*Environmental Research and Ecotoxicity*. 2025; 4:181
doi: 10.56294/ere2025181

ORIGINAL

# Environmental externalities, from an economic perspective

## Externalidades ambientales, desde una perspectiva económica

Elvia María Jiménez Zapata[1]

[1]Universidad Surcolombiana. Pitalito, Colombia

**Cite as:** Jiménez Zapata EM. Environmental externalities, from an economic perspective. Environmental Research and Ecotoxicity. 2025; 4:181. https://doi.org/10.56294/ere2025181

**Submitted:** 02-06-2024 **Revised:** 20-12-2024 **Accepted:** 20-05-2025 **Published:** 21-05-2025

**Editor:** PhD Manickam Sivakumar

**Corresponding Author:** Elvia María Jiménez Zapata

## ABSTRACT

**Introduction:** environmental externalities represent a profoundly relevant economic phenomenon in the interaction between human activities and natural systems.
**Method:** through an argumentative approach, it argues that the internalization of these environmental costs is essential for achieving sustainable development, and proposes economic instruments and public policies to correct these distortions.
**Results:** this article analyzes these externalities from an economic perspective, highlighting their impact on environmental degradation and their influence on the inefficient allocation of resources. It also examines the market mechanisms that generate these externalities, as well as the institutional failures that perpetuate their undervaluation.
**Conclusion:** the correlation between the economy and the environment is addressed comprehensively, emphasizing the need for a robust regulatory framework that balances economic growth and ecological preservation.

**Keywords:** Environment; Sustainable Development; Environmental Externalities; Internalization Of Costs; Environmental Policy.

## RESUMEN

**Introducción:** las externalidades ambientales representan un fenómeno económico de profunda relevancia en la interacción entre las actividades humanas y los sistemas naturales.
**Método:** a través de un enfoque argumentativo, se sostiene que la internalización de estos costos ambientales es fundamental para alcanzar un desarrollo sostenible, se proponen instrumentos económicos y políticas públicas que permitan corregir estas distorsiones.
**Resultados:** en este artículo se analizan dichas externalidades desde una perspectiva económica, se destaca su impacto en la degradación ambiental y su influencia en la asignación ineficiente de recursos. Se examinan, además, los mecanismos de mercado que generan estas externalidades, así como las fallas institucionales que perpetúan su subvaloración.
**Conclusiones:** la correlación entre economía y medio ambiente se aborda de manera integral, y se enfatiza en la necesidad de un marco regulatorio robusto que equilibre crecimiento económico y preservación ecológica.

**Palabras clave:** Ambiente; Desarrollo Sostenible; Externalidades Ambientales; Internalización De Costos; Política Ambiental.

## INTRODUCTION

Environmental externalities are one of the most significant challenges at the intersection of economics and the environment.[1] Their presence highlights a structural flaw in market systems, where the environmental costs of production and consumption are not reflected in prices or allocated efficiently.

This distortion generates a vicious cycle in which the exploitation of natural resources intensifies without economic agents assuming full responsibility for ecological damage.[2] The result is progressive degradation of ecosystems, whose consequences transcend the economic sphere and manifest themselves in social crises, loss of biodiversity, and climate change.

From an economic perspective, environmental externalities represent a paradigmatic case of market failure.[3] Industrial, agricultural, and urban activities produce side effects that, as they are not incorporated into commercial transactions, fall on society as a whole or on vulnerable communities that do not share in the economic benefits of these activities. This imbalance not only perpetuates inequalities but also distorts decision-making and favours growth models that are unsustainable in the long term.

The analysis of these externalities cannot be limited to a purely economic approach.[4] The correlation between the economy and the environment requires a comprehensive approach, where production processes are evaluated based on their ecological footprint and resilience. The internalization of environmental costs emerges as a necessary condition for reorienting development towards more sustainable patterns. This process faces significant obstacles, from resistance from sectors with vested interests to a lack of consensus on regulatory frameworks.[5]

The internalization of environmental externalities faces a fundamental dilemma: how to quantify the real value of ecosystem goods and services in an economic system that operates under short-term parameters. In their conventional dynamics, markets lack intrinsic mechanisms to adequately value resources such as clean air, pollination, or water regulation provided by forests.[6] This systematic undervaluation leads to a paradox where what is essential for life is priceless, while the dispensable but marketable accumulates disproportionate value.

Environmental economics has attempted to correct this asymmetry through contingent valuation or replacement cost methodologies, but these approaches encounter practical and ethical limitations. An important question is how to assign a monetary value to the irreversible loss of a glacier or the pollution of a river that sustains ancestral communities.[7] The difficulty does not invalidate the effort, but it does expose the need to transcend traditional frameworks of economic analysis. Issues associated with the use of digital tools and AI must be taken into account.[8]

A second critical issue lies in the environmental effects' geographical and temporal distribution. Externalities are rarely concentrated in the same place or period in which they are generated. Industrial pollution in one country can affect air quality in neighboring territories, just as deforestation in the tropics alters global climate patterns. Temporally, the most severe impacts of activities such as fossil fuel extraction or the use of agrochemicals manifest themselves years or decades after their implementation.[9]

This spatiotemporal disconnect creates an agency problem where decision-makers do not bear the consequences of their actions, while those who suffer them lack the power to influence those decisions.[10] Conventional economic instruments, designed for static contexts and defined jurisdictions, cannot address this transnational and intergenerational dimension of externalities.

Environmental governance is emerging as a key factor in managing these externalities, but structural tensions compromise its effectiveness. On the one hand, international bodies promote environmental agreements and standards, from the Paris Agreement to the Sustainable Development Goals.[11] On the other hand, national sovereignty and immediate economic interests often take precedence over these global commitments.

This contradiction is exacerbated by the absence of binding mechanisms that compel the most polluting economic actors to internalize costs. Even when carbon taxes or cap-and-trade systems are established, their scope is often limited and their application uneven across sectors and regions. The result is a fragmented landscape where partial progress in some jurisdictions is offset by predatory practices in others, perpetuating the problem of free riders in global environmental management.[12]

The role of technological innovation presents a duality that deserves critical examination. While some advances make it possible to decouple economic growth from environmental degradation, such as renewable energy or the circular economy, others generate new externalities or intensify existing ones.[13] Lithium mining for 'green' batteries illustrates this dilemma: although it reduces end-use emissions, its extraction causes ecological and social havoc in the Andean salt flats. This paradox reveals that technology alone does not solve the underlying problem: the extractivist logic that dominates the economic system. Without structural change in production and consumption patterns, even the most promising technological solutions can become vectors of new externalities. Hence, it is essential to complement innovation with forward-looking regulatory frameworks that anticipate and mitigate risks rather than merely reacting to crises once they have taken hold.

In this context, this article examines environmental externalities as an economic problem with profound ecological implications. It argues that correcting these externalities is feasible and indispensable to ensuring

https://doi.org/10.56294/ere2025181

sustainable economic growth without sacrificing natural balances. Through critical analysis, the article explores the theoretical and practical tools available to achieve a more equitable and efficient management of environmental resources, always under the premise that the economy should serve as an instrument for the preservation, not the destruction, of the environment.

## METHOD

This study takes a qualitative, analytical-interpretative approach to examine environmental externalities from an interconnected economic and ecological perspective. The methodology is structured in four clearly defined stages, each with specific procedures that ensure academic rigour and depth of analysis.

### First stage: Critical literature review

An exhaustive exploration of specialized literature on environmental economics, political ecology, and development theory was carried out, and academic sources, technical reports from international organizations, and regulatory documents were selected. The process was not limited to mere compilation, but involved a hermeneutic analysis of the texts to identify conceptual patterns, theoretical contradictions, and gaps in the treatment of environmental externalities. Priority was given to publications from the last fifteen years, although foundational works that contextualized the concept's historical evolution were also included. The triangulation of sources (academic, institutional, and technical) made it possible to contrast perspectives and avoid disciplinary biases.

### Second stage: Comparative analysis of emblematic cases

Six representative cases of environmental externalities in different geographical contexts and productive sectors (mining, agribusiness, energy, and manufacturing) were selected. The selection was based on criteria of theoretical relevance, proven ecological impact, and availability of verifiable information. Each case was studied through: 1) historical reconstruction of the externality, 2) identification of stakeholders, 3) evaluation of failed or successful internalization mechanisms, and 4) analysis of cumulative socio-environmental consequences. This approach made it possible to identify standard variables and contextual particularities that influence the generation and perpetuation of externalities.

### Third stage: Semi-structured interviews with key stakeholders

Fourteen in-depth interviews were conducted with professionals with strategic profiles: three environmental economists, two government regulators, four specialized NGO representatives, three academics in ecological studies, and two community leaders affected by externalities. The interview script was organized around three axes: 1) diagnosis of market/institutional failures, 2) critical evaluation of internalization instruments, and 3) alternative proposals from their field of expertise. The sessions were recorded (with consent) and transcribed for categorical content analysis, identifying recurring discursive nuclei and paradigmatic positions.

### Fourth stage: Interpretative synthesis and conceptual modelling

The information gathered was subjected to a critical integration process through: 1) identification of causal relationships across the cases studied, 2) comparison between empirical findings and revised theoretical frameworks, and 3) development of a proprietary analytical framework that articulates economic, ecological, and political dimensions.

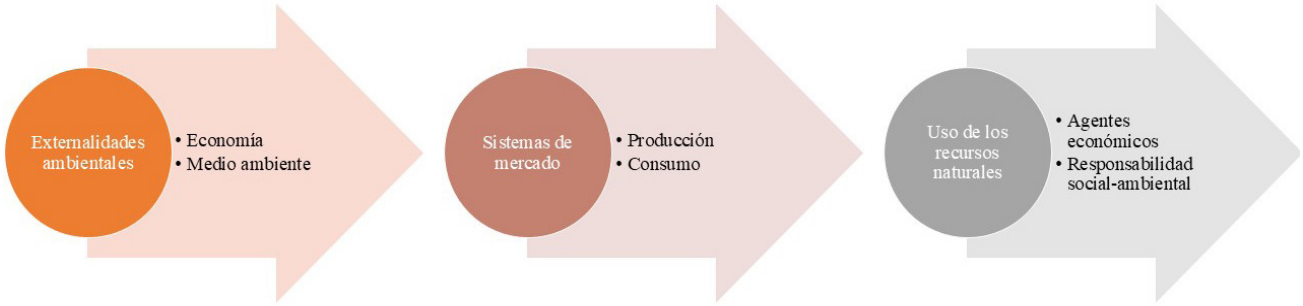
Specialized software (ATLAS.ti) was used to code and cross-reference qualitative data, thus ensuring traceability in the interpretations. The results were validated through methodological triangulation (documentary-case-interviews) and peer review by experts in ecological economics.

This methodology enabled the study to overcome the limitations of purely theoretical or quantitative studies and capture the systemic complexity of environmental externalities. By combining documentary analysis, case studies, and key stakeholder perspectives, the study achieved a multidimensional understanding of the problem, which is essential for proposing viable management alternatives. Qualitative rigour was ensured through explicit protocols at each stage, procedural auditing, and ongoing critical reflection on the researcher's epistemological positions.

## RESULTS

The study reveals that environmental externalities are a symptom of a structural contradiction between economic systems and ecological limits. The findings expose recurring patterns that explain why market mechanisms systematically fail to protect natural common goods, while identifying transformative opportunities to reorient this dynamic. Figure 1 shows the essential aspects of environmental externalities and their link to market systems and the efficient use of natural resources.

https://doi.org/10.56294/ere2025181




**Economics versus thermodynamics: the root of the conflict**

The cases analyzed show that the dominant production models ignore basic principles of ecological thermodynamics. While nature operates in closed cycles of matter and limited energy flows, economic systems behave as if resources were infinite and waste sinks were unlimited. This mismatch generates externalities that accumulate in irreversible pollution, loss of biodiversity, and disruption of ecosystem balances.[14] Comparative analysis shows how sectors such as open-pit mining and industrial agriculture externalize most of their real costs and transfer to society and the environment expenses that should be part of their operating structures.

**The myth of compensation and its failures**

Instruments designed to internalize externalities, such as green taxes or tradable permits, have severe limitations in practice. Three recurring problems were identified: 1) the chronic undervaluation of environmental damage, where fines or taxes amount to almost a quarter of the real ecological cost; 2) the fallacy of compensation, where destructive projects are justified by reforestation or conservation initiatives that never achieve ecosystem equivalence; and 3) temporal asymmetry, where economic benefits are immediate but environmental costs are deferred for decades. Interviews with affected communities showed how these mechanisms legalize damage rather than prevent it.

**Geopolitics of externalities: concentrated vulnerability**

The research finds that environmental impacts are not distributed randomly, but follow pre-existing lines of inequality. Most cases studied show that externalities are shifted to territories with less political and economic power: indigenous communities, peripheral countries, or marginalized rural areas. This pattern creates what interviewees called 'environmental colonialism,' where benefits are privatized in centres of economic power while costs are socialized in vulnerable populations.[15] Rare earth mining for green technologies illustrates this paradox. While corporations and consumer countries capture the added value, extraction areas in the Global South suffer water pollution and loss of livelihoods.

**Emerging alternatives from the periphery**

Against this backdrop, the study documents innovative experiences that point to new paradigms. Three models stand out: 1) ecological accounting systems that integrate physical indicators of environmental degradation into national accounts; 2) environmental courts with transnational jurisdiction that overcome the limitations of national regulations; and 3) circular production cooperatives where waste from one process becomes input for another and externalities are reduced through systemic design. These cases, although still marginal, demonstrate that it is possible to build economies that operate within ecological limits when incentive and ownership structures are modified.

**The illusion of green growth**

The data collected refute the dominant discourse on the compatibility of infinite economic growth and environmental sustainability. In all sectors analyzed, even the most efficient technologies generate externalities when implemented on a massive scale.[16] The study reveals an unwritten law of contemporary environmentalism:

every technological solution creates new environmental problems if a material reduction in consumption does not accompany it. This reality requires a rethinking of the very foundations of the modern economy, where success is measured by indicators that systematically ignore natural capital.

These results challenge conventional economic models and chart a path for genuinely sustainable transitions. They point out that the true internalization of externalities requires structural changes—not just marginal adjustments—in how societies produce, distribute, and consume. The study concludes that effective solutions will emerge not from optimizing the current system but from redesigning it with biophysical and environmental justice criteria at its core.

## DISCUSSION

The findings of this study open a fundamental debate on the viability of current economic systems in the face of the planet's ecological limits. The results confirm the existence of structural flaws in the treatment of environmental externalities and challenge the dominant paradigms that have governed the relationship between economy and nature over the last century.

This discussion delves into these findings' theoretical and practical implications, confronting conventional narratives with the empirical evidence gathered. Figure 2 presents the three essential components of environmental externalities, including technological innovation, ecological implications, and responsible production and consumption.

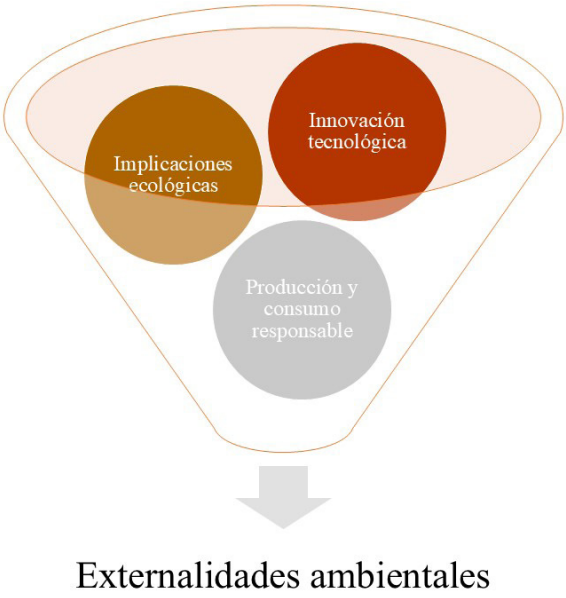



**Figure 2.** Components required for environmental externalities

The first axis of discussion revolves around the very concept of externalities. Research shows that what classical economic theory considers 'side effects' are symptoms of a civilizational model that has built its prosperity based on unrecognized ecological subsidies.[17] When an industry pollutes a river or intensive agriculture degrades the soil, these are not isolated market failures, but predictable consequences of a system that treats nature as an infinite resource and unlimited sink. This reality forces us to rethink the entire theoretical framework: so-called externalities are not system anomalies, but intrinsic characteristics of its normal functioning.

A second critical point emerges when analyzing attempts to internalize environmental costs. The data reveal that current mechanisms – green taxes, carbon markets, ecological offsets – operate within the logic that created the problems they seek to solve.[18] By monetizing ecological damage without questioning the production and consumption structures that cause it, these instruments are cosmetic measures that legitimize unsustainable practices. Research shows how, in many cases, companies incorporate these costs as operating expenses without substantially modifying their processes, thus creating a kind of 'green capitalism' that keeps the extractivist dynamic intact while paying for the right to pollute.

The geopolitical dimension of externalities emerges as a third key element in this discussion. Documented patterns reveal that economic globalization has created a system where benefits are concentrated in financial power centers while environmental costs are exported to the periphery.[19] This phenomenon is not accidental,

but a direct consequence of power asymmetries consolidated over centuries. The countries and communities that have contributed least to climate change and global ecological degradation are precisely those that suffer its worst consequences. This reality demands a rethinking of the principles of environmental justice on a worldwide scale, recognizing that technical solutions are insufficient without profound transformations in North-South relations and international trade patterns.

The study challenges the dominant discourse on green growth and the dematerialization of the economy. The evidence shows that, while some technologies have succeeded in reducing specific impacts per unit of product, the rebound effect and aggregate growth have cancelled out these gains globally. Increases in total consumption offset every advance in efficiency.[20] This suggests that the fundamental problem lies not in how we produce, but in how much we produce and for what purposes. A genuinely sustainable economy would require cleaner technologies, clear criteria on absolute material limits, and new ways of measuring well-being beyond GDP.

The alternatives identified in the study—ecological accounting, transnational environmental jurisdictions, and circular models—point to a necessary but still incipient paradigm shift.[21] Their transformative potential lies precisely in the fact that they do not merely correct externalities within the current system but propose new rules of the economic game based on biophysical principles and intergenerational equity. Their large-scale implementation faces monumental resistance from established interests and power structures that benefit from the status quo.

This discussion leads to an uncomfortable but inevitable conclusion: the dominant economic model is incompatible with the preservation of the systems that sustain life on the planet.[22] Environmental externalities are not technical problems that can be solved with marginal adjustments, but manifestations of a deeper conflict between the logic of infinite growth and the finite limits of the biosphere. Any real solution will require new environmental policies and a fundamental redefinition of what we consider progress, development, and quality of life.[23] The study suggests that the path to sustainability lies less in perfecting green capitalism than in imagining and building radically different civilizational alternatives.

The alternatives identified – circular models, ecological accounting, new forms of governance – point to possible paths towards truly sustainable economies, but their implementation faces obstacles beyond the technical. They require a profound cultural transformation that questions consumerism as a way of life, growth as dogma, and the exploitation of nature as a right. The study shows that partial solutions have exhausted their potential; what is needed now is political courage to push for structural changes that redefine the relationship between humanity and the biosphere.

This research argues that the 21st century will witness one of two possibilities: either human societies embark on an orderly transition to economic models compatible with ecological limits, or nature will impose its adjustments through the collapse of the systems that sustain life. Environmental externalities are the alarm bells heralding this historic choice. Ignoring it will not make it go away; it will only guarantee that the final adjustment will be more abrupt and painful. The true legacy of our time could be summed up in a simple but momentous choice: internalize environmental costs now through a conscious transformation of civilization, or pay for them later through the irreversible deterioration of the conditions that make human life on Earth possible.

## CONCLUSIONS

This study shows that environmental externalities are the clearest symptom of the structural divorce between economic systems and the planet's ecological limits. The results do not support the fiction that it is possible to fully internalize these environmental costs within the current economic framework without questioning its foundations. The conclusions point to an uncomfortable but scientifically irrefutable truth: the dominant development model has reached a point of insoluble contradiction with the fundamental laws governing natural systems.

The analysis shows that conventional economics operates under a fundamental category error in considering externalities as exceptional market failures. The evidence gathered shows precisely the opposite: they are systemic and inevitable characteristics of a model that requires perpetual material growth on a finite planet. None of the tools analyzed – environmental taxes, carbon markets, ecological offsets – has succeeded in reversing the curve of environmental degradation on a global scale, because they all operate within the same paradigm that generates the problem. This reality forces us to admit that the real challenge lies not in perfecting internalization mechanisms, but in transcending the conceptual framework that makes them necessary.

The research starkly reveals the ethical dimensions of this crisis. Environmental externalities function as a mechanism for transferring wealth and well-being from vulnerable communities to centres of economic power. What national accounts record as economic growth often hides ecological and social impoverishment that is not accounted for. This finding calls for a radical rethinking of progress indicators. It recognizes that a society that destroys its natural foundations of subsistence cannot be considered successful, no matter how much its

GDP increases.

## BIBLIOGRAPHICAL REFERENCES

1. Ahmad S, Daddi T, Novi A, Marrucci L. Evaluating environmental impacts and techno-economic feasibility of an integrated and novel wastewater and sludge treatment system for circular economy objectives. Computers & Industrial Engineering. 2025; 111035. https://doi.org/10.1016/j.cie.2025.111035

2. Núñez Barahona EG, Espinosa Cristia JF. Liderazgo ético y comportamiento de los empleados. Análisis cienciométrico en la producción científica. Región Científica. 2024; 3(2):2024295. https://doi.org/10.58763/rc2024295

3. Azarkamand S, Ríos AF, Batlle Bayer L, Bala A, Sazdovski I, Roca M, et al. Calculating the true costs of protein sources by integrating environmental costs and market prices. Sustainable Production and Consumption. 2024; 49:28-41. https://doi.org/10.1016/j.spc.2024.06.006

4. Bai Y, Zhang T, Zhai Y, Shen X, Ma X, Zhang R, et al. Water footprint coupled economic impact assessment for maize production in China. Science of The Total Environment. 2021; 752:141963. https://doi.org/10.1016/j.scitotenv.2020.141963

5. Sánchez Castillo V, Gómez Cano CA, Pérez Gamboa AJ. La Economía Azul en el contexto de los objetivos del desarrollo sostenible: una revisión mixta e integrada de la literatura en la base de datos Scopus. AiBi Revista de Investigación, Administración e Ingeniería. 2024; 12(2):215-30. https://doi.org/10.15649/2346030X.4028

6. Bajaj A, Singh SP, Nayak D, Nagar A. Economic perspectives on groundwater conservation: Insights from farmers in western Uttar Pradesh, India. Groundwater for Sustainable Development. 2025; 29:101412. https://doi.org/10.1016/j.gsd.2025.101412

7. Lahcen B, Eyckmans J, Brusselaers J. Linking methodologies to assess climate impacts and circular economy strategies along supply chains. Sustainable Production and Consumption. 2024; 47:544-56. https://doi.org/10.1016/j.spc.2024.04.019

8. Pérez Gamboa AJ, Gómez Cano CA, Sánchez Castillo V. Decision making in university contexts based on knowledge management systems. Data and Metadata. 2022; 1:92. https://doi.org/10.56294/dm202292

9. Carranza G, Nascimiento MD, Fanals J, Febrer J, Valderrama C. Life cycle assessment and economic analysis of the electric motorcycle in the city of Barcelona and the impact on air pollution. Science of The Total Environment. 2022; 821:153419. https://doi.org/10.1016/j.scitotenv.2022.153419

10. Chiarini B, D'Agostino A, Marzano E, Regoli A. The perception of air pollution and noise in urban environments: A subjective indicator across European countries. Journal of Environmental Management. 2020; 263:110272. https://doi.org/10.1016/j.jenvman.2020.110272

11. Mazzoli E, Parashar A, D'Odorico P, Branca G. Greening the city: A holistic assessment of waste management alternatives in India. Science of The Total Environment. 2024; 955:176894. https://doi.org/10.1016/j.scitotenv.2024.176894

12. Gunawardena MA, Lokupitiya E. Comparison of conventionally and organically grown pineapple in Sri Lanka: An integrative approach applying life cycle assessment and externalities. Cleaner Environmental Systems. 2024; 14:100219. https://doi.org/10.1016/j.cesys.2024.100219

13. Sánchez Castillo V, Pérez Gamboa AJ, Gómez Cano CA. Circuitos cortos de comercialización como estrategia para el fortalecimiento del sector agropecuario. FACE. 2024; 24(3):163-74. https://doi.org/10.24054/face.v24i3.3329

14. Giannitsopoulos ML, Graves AR, Burgess PJ, CrousDuran J, Moreno G, Herzog F, et al. Whole system valuation of arable, agroforestry and tree-only systems at three case study sites in Europe. Journal of Cleaner Production. 2020; 269:122283. https://doi.org/10.1016/j.jclepro.2020.122283

15. Yang Y, Shen L, Sang M, Ding X. The impact of digitalization on urban sustainable development –

An economic perspective. Technological Forecasting and Social Change. 2025; 212:124005. https://doi.org/10.1016/j.techfore.2025.124005

16. Löwgren BH, Hoffmann C, Vijver MG, Steubing B, Cardellini G. Towards sustainable chemical process design: Revisiting the integration of life cycle assessment. Journal of Cleaner Production. 2025; 491:144831. https://doi.org/10.1016/j.jclepro.2025.144831

17. Camastra FD, González Vallejo R. Inteligencia artificial, sostenibilidad e impacto ambiental. Un estudio narrativo y bibliométrico. Región Científica. 2025; 4(1):2025355. https://doi.org/10.58763/rc2025355

18. Lu QL, Qurashi M, Antoniou C. Simulation-based policy analysis: The case of urban speed limits. Transportation Research Part A: Policy and Practice. 2023; 175:103754. https://doi.org/10.1016/j.tra.2023.103754

19. Debortoli DO, Brignole NB. Inteligencia empresarial para estimular el giro comercial en el microcentro de una ciudad de tamaño intermedio. Región Científica. 2024; 3(1):2024195. https://doi.org/10.58763/rc2024195

20. Yeo J, Chopra SS, Eiff D von, Jeong S, Zhang L, An AK. An integrated techno-economic analysis on wastewater reclamation in Hong Kong: A comprehensive cost – Benefit analysis with life cycle assessment. Journal of Cleaner Production. 2022; 357:131838. https://doi.org/10.1016/j.jclepro.2022.131838

21. Zhang T, Li C, Wang S, Cheng Z, Li Z, Xu T, et al. Promoting sustainable potato production - Insights from an integrated life cycle environmental–economic assessment. Agricultural Systems. 2024; 219:104029. https://doi.org/10.1016/j.agsy.2024.104029

22. Raudales Garcia EV, Acosta Tzin JV, Aguilar Hernández PA. Economía circular: una revisión bibliométrica y sistemática. Región Científica. 2024; 3(1):2024192. https://doi.org/10.58763/rc2024192

23. Gómez Cano CA, Sánchez Castillo V, Eslava Zapata R. Bibliometric analysis of the main applications of digital technologies to business management. Data and Metadata. 2024; 3. https://doi.org/10.56294/dm2024321

## FUNDING

None.

## CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

## AUTHOR CONTRIBUTION

*Conceptualisation:* Elvia María Jiménez Zapata.
*Data curation:* Elvia María Jiménez Zapata.
*Formal analysis:* Elvia María Jiménez Zapata.
*Research:* Elvia María Jiménez Zapata.
*Methodology:* Elvia María Jiménez Zapata.
*Project management:* Elvia María Jiménez Zapata.
*Resources:* Elvia María Jiménez Zapata.
*Software:* Elvia María Jiménez Zapata.
*Supervision:* Elvia María Jiménez Zapata.
*Validation:* Elvia María Jiménez Zapata.
*Visualisation:* Elvia María Jiménez Zapata.
*Writing – original draft:* Elvia María Jiménez Zapata.
*Writing – revision and editing:* Elvia María Jiménez Zapata.