual value drops over time and how functional value is lost during reuse and recycling. To fix this, the study suggests adding economic value and a residual value indicator. The results show big differences compared to assessments based only on quantity.

These findings suggest that circularity indicators can give overly positive results. They may not accurately reflect the real environmental impact or how the value of resources changes over time. This increases the risk of misreading project performance.

Resource Quality and the Retention of Functional Value

Beyond the limits of quantitative indicators, recent literature points to the important role of quality in circular economy assessment. Vulsteke et al. (2025) argue that keeping functional value is at the core of the circular economy. But most existing indicators do not capture this well. The authors note that quality is often mentioned but rarely defined clearly. It is also measured in inconsistent ways. This makes it hard for assessments to capture real value losses across use cycles.

Vulsteke et al. (2025) developed a typology of quality metrics. Their work shows that circularity evaluation changes a lot depending on the level of analysis whether you look at materials, components, or products. It also depends on what characteristics are considered. A focus on quantitative recycling can hide problems like downcycling and open-loop uses. These reduce the functional value of resources but are still reported as circularity successes.

This shows that circular performance cannot be properly assessed without looking at the qualitative side of resources and outcomes.

Different Forms of Circularity and the Complexity of the Institutional Context

Recent literature also shows that the circular economy is not one single concept. It can take different forms depending on how resource flows are organized. Goldstein et al. (2025) propose a typology of resource circularity in urban settings. They distinguish between industrial symbiosis, conventional waste management, and urban symbiosis. These forms differ a lot in terms of who is involved, how coordination works, and how well they are integrated into local structures.

The authors introduce the concept of "urban embeddedness". This means that circularity depends heavily on the institutional and socio-economic context. This makes it harder to standardize assessments and compare results across different settings.

This is especially relevant for EU-funded projects. These projects operate in very different contexts and use different circular strategies. Evaluating them with the same set of indicators is not easy.

Circularity, Optimization, and Operational Realities

Another part of the literature looks at circular supply chains. The focus here is on designing logistical systems that combine sustainability with economic efficiency. Bavar et al. (2026) built a circular supply chain model for the agricultural sector. Their model takes into account real problems like water use, agrochemical inputs, and the use of agrivoltaic technologies. The findings show that circular performance depends a lot on key decisions where facilities are located, how transport is organized, and how inventory is managed.

But there is a limitation. These models usually assume that the indicators used to measure performance are correct and reliable. They do not really look at the risks of measuring and reporting results in real-world settings, like publicly funded projects.

Research Gap

The literature review shows a clear gap. It sits at the intersection of circular economy, performance assessment, and financial audit. Existing research helps us understand the limits of circularity indicators (Jiang et al., 2022), the role of quality and functional value (Vulsteke et al., 2025), the different forms of circularity (Goldstein et al., 2025), and how to optimize circular supply chains (Bavar et al., 2026). But none of this provides a practical framework for assessing the risks linked to reporting circular performance. In my own audit practice, I have encountered this gap repeatedly, circularity objectives are present in project documentation, but there is no procedure to verify them.

There is no tool designed to help financial auditors identify and assess circularity risks in EU-funded projects. This is a problem, because performance in these projects is often judged using indicators that have clear methodological weaknesses. This paper tries to fill that gap. It proposes a circularity risk matrix. The goal is to create a practical tool for assessing whether projects really contribute to a cleaner environment.

Circular economy, audit and performance risk

The circular economy literature has grown a lot in recent years. But circularity has not been well integrated into financial audit and assurance practices. Most studies look at sustainability reporting and environmental performance from a management or policy perspective. The risk dimension related to the auditability of circularity claims gets very little attention.

Research on sustainability assurance shows big differences in the scope, methodology, and credibility of non-financial assurance engagements (Simnett et al., 2009; Mock et al., 2013). These studies show that non-financial performance indicators are often reported without solid and verifiable evidence. This increases the risk of overstating environmental performance and weakens accountability.

In the public sector, the performance audit literature points to a structural problem. It is hard to link spending to real outcomes and impacts, especially in complex areas like environmental

protection (Lonsdale et al., 2011). Performance audits often find a gap between following funding rules and actually achieving the intended results. This is very relevant for EU-funded projects.

From a risk management point of view, Power (2019) argues that modern governance systems rely too much on formal controls and indicators. These create an illusion that everything is under control, while real performance risks are not properly addressed. For circular economy projects, this means that compliance-focused audits may miss risks related to the credibility and long-term sustainability of circularity outcomes.

Despite all these contributions, the literature still does not offer a practical framework for financial auditors. There is no tool to help them identify, assess, and prioritize circularity risks in funded projects. This gap is exactly what this paper tries to address. The goal is to develop a circularity risk matrix that turns circularity claims into auditable risk categories.

Methodology

The data used in this research comes from projects financed by European funds. These projects were audited through engagements conducted in accordance with ISRS 4400. The audit work served as a data source. But the research does not aim to evaluate or describe the audit activity itself. The academic approach involved comparing the available information, identifying recurring types of circularity risks, and organizing them into a risk matrix. The goal was to support evaluation from a financial audit perspective.

This study uses a mixed methodological approach. Qualitative analysis is combined with a quantitative component. The quantitative part helps with comparability and interpretation of results. The aim is to analyze circularity as a distinct source of risk in EU-funded projects, from a financial audit perspective, and to build a circularity risk matrix that auditors can use in practice.

The research is based on a multi-case study design. This approach is suitable for complex situation that are not well standardized and depend heavily on context. Four EU-funded projects were analyzed. All four were audited through agreed-upon procedures under ISRS 4400. They were selected to cover different forms of circularity and different types of beneficiaries.

One project was in the public health sector with indirect environmental impact. Two were in the renewable energy sector one implemented by a local public authority and one by a private beneficiary. The fourth focused on improving energy efficiency in residential buildings. This selection allows a comparative analysis of circularity risks across sectors, beneficiary types, and intervention types.

Data was collected through systematic documentary analysis. Only official project documents were used. These included funding contracts, funding applications, technical documentation, progress reports, procurement documents, audit reports, and agreed-upon procedures reports under ISRS 4400. All materials were analyzed in anonymized form, following confidentiality and research ethics principles.

The qualitative analysis was done through thematic analysis, in several stages. In the first stage, circularity claims were identified in each project. Some were explicit, through environmental and energy efficiency indicators. Others were implicit, through objectives related to prevention, durability, or reducing environmental impact.

In the next stage, these claims were compared with the types of evidence available in financial audit work. The focus was on the gap between declared circular performance and performance that can actually be supported by auditable evidence. From this comparison, recurring

types of circularity risk were identified across multiple projects. These form the conceptual basis of the circularity risk matrix.

To make results comparable and to turn the qualitative analysis into a practical audit planning tool, a quantitative scoring component was added. For each type of circularity risk, three dimensions were assessed. These are the probability of risk occurrence and the potential impact on environmental objectives, both on a scale from 1 to 5 and the effectiveness of existing controls, on a scale from 1 to 3. The inherent risk score was calculated by multiplying probability and impact. The residual risk score was calculated by dividing the inherent risk score by control effectiveness. These calculations help rank and compare risks across projects. They are not meant for statistical hypothesis testing.

The main hypothesis is that circularity claims in EU-funded projects generate specific risks that compliance-focused financial audits do not capture well. A second hypothesis is that ISRS 4400 procedures are good for checking eligible spending and contractual compliance, but not enough for validating circular performance or environmental impact. The methodology is designed to show why integrating circularity into financial audit risk analysis is useful.

The quantitative part involved applying simple arithmetic formulas to ordinal scores, presented in tables. Results were interpreted by combining the scores with the qualitative analysis of project documents and applying the professional judgment of the financial auditor. The goal was to draw conclusions relevant both to academic literature and to financial audit practice in the context of EU funding.

Methodological positioning and data processing

The methodological approach used in this study is not new. It builds on prior research that applied qualitative risk analysis and case-based designs. The goal of that research was to investigate complex audit and sustainability issues. Lonsdale et al. (2011) and Power (2019) are relevant examples. Similar approaches have been used in performance audit research. They have also been used in sustainability assurance research. The common goal was the same, to turn qualitative judgments into structured analytical tools that can be applied in practice.

The analysis is based on documentary evidence collected from project applications, implementation reports, and supporting technical documentation. Data was coded and organized using Microsoft Excel. This allowed cross-case comparison and transparent risk scoring. This approach keeps analytical rigor while preserving the professional judgment needed in audit work, in line with established audit practice.

Results and Discussion

This section presents the main findings of the research. The results come from applying both the qualitative methodology and the quantitative scoring to the four EU-funded projects analyzed. The findings are discussed in relation to the research hypotheses. They are also connected to relevant conclusions from the literature. The goal is to assess how robust and applicable the proposed contribution is.

The analysis is structured around the circularity risk matrix. This ensures consistency between the methodology and the presentation of results. The scoring system is used to rank and compare risks across the four cases.

Results of the Qualitative Case Study Analysis

The general characteristics of the analyzed projects are summarized in Table 1. This includes the intervention sector, the type of beneficiary, and the form of circularity targeted. Table 1 provides the comparative framework needed to interpret the results.

Table 1. Characteristics of the Analyzed Projects

Case	Sector	Type of Beneficiary	Type of Circularity	Type of Audit
A	Public health	Public hospital	Indirect circularity (prevention)	ISRS 4400
B	Renewable energy	Local public authority	Energy circularity	ISRS 4400
C	Renewable energy	Private beneficiary	Energy circularity	ISRS 4400
D	Building energy efficiency	Public authority	Material and energy circularity	ISRS 4400

Source: Authors' own research results.

The qualitative analysis showed that circularity is present in all four projects. In some cases it is explicit. In others it is implicit. But the way it is formulated, how operational it is, and how auditable it is, differ a lot depending on the sector and the type of beneficiary.

In the public health project (Case A), circularity is formulated indirectly. It appears through objectives related to prevention and resource use optimization. There are no clear and verifiable environmental indicators. The financial audit confirms that spending was eligible and assets exist. But it does not provide evidence about the project's actual contribution to reducing environmental impact. This confirms the existence of a declarative circularity risk. This type of risk is typical for projects with indirect environmental impact.

In the renewable energy projects (Cases B and C), circularity is explicit. It is expressed through indicators related to energy production and CO₂ emission reductions. But the audit reports show that these indicators are not verified through performance procedures. They remain outside the scope of ISRS 4400 engagements. The difference between the two cases comes from post-implementation monitoring. In the public sector case, monitoring is more structured. In the private sector case, it is much weaker. This increases the risk of overstating circular performance for private beneficiaries.

In the building energy efficiency project (Case D), circularity is supported by detailed indicators on energy consumption reduction and carbon emission savings. But these indicators are calculated before implementation. They are not validated through audited post-implementation measurements. Technical changes during implementation and dependence on user behavior add further risks. These relate to the sustainability of results over time.

The recurring types of circularity risk identified through thematic analysis are presented in Table 2.

Table 2. Identified Typologies of Circularity Risks

Risk Code	Description of Circularity Risk
R1	Declarative circularity (objectives without operational support)
R2	Unvalidated / unaudited performance indicators
R3	Expenditure–impact decoupling
R4	Limited material traceability
R5	Performance degradation over time / maintenance

Source: Authors' own research results.

R1 – Declarative Circularity (Objectives without Operational Support)

This risk was found mainly in the public health project (Case A). In this project, circularity is not stated directly. It appears through prevention objectives and the optimization of resource use. There are no clear, measurable, and verified environmental indicators to support these objectives. The project meets eligibility and financial requirements. But the documents analyzed do not provide evidence for an operational assessment of environmental impact. This leads to a high risk of declarative circularity. In renewable energy projects, this risk is smaller. Explicit indicators exist in those cases. But the risk does not disappear entirely. Without performance validation, the indicators alone are not enough.

R2 – Unvalidated / Unaudited Performance Indicators

This risk was found in all four projects. It is one of the most common circularity risks identified in this research. In the renewable energy projects (Cases B and C), indicators for energy production and CO₂ emission reductions are calculated before implementation. They are formally reported. But they are never verified through performance procedures within ISRS 4400 engagements. The same problem was found in the building energy efficiency project (Case D). There, indicators for energy consumption reduction are theoretically estimated. They are not validated through audited measurements after implementation. This means that reported performance may not reflect reality.

R3 – Expenditure–Impact Decoupling

This risk was found in all analyzed projects. It describes situations where spending is properly made and confirmed through financial audit, but the link between that spending and actual environmental impact cannot be shown through auditable evidence.

In the public health project (Case A), environmental impact is assumed through indirect preventive effects. There are no specific indicators to support this assumption. In the photovoltaic and building envelope projects (Cases B, C, and D), impact is estimated using standardized calculations and technical assumptions. There is no ex post validation. This makes the decoupling between expenditure and impact even harder to address.

R4 – Limited Material Traceability

This risk was found mainly in the building energy efficiency project (Case D). In this project, material use is checked from a quantitative and financial point of view. But materials are not analyzed in terms of life cycle, origin, or potential for reuse and recycling. In the other projects, this risk is less visible. However, it remains relevant. Funding documentation and audit procedures do not include explicit requirements for material traceability. This gap exists across all projects, not just Case D.

R5 – Performance Degradation over Time / Maintenance

This risk was identified in the private renewable energy project (Case C) and in the building energy efficiency project (Case D). In both cases, maintaining circularity outcomes over time is not straightforward. It depends on equipment maintenance, user behavior, and the availability of financial resources in the long run. The documents analyzed show that general obligations to maintain the investment exist. But there are no mechanisms to monitor and validate performance throughout the entire monitoring period. This is a significant gap. Contractual obligations alone are not enough to ensure that circular performance is sustained over time.

Circularity Risk Matrix

The circularity risk matrix was built using two main inputs. The first was documentary analysis of EU-funded projects. The second was the professional judgment of the financial auditor. The starting point was the circularity claims found in funding documentation and implementation reports. These included claims about reducing environmental impact, increasing energy efficiency, lowering CO₂ emissions, and the sustainable use of materials.

Each claim was analyzed from an auditability perspective. The key question was simple: can this claim be supported by verifiable evidence within a financial audit engagement? The answer was often no. Circularity objectives are frequently stated at a declarative level. But the operational mechanisms and indicators needed to validate actual performance are often poorly defined or completely absent.

Based on this analysis, recurring types of circularity risk were identified. These were common across multiple projects and sectors. For each type of risk, three things were examined. First, the main causes. Second, the existing controls. Third, the types of audit evidence available. This made it possible to assess the residual risk that remains after formal controls are applied. The result of this process is the matrix presented in Table 3. It shows the relationship between circularity claims, associated risks, and the current limitations of financial audit in evaluating environmental performance. The matrix is an operational tool. It was built both inductively from empirical observations in the analyzed projects and deductively by reference to established concepts in circular economy and risk management literature.

Table 3. The Circularity Risk Matrix

Circularity Claim	Associated Risk	Main Causes	Existing Controls	Available Audit Evidence	Residual Risk
Reduction of environmental impact	R1	General formulations, indirect impact	Eligibility rules	Financial documents	Medium–high
Increase in energy efficiency	R2	Ex ante indicators	Technical documentation	Lack of measurements	High
Reduction of CO ₂ emissions	R3	Compliance ≠ impact	Financial audit	No impact validation	High
Sustainable use of materials	R4	Lack of life-cycle approach	Works acceptance procedures	Incomplete data	Medium
Maintaining performance over time	R5	Lack of monitoring	Contractual guarantees	No follow-up	High

Source: Authors' own research contribution.

The circularity risk matrix was built starting from the circularity claims found in the documentation of the audited projects. These claims included objectives related to reducing environmental impact, increasing energy efficiency, reducing CO₂ emissions, ensuring the sustainable use of materials, and maintaining performance over time. These claims were compared across projects in three sectors: public health, renewable energy, and building energy efficiency. The goal was to assess how well they can be supported by auditable evidence.

For each circularity claim, the associated risk was identified. This was done by looking at the gap between declared objectives and the information available within financial audit

engagements. In projects with indirect environmental impact, the risk of declarative circularity (R1) was found. In renewable energy projects, two risks were observed: the use of ex ante calculated performance indicators (R2) and the decoupling between expenditure and impact (R3). In building energy efficiency projects, risks related to material traceability (R4) and the maintenance of performance over time (R5) were identified.

The columns on main causes, existing controls, and available audit evidence were developed through the analysis of implementation documents and audit reports. This analysis showed that control mechanisms are mostly focused on financial and procedural compliance. Comparing these controls with the identified risks made it possible to assess the residual circularity risk. In most cases, this risk remains medium or high. This justifies the use of the matrix as a practical tool in the planning and execution of financial audit engagements.

Results of the Quantitative Component: Scoring of Circularity Risks

To compare risks across cases, the matrix was operationalized through a scoring system. The residual scores for each type of risk and each case are presented in Table 4.

The scoring system was designed to enable comparison of circularity risks across projects. It also supports qualitative interpretation through a transparent ranking. Each type of risk (R1–R5) was assessed for each case study (A–D) along three dimensions. These are the probability (P) of risk occurrence, the impact (I) on circularity objectives, and the effectiveness of existing controls (C). The scores are not statistical measurements or probabilistic estimates.

They are ordinal assessments. They were built on documentary analysis and the professional judgment of the financial auditor. Probability reflected how likely the risk is to arise under the specific conditions of each project. This depended on things like the clarity of objectives, the existence of indicators, and the availability of information. Impact reflected the potential consequences for the credibility of circular performance.

More specifically, it reflected how much the risk affects the demonstration of results and environmental impact. Control effectiveness was assessed based on how well existing mechanisms can reduce the risk from an audit perspective. These mechanisms included eligibility procedures, technical documentation, acceptance protocols, contractual guarantees, and administrative checks. It is important to note that ISRS 4400 engagements are mostly focused on financial and procedural compliance. This limits how effective these controls are in addressing circularity risks.

The residual risk score was calculated using a simple formula: $\text{Residual risk score} = (P \times I) / C$. Risk increases when probability and/or impact are higher. It decreases when controls are more effective. In practical terms, this calculation helped identify situations where projects are financially compliant and well documented, but significant vulnerabilities still exist in demonstrating circular performance. Details on the P, I, and C values for each risk and each case are provided in Appendix A.

The values in Table 4 reflect explainable differences between projects. For example, R2 (Unvalidated indicators) scores high across all cases. This shows that circularity indicators, such as energy produced, CO₂ reduction, and consumption savings, are frequently calculated before implementation. They are not accompanied by auditable validation mechanisms after implementation. In the private renewable energy project (Case C), this risk is even higher.

Post-implementation monitoring controls are weaker there. R5 (Performance degradation over time) also scores high in projects where impact depends on maintenance and user behavior. This is especially true for building energy efficiency projects. In these cases, contractual guarantees

are not enough. They do not replace actual performance monitoring throughout the sustainability period.

Table 4 does not aim to quantify risks exactly. Its purpose is to offer a comparative ranking. It translates qualitative findings into numbers. This helps identify the most dominant risks and highlights areas where a compliance-focused financial audit leaves relevant residual circularity risk.

Table 4. Quantitative Scoring of Circularity Risks (P × I / C)

Risk	Case A	Case B	Case C	Case D
R1 Declarative circularity	15.0	3.0	3.0	4.5
R2 Unvalidated indicators	12.0	8.0	16.0	10.0
R3 Expenditure–impact decoupling	8.0	6.0	12.0	8.0
R4 Material traceability	4.5	2.0	2.0	6.0
R5 Performance degradation over time	9.0	4.5	12.0	16.0

Source: Authors' own research results.

The table shows significant variations in circularity risk levels. These variations appear both across the analyzed projects and among the identified risk types. Higher values are linked to risks related to unvalidated performance indicators and the maintenance of performance over time. These point to recurring vulnerabilities in demonstrating circular impact. This is especially true for projects implemented by private beneficiaries and those that depend heavily on post-implementation monitoring.

Based on the residual risk scores and the frequency of risk occurrence across the case studies, a cross-case analysis was conducted. The results are presented in Table 5. To find recurring patterns beyond the specificities of each individual case, the research was extended through a cross-case analysis. This analysis is based on the results from the circularity risk scoring. The goal is to identify risks that appear repeatedly across different projects. It also aims to identify risks that depend on the type of intervention or the sector involved.

Table 5. Ranking of Circularity Risks (Cross-Case Analysis)

Risk	Average Residual Score	Frequency	Observation
R2 Unvalidated indicators	~11.5	4/4	Most critical risk
R5 Performance degradation over time	~10.4	3/4	Specific to private beneficiaries and buildings
R3 Expenditure–impact decoupling	~8.5	4/4	Transversal risk
R1 Declarative circularity	~6.4	2/4	Indirect impact
R4 Material traceability	~3.6	2/4	Specific to buildings

Source: Authors' own research results.

The ranking in Table 5 was built using two dimensions. The first is the average residual risk score. The second is how often each risk appears across the analyzed case studies. The average residual score was calculated as the arithmetic mean of the residual scores for each risk type across the four projects. Frequency reflects the number of cases in which the risk was identified as relevant. This approach allows a simple assessment of risk severity. It does not require inferential statistical methods. It is appropriate for an applied qualitative research design.

The results in Table 5 show that R2 (Unvalidated performance indicators) ranks first. It has both a high average residual score and maximum frequency. This suggests a structural vulnerability in EU-funded projects. It is hard to substantiate circular performance through auditable evidence. R3 (Expenditure-impact decoupling) is also present in all analyzed cases. This reflects the limitations of a financial audit approach focused only on compliance.

R5 (Performance degradation over time) sits in the middle of the ranking. It is more pronounced in projects where environmental impact depends on maintenance and post-implementation monitoring. This highlights the importance of beneficiaries' institutional capacity. It also highlights the need for mechanisms to track results over the medium and long term.

R1 (Declarative circularity) and R4 (Material traceability) appear less often. They are more dependent on the type of project. Their influence on circular performance is indirect or contextual. Overall, the cross-case analysis confirms the main hypothesis. Circularity generates recurring risks that compliance-focused financial audits do not capture well. The ranking in Table 5 reinforces the findings of the individual case analyses. It also supports the usefulness of the circularity risk matrix as a practical tool for integrating the environmental dimension into audit risk analysis.

Validation of research hypotheses

The empirical findings support both research hypotheses.

H1 is confirmed. The analysis showed that circularity claims in EU-funded projects generate specific risks. These risks are not captured well by compliance-oriented financial audit procedures. In all analyzed cases, risks were found related to unvalidated performance indicators, overstated environmental benefits, and limited traceability of circular outcomes. This confirms the existence of circularity-specific audit vulnerabilities.

H2 is also confirmed. ISRS 4400 engagements provide enough evidence to verify expenditure eligibility. But they are not enough for validating circular performance or environmental impact. This finding is consistent with prior results in the sustainability assurance literature. Simnett et al. (2009) and Mock et al. (2013) have already shown the limitations of non-financial assurance in capturing real performance outcomes. This paper extends those insights to the context of circular economy projects financed from public funds.

Conclusion

This research had two main goals. The first was to explore circularity as a distinct source of risk in EU-funded projects. The second was to develop a practical tool to help financial auditors assess the credibility of environmental performance. The paper combines qualitative case study analysis with a quantitative scoring component. The findings show that circularity claims in projects are often hard to validate from a financial audit perspective. This is true even when financial and procedural compliance requirements are met.

The main contribution of this paper is the circularity risk matrix. It links declared circularity objectives with associated risks, their causes, existing controls, and available audit evidence. Applying this matrix to the four analyzed projects revealed recurring risks. The most common were risks related to unvalidated performance indicators and the long-term maintenance of circularity outcomes. These risks are not captured well by compliance-focused financial audits. This limits the ability to assess the real environmental impact of projects.

The findings also point to the emerging role of the financial auditor in the transition to a circular economy. This role goes beyond checking the legality and regularity of spending.

Integrating circularity into audit risk analysis gives a more realistic picture of the link between expenditures, outputs, and impacts. This supports transparency and accountability in EU funding aimed at a cleaner environment.

In practical terms, the matrix can be used as a support tool in audit planning and execution. It helps identify early on the areas with high risk of declarative circularity or unvalidated performance. The results may also be useful for managing authorities and control bodies. They could use the matrix to improve monitoring and reporting requirements for environmental indicators.

This research has limitations. The sample is small. The analysis is exploratory and relies on a limited number of case studies. It also depends on the professional judgment of the financial auditor. The scoring system is comparative and interpretative. It does not provide an exact quantification of risks. Future research could analyze more projects, include other types of EU-funded interventions, and explore extended assurance over environmental performance and circularity indicators.

Overall, this paper contributes to the literature by making circularity an auditable risk concept. It also highlights the role of financial audit in promoting a cleaner and more sustainable model of economic development.

Conclusions – contributions, relevance and future research

This study makes both theoretical and practical contributions. On the theoretical side, it conceptualizes circularity as a distinct source of auditable risk in EU-funded projects. On the practical side, it develops an operational matrix for assessing circularity-related risks. The paper also extends the performance audit and sustainability assurance literature. It does this by integrating circular economy principles into the professional judgment framework of the financial auditor.

The study is relevant for several groups. Auditors, managing authorities, and control bodies can all use the proposed matrix. It helps them improve the assessment of risks linked to circularity claims. It also strengthens the credibility of reported outcomes.

Future research could go in several directions. The tool could be tested on larger samples of projects. Quantitative circularity indicators could be integrated and the matrix could also be adapted for other types of non-financial assurance engagements.

Statements

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Appendix A. Calculation of circularity risk scores

This appendix details the method used to calculate the circularity risk scores applied in **Table 4** of the article. The scoring system was designed as a support tool for comparative risk analysis. It does not aim to provide statistical estimations of probabilities or impacts.

A1. Definition of the variables used

Each circularity risk was assessed using three dimensions.

P – Probability of risk occurrence. This was measured on a scale from 1 to 5, based on how often and in what context the risk appears in the analyzed project.

I – Potential impact on circularity objectives. This was also measured on a scale from 1 to 5, reflecting how much the risk affects the credibility of the declared environmental performance.

C – Effectiveness of existing controls. This was measured on a scale from 1 to 3, based on how well the identified control mechanisms, such as procedures, documentation, and administrative checks can reduce the risk from an audit perspective.

A2. Calculation formula

The residual circularity risk score was determined using the following relationship:

$$\text{Residual risk score} = (P \times I) / C$$

This formula reflects the fact that the level of risk increases with higher probability and potential impact and decreases as the effectiveness of existing controls improves.

A3. Table for calculating P, I, and C values

R1 – Declarative circularity

Case	P	I	C	Score
A – Public health	5	3	1	15.0
B – Renewable energy (public)	3	3	3	3.0
C – Renewable energy (private)	3	3	3	3.0
D – Building energy efficiency	3	3	2	4.5

R2 – Unvalidated / unaudited performance indicators

Case	P	I	C	Score
A – Public health	4	3	1	12.0
B – Renewable energy (public)	4	4	2	8.0
C – Renewable energy (private)	4	4	1	16.0
D – Building energy efficiency	4	5	2	10.0

R3 – Expenditure–impact decoupling

Case	P	I	C	Score
A – Public health	4	2	1	8.0
B – Renewable energy (public)	3	4	2	6.0
C – Renewable energy (private)	3	4	1	12.0
D – Building energy efficiency	4	2	1	8.0

R4 – Limited material traceability

Case	P	I	C	Score
A – Public health	3	3	2	4.5
B – Renewable energy (public)	2	2	2	2.0
C – Renewable energy (private)	2	2	2	2.0
D – Building energy efficiency	3	4	2	6.0

R5 – Performance degradation over time / maintenance

Case	P	I	C	Score
A – Public health	3	3	1	9.0
B – Renewable energy (public)	3	3	2	4.5
C – Renewable energy (private)	4	3	1	12.0
D – Building energy efficiency	4	4	1	16.0

This appendix ensures transparency in the risk scoring calculation process. It also allows the replication of the reasoning applied within the research. The presented values were used exclusively for comparative and interpretative purposes. Their role was to support the qualitative analysis and to rank the circularity risks identified in the analyzed projects.

Source: Authors' own research results.