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# Public policy supporting innovation for sustainable development

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What are the market priorities driving public funding for innovation? Do they reflect the priorities/interests of wider society or the sustainable development agenda? The market's failure to deliver desirable innovation outcomes aligned with sustainable development must be addressed by public policy in the scope of responsible (and research) innovation principles. Public funding for innovation must support sustainable development to the benefit of society as a whole. Given the urgent need for action, the article proposes some innovative instruments with a view to achieving sound sustainable development.

KEYWORDS

**policy-level, responsible innovation, sustainable development, environmental sustainability, innovation-driven policies, public funding, 2030 Agenda, post-2030 Agenda**

## 1 Introduction

Entrepreneurship, start-ups and business ventures are among the emergent hot topics. They are often associated to private initiative success so it is usually the successful entrepreneurs we see in the media. However, another side of the coin is often overlooked; more specifically, the public policies that strengthen the innovation system so that favourable conditions can be created which allow businesses to flourish and new projects to be set up.

Innovation policy involves great uncertainty and its impact on growth remains ambiguous (Bogers et al., 2018). Although Vickers et al. (2017) argue that public policies supporting innovation are shaped by logics of the state, market and civil society, it is relevant to confirm whether the priorities of the market driving these policies reflect the interests of wider society. What should the role of public policy be if "an innovation system is the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors" (Granstrand and Holgersson, 2020, p. 3)?

## 2 Policy challenges

### 2.1 Current context

The effects of the 2007–2008 financial crisis and, the recent COVID-19 pandemic, as well as the military conflict between Russia and Ukraine and the ongoing military action in the Middle East have provided a new and complex geopolitical landscape. In light of this scenario,

it seems reasonable to draw attention to the increase in public funding for defense (Hoeffler et al., 2024); indeed, "in many OECD countries, expenditures for defence-related R&D represent by far the most important form of public subsidies for innovation" (Moretti et al., 2023, p. 1). In the past, some authors advocated public investment in innovation for long-term growth as a strategic response to both financial and pandemic crises (Mazzucato and Dibb, 2020), but today the constraints posed by the defence budget may be an obstacle to this strategy. The huge numbers of war casualties represent a failure for society today, but we are also failing future generations because the wars have a negative impact on our progress towards the Sustainable Development Goals (SDGs) (Novelli, 2023). Not only have global defence budgets risen, but they are diverting resources away from crucial sustainability efforts (Nguyen et al., 2023) and delaying progress on environmental initiatives and humanitarian aid. Geopolitical tensions have disrupted international cooperation on climate policies, sustainable trade, and development projects, making it harder to meet global sustainability goals (Bashir et al., 2023). Moreover, the social and environmental consequences of war and conflict, such as displacement, ecological damage, and resource depletion, further hinder sustainability efforts (Schillinger et al., 2022).

The 2007–2008 financial crisis has had profound socio-economic consequences (Mohseni-Cheraghlou, 2016), with heightened levels of poverty (Antoniades et al., 2020), rising inequality, wage stagnation (Wisman, 2013), and a lack of social protection (McCord, 2010) leading to a decline in human and social wellbeing. This has been compounded by rising unemployment and job destruction (Carneiro et al., 2014) and even the deterioration of health promotion policies and public health care (Ifanti et al., 2013), further exacerbating the challenges to economic stability and human welfare.

Stiglitz (2009) provided the timely warning against underestimating the potential job-destruction caused by the financial crisis and called for global stimulus, revised economic policies, support for developing countries, and stronger social protection. Guellec and Wunsch-Vincent (2009) also called for public investment in innovation following the onset of the financial crisis. Critics argue that the lack of immediate action has led to prolonged economic stagnation and increased inequality, suggesting that timely intervention could have mitigated these adverse effects (Kiendrebeogo et al., 2017). Contrasting sharply with the measures taken during the 2007–2008 financial crisis, COVID-19 pandemic involved unprecedented economic stimulus packages and public investments, with authors highlighting the importance of public investment in green innovation (Barbier, 2020; Martin et al., 2020).

Public policies supporting innovation should be seen as a holistic process that uses new technology and improved processes to empower citizens and communities (Borins, 2001), and also as the pathway to development (Ciaffi et al., 2024). However, caution should be taken when considering this desirable equilibrium in public policies as the innovation system in the public interest opposes more traditional technopolis, triple-helix, and cluster initiatives (Oh et al., 2016), all of which are related to market criteria. In fact, if innovation is only mediated and valued by the market, it "is an inducer of production and consumption, real or virtual, but both resource consumers" (Nunes et al., 2021, 94) and therefore potentially harmful to environmental sustainability. Adding to this, Schomberg (2019) and van den Hove et al. (2012) point out the market's failure to deliver sound innovation outcomes. While innovation can be highly beneficial in many circumstances, it is important to recognise that it is not the sole solution to the planet's sustainability challenges; on the contrary, some successive innovations introduced by the markets may also be seen as contributing factors to the very sustainability challenges we face today (Nunes et al., 2021). More specifically, some innovations may be harmful for environmental sustainability (Taormina et al., 2018; Lin and Zhu, 2019; Vuong et al., 2024) and the inappropriate spatial distribution of innovations may foster inequalities with negative impacts on economic and social sustainability (Oehler and Vega, 2021).

## 2.2 Public policy

Public policy plays a key role in supporting and monitoring a balance whereby economic growth does not come at the expense of environmental and social sustainability or of introducing programmes that prioritise sustainable development in business strategies; this is the case, regardless of whether markets are also engaged in innovation processes. It is necessary to mitigate private (or market) and public tensions in innovation processes for sustainable development, and to make an in-depth evaluation of the consensus around some sustainable measures. For instance, the beneficial change from a linear to a circular economy (Brás and Moniz, 2021) should be implemented with caution given that the resulting benefits are largely offset by economic growth, the so called rebound effect (Zink and Geyer, 2017). Whether addressed through innovative policies (Stahel, 2010; Zink and Geyer, 2017) or an innovative policy mix with a multidisciplinary approach (Santarius et al., 2018), public policy is critical to minimise this rebound effect and to ensure other sustainable objectives are met in light of the known conflict between innovation and sustainability within mainstream economics (Courvisanos, 2005). In addition to the benefits of the circular economy through reuse, recycling, and waste-reduction, the transition to a circular economy needs robust public governance to address cultural and psychological barriers, among others (Kirchherr et al., 2018). Given that the circular economy is known to be at a nascent stage for most developing countries (Wikurendra et al., 2022), it is urgent to reinforce public policies as major enablers for this transition.

On one hand, "Corporate sustainability is paradoxical in nature, as corporates and managers have to achieve economic, social, and environmental goals, simultaneously" (Luo et al., 2020, p. 1) but, on the other, public policy is able to induce corporate innovations for sustainable development through regulation and programme guidance/stimulus (Ashford and Hall, 2011). In fact, different policy frameworks (e.g., Rational Choice Theory [RCT], Policy Transfer [PT], and Learning Frameworks [LF]) impact innovation outcomes differently: (i) RCT promotes efficient, cost-effective innovation but may constrain more ambitious, high-risk innovations due to a preference for safer and predictable outcomes (Chan et al., 2024); (ii) PT accelerates the adoption of innovations by adapting policies from other contexts, but its success hinges on how well these policies are tailored to the new environment (Ockwell and Byrne, 2016); and (iii) LF foster continuous improvement and dynamic innovation through adaptation and knowledge exchange, but they require a flexible and open policy environment to be effective (Borrás, 2011).

The contemporary theories of public policy are able to influence behaviours "by examining how policymakers and pressure participants

adapt to their policy environment by, for example, interpreting socioeconomic shifts in a specific way to set the policy agenda" (Cairney, 2019, p. 11).

Public policy also plays a role in shaping corporate behaviour through corporate welfare, which has evolved into an institutionalised tool that delegates public good functions to private actors via privatisations, procurement, and public-private partnerships (Bulfone et al., 2022). This "de-risking" approach mobilises private investment for development and sustainability projects by minimising investor risks (Busemeyer and Thelen, 2020; Gabor, 2021). To ensure these investments benefit society as a whole, the state must be able to condition public assistance and ensure that private firms adhere to government guidelines (Bulfone et al., 2022). This conditionality ensures that the social and economic spillovers of public investment are shared broadly, rather than appropriated by private actors (Maggor, 2020). Moreover, the political dynamics between innovation agencies and key social actors play a critical role in shaping and developing these institutional capacities (Mazzucato, 2015), particularly with the aim of meeting SDGs.

Public policy's vital role could be underpinned by new voices from civil society collectively engaged in the search for integrated solutions in innovation systems aimed at meeting the SDGs. In addition to allowing innovation systems to create conditions that favour new businesses, this inclusive process would also benefit the public sector and positively impact people's lives (Ansell and Torfing, 2014) as it would promote social sustainability through smart sustainable cities (Bouzguenda et al., 2019). Hippel (2006) went further by arguing that democratic innovation, i.e., one that encompasses the expertise of the broader public, is also more effective.

## 2.3 Responsible innovation

Responsible innovation (RI) is a process that assures innovation outcomes are socially desirable and undertaken in the public interest (Schomberg and Blok, 2021). Innovation is seen in a broader social context that meets the needs of society as a whole and is aligned with sustainable dimensions (environmental, economic, and social) (Burget et al., 2017). RI involves different levels of sustainability, e.g., ranging from the personal or project level to international and global. Both academics and project teams can use RI to steer research towards social needs and global challenges (Hartley et al., 2019). By implementing a mix of soft and hard law regulations through global governance, firms can be better supported in their RI efforts (Voegtlin and Scherer, 2017).

"Regulation (EU) No 1291/2013" marked the first appearance of the Responsible Research and Innovation (RRI) concept under the umbrella of RI and in light of widespread new technologies and the need for a research agenda on the ethics of science and technological advances. RRI centred the RI framework on research into science and technology through democratic governance with a view to achieving a beneficial collective impact in the future (Stilgoe et al., 2013). RRI is based on a collective and participative approach of the innovation process that is ethical, acceptable, sustainable and socially desirable so as to attain appropriate scientific and technological advances in society. Hence, RRI is a flexible concept, consisting of a set of principles, methods, and approaches that can be tailored and applied to various specific contexts (Buchmann et al., 2023).

Although both RI and RRI bring obvious advantages, societies may choose to base their decisions on their own interests rather than global societal interests even though this is both unethical and unacceptable (Weckert et al., 2016). It is therefore essential to embed RI in public policy (Schomberg, 2019), although this does not automatically guarantee alignment with global societal interests. According to this author, embedding RI in public policy could help address key issues, such as the exclusive focus on risk and safety as state responsibilities, the absence of public governance over the outcomes of research and innovation, and the misalignment of public values with innovation policies that overemphasise macroeconomic benefits. In other words, we must ensure that countries cannot become hostages of their own public funding for innovation as happened, for example, in the case of COVID-19 vaccines commercialised by the Pharmaceutic Sector. It is easier to foster collaboration between countries and work towards achieving global SDGs if RI is embedded within public policy (Voegtlin and Scherer, 2017).

## 2.4 Innovation systems for sustainable development: a transformative view

Anchored on the four RI dimensions proposed by Stilgoe et al. (2013), namely anticipation, reflexivity, inclusion, and responsiveness, public policy might be the key to legitimating public interests and to addressing global societal issues. Anticipation is related with foresight, scenarios, and horizon scanning; Reflexivity has to do with multidisciplinary collaboration and training, the assessment of ethical technology, and codes of conduct; Inclusion, consists of citizens' juries and panels, focus groups, deliberative mapping and polling or open innovation; lastly, Responsiveness involves regulation, standards, open access and other mechanisms of transparency, that is, the response to new knowledge as it emerges and to emerging perspectives, views and norms. Public policy supporting innovation should be more proactive and based on shaping and creating value, not passive or focused on market and system failures (Mazzucato and Semieniuk, 2017). Therefore, public funding for innovation should take into account issues of directionality (what future do we want?), legitimacy (why do we want this future, who defines it?) and responsibility (transformation by and for whom?) to accommodate more transformative views in the public interest (Uyarra et al., 2019). An ecosystem in which responsibility innovation is embedded in public policy can thus enable a knowledge and technology transfer system to support such transformative views in the public interest. The proposed ecosystem, illustrated in Figure 1, can be particularly relevant given the current global challenges, notably: climate change, sustainable and inclusive development, the green transition, the digital transition, carbon neutrality, circular economy and the interplay between technology and humanity.

Are we doing enough to face these challenges? Are we doing enough to save our planet? Collectively, our behaviour undoubtedly changed during the COVID-19 pandemic even though its consequences were unknown, so why do we not act collectively when we are fully aware of the irreversible damage we are causing to our planet? Should countries pursue economic growth using the same (damaged) framework or should they replace this framework with a holistic process in pursuit of sustainable development?

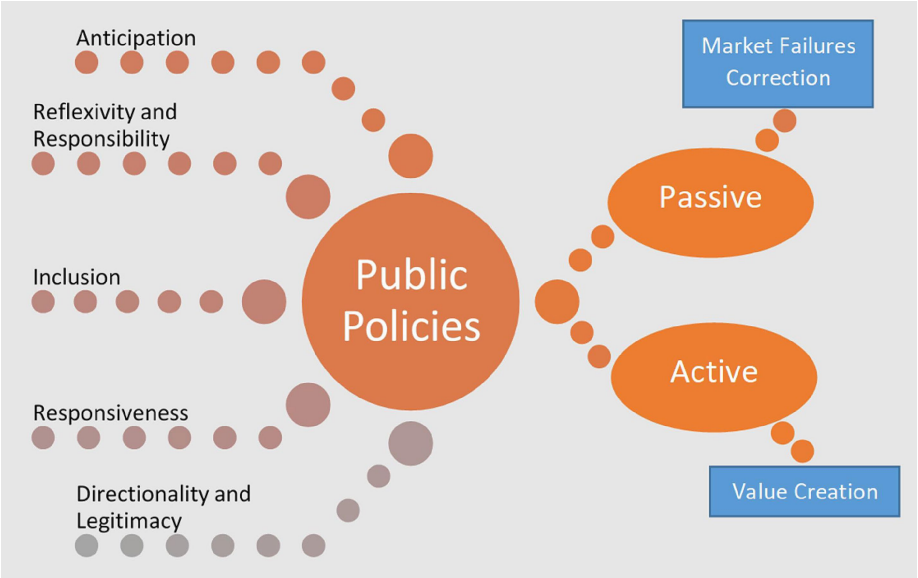


FIGURE 1
Ecosystem of public policy's role in facilitating knowledge and technology transfer to address current global challenges.

This complexity can only be addressed through, an interdisciplinary approach. From the economic perspective, it is important to understand how markets, resource allocation, and incentives can foster or hinder sustainable development. Political science can further explore governance structures and stakeholder dynamics that influence policy implementation. Finally, environmental studies emphasise the long-term impacts of policy measures on ecosystems and biodiversity, and provide an ecological framework for sustainability. By integrating these dimensions, we can develop more holistic strategies that balance economic growth with social equity and environmental conservation. Based on this approach, we propose several actionable measures for policymakers that aim to align innovation-driven policies with the SDGs. We believe these measures provide a richer context for assessing the synergies and trade-offs in public policy, making the recommendations more robust and globally applicable.

## 3 Actionable recommendations

The question we should be asking is: how can countries move into mandatory sustainable development and improve living standards across all regions? A public policy for innovation obviously plays a major role here turning Adam Smith's invisible hand into a visible one to achieve sustainable development. When this desirable shift is made, public policy supporting innovation that funds both public and private institutions is beneficial if it strives to benefit society as a whole and not only business and commerce. Innovation is thus vital to fostering sustainable development (Silvestre and Ţîrcă, 2019) and public policy must adopt innovative instruments in several domains that impact SDGs. Building on this foundation, we propose several innovative measures (Table 1), that ensure each initiative aligns with its potential impact on the SDGs (Figure 2). These complementary measures allow innovation-driven policies to be effectively geared towards holistic sustainable development.

Regardless of the merits of the abovementioned innovative measures, their implementation and impact on SDGs depend on the typology of public policy adopted (from RCT to PT and LF). The following are examples of public policies that successfully incorporated innovation to achieve SDGs: the implementation of sustainable palm oil certification under the RCT framework (Rizal et al., 2021), the advance towards sustainable urban transport within the PT framework (May, 2013), and the promotion of sustainable consumption through the LF framework (Quist and Tukker, 2013). However, as noted by Borrás and Edquist (2019) there is no one-size-fits-all solution.

Public policy and perception is dependent upon the country\region. The COVID-19 measures clearly demonstrate the differences in people's reactions to uniformised public policies across European countries (Sabat et al., 2020). In addition, stakeholders' perceptions of public policy even differ within the same country; a deeper understanding of context leads to more informed decision making and thus more effective public policies (Ramirez and Belcher, 2019). Moreover, as measures might need to be adapted to address geographical differences, notably between developed and developing countries, as this would improve their global applicability (Xu et al., 2020). Whereas developed countries should prioritise environmental and social sustainable development in their policies, developing countries should concentrate on economic and social sustainable development, recognising the interconnectedness of these dimensions (Swain, 2018). Despite the variations between and within nations, public policies that foster innovation for sustainable development can always be enhanced.

In addition to this intricate global landscape, it is important to highlight the tensions between RI and the political and economic realities faced by policymakers. For example, aligning long-term

TABLE 1 Description of proposed innovative measures.[1]

| # | Measure description | Relevant research works |
|---|---|---|
| 1 | Introducing a well-designed carbon tax to achieve environmental goals based on tax progressivity and environmental justice, protecting lower income families | Vona (2023) and Goulder et al. (2019) |
| 2 | Raising stimulus packages for the change from a linear to a circular economy, particularly in the industry sector, cutting emissions | Sharma et al. (2021) and Yang et al. (2023) |
| 3 | Establishing partnerships with Non-Governmental Organisations directly related with sustainable development to strengthen and articulate positions | Harangozó and Zilahy (2015) and Eweje et al. (2021) |
| 4 | Including sustainable development education at universities, preparing people for new jobs in this ongoing transition | Corazza et al. (2022) and Tasdemir and Gazo (2020) |
| 5 | Establishing and implementing new criteria for growth instead of GDP (e.g., Gross National Happiness/Human Development Index/Genuine Progress Indicator/Social Progress Index) | Berik (2020) and Kubiszewski et al. (2013) |
| 6 | Mobilising new sources of financing for sustainable mobility; a much-needed systemic transformation of mobility, particularly in cities | Werland and Rudolph (2019) and Toxopeus and Polzin (2021) |
| 7 | Reducing dependence on fossil fuels, with renewable energies providing effective support rather than being merely alternative energy sources | Holechek et al. (2022) and Østergaard et al. (2022) |
| 8 | Promoting energy efficiency in housing | Solà et al. (2020) and Hafez et al. (2023) |
| 9 | Transforming intensive and super-intensive farming into sustainable agricultural approaches | Malorgio and Marangon (2021) and Shah et al. (2021) |
| 10 | Protecting biodiversity on earth and preserving biodiversity in our oceans | Sala et al. (2021) and Hermoso et al. (2022) |
| 11 | Presenting solutions to deforestation (forest protection and restoration) | Temperton et al. (2019) and Chazdon (2008) |
| 12 | Acting and promoting initiatives to decarbonise companies' supply chains | Nordt et al. (2024) and Gopalakrishnan et al. (2020) |
| 13 | Ending precarious employment systems and, despite the current trend for remote work, restoring the sense of labour as a collective act | De Coster and Zanoni (2022) and Muntaner (2018) |
| 14 | Developing new and holistic guidance for taxing the digital economy with a redistributive effect to tackle inequality in its diverse forms (income, health, education, and general wellbeing, among others) | Shome (2021) and Zucman (2014) |
| 15 | Controlling financial capital flows from poorer countries to rich-world offshore tax havens as soon as possible; in the short-run, stop the offshore system | Murphy (2017) and (Alstadsæter et al., 2018) |
| 16 | Engaging citizens with the Sustainable Development Goals through various initiatives (cultural, scientific, and educational, among others) | Shulla et al. (2020) and Fritz et al. (2019) |
| 17 | Expanding and improving "Education for Sustainable development" from UNESCO | del Sol (2020) and Annan-Diab and Molinari (2017) |
| 18 | To strengthen and reinforce the mission of the United Nations (UN) by maintaining international peace and security, protecting human rights, upholding international law and providing humanitarian assistance in times of crisis; the EU should reshape its foreign policy and establish a Commissioner for Peace and Human Dignity | Mingst et al. (2022) and Kenkel and Foley (2021) |
| 19 | Amplify the impact of the Sanitation and Hygiene Fund, helping it reach more communities and improve global WASH outcomes | Pugel et al. (2022) and Bishoge (2021) |
| 20 | Incorporating nature-based solutions to mitigate climate change and promote resilience in urban and rural settings | Lafortezza et al. (2018) and Kabisch et al. (2016) |

[1]References are available for consultation to further elucidate policymakers.

sustainability goals with short-term political agendas and economic pressures is often challenging (Bornemann and Weiland, 2021). Moreover, implementing RI in less developed or politically unstable regions may be difficult due to limited resources and governance issues (Hartley et al., 2019). When devising public policies for sustainable development, policymakers must thoroughly evaluate the synergies and trade-offs between them and take the unique circumstances of each country into account (Lyytimäki et al., 2021). Country-specific assessments are fundamental for effective public policies that advance global sustainable development (Murphy et al., 2023). Figure 3 provides a dynamic framework for evaluating how the proposed innovative measures might contribute to sustainable development in different countries. This approach promotes tailored solutions, ensures equitable outcomes, and strengthens international cooperation.

## 4 Conclusion

It is essential to recognise that policy makers are not doing enough to promote the 2030 and post-2030 Agendas for sustainable development and should take immediate action to correct this (Pradhan, 2023). Hence, we propose innovative instruments aimed at promoting sustainable development within the public policy framework. These instruments focus on creating an ecosystem where public policy actively facilitates knowledge and technology transfer

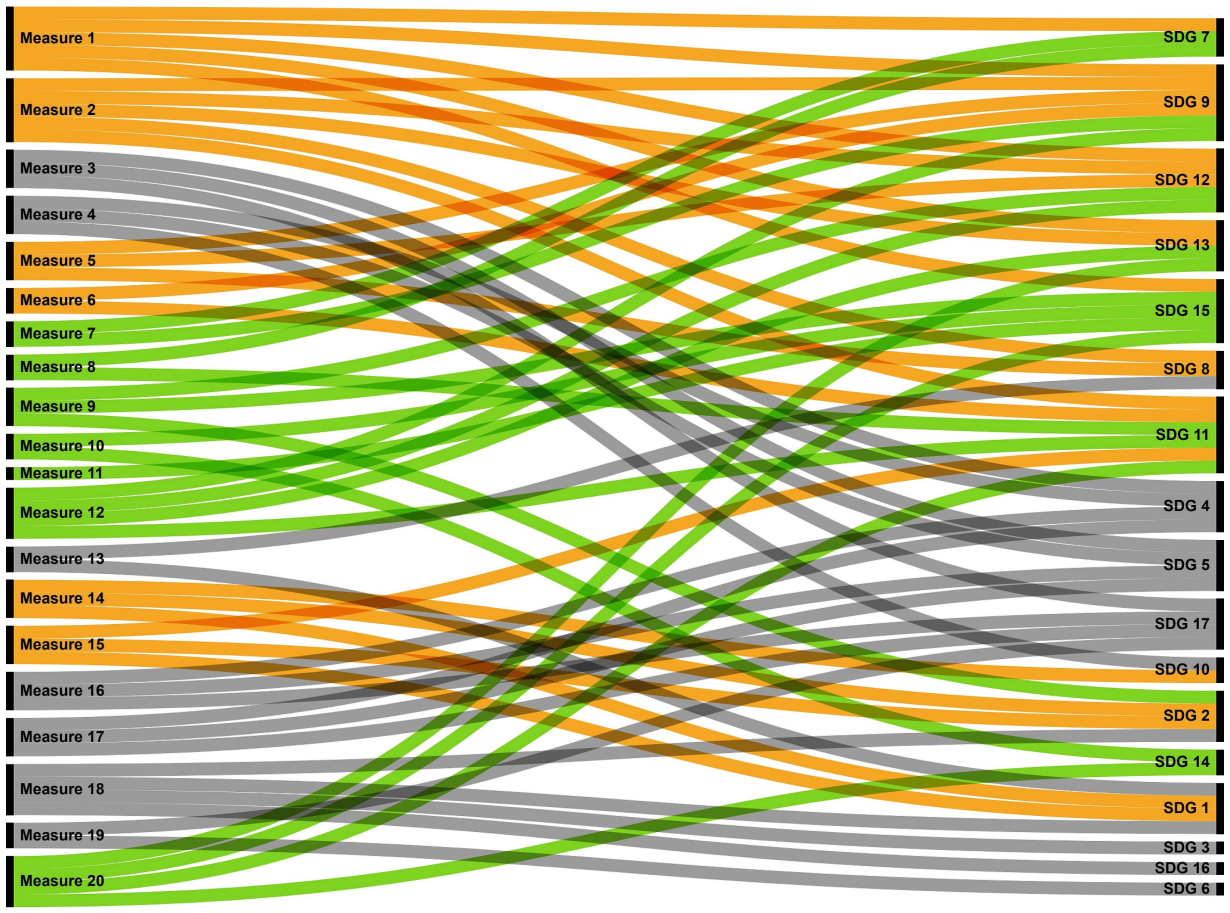


FIGURE 2
Alluvial diagram illustrating the impacts of the proposed innovative measures (1–20) on each SDG. Economic measures, Policy measures, Environmental measures.

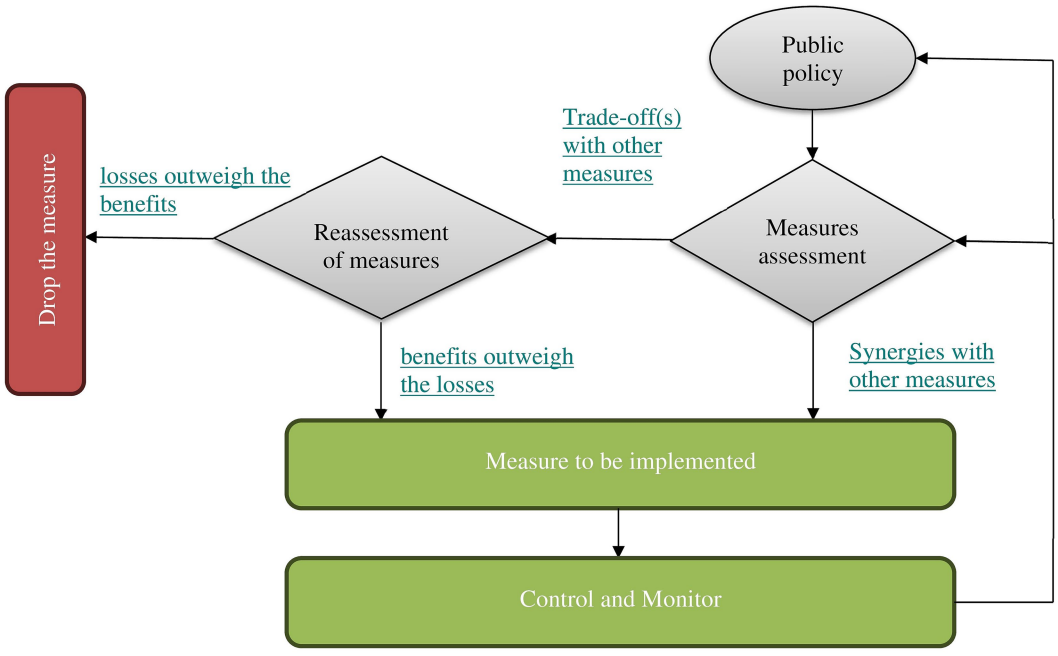


FIGURE 3
Framework for assessing the impact of innovative measures on sustainable development across diverse national contexts.

(see Figure 1), alongside a holistic approach that supports the implementation of the proposed measures to address the SDGs (see Table 1). Acknowledging that there is no single solution to today's complex and dynamic global challenges, our approach emphasises inclusive public policies that encourage responsible innovation for greater societal benefit in the realm of sustainable development, avoiding a "de-risking" approach.

Adjustments should be made to public policies supporting innovation for sustainable development in line with the idiosyncrasies of each country. In addition, there should be supranational guidance to foster support and solidarity in sustainable domains from developed to developing countries; this should not be merely through the transfer of money (COP27 Summit in Egypt) but by enhancing knowledge sharing, collaboration and exchanging programmes such as UNESCO's Education for Sustainable Development.

The future is now, and the policy makers' inertia is causing huge and potentially irreversible damage to our planet and to all of us; the United Nations (UN) Secretary-General, António Guterres, recognised this in June 2023 at the start of a two-day international meeting titled "Stockholm+50: A healthy planet for the prosperity of all—our responsibility, our opportunity."

Finally, military activities exacerbate climate change and biodiversity loss and are often overshadowed by national security concerns, hampering global environmental efforts and international cooperation (Idachaba, 2023). To address these challenges, policymakers must prioritise stronger international frameworks that ensure continued progress on sustainability even during periods of geopolitical instability (Vogler, 2024). The UN's role as a champion of global peace and security through conflict resolution and collective action should therefore be strengthened. "Promoting peace is the humanistic and planetary conscience" (Vuong et al., 2024, p. 1089). If this conscience were sharpened, it would serve as a starting point for implementing and advancing public policies for innovation aimed at achieving sustainable development that benefits citizens worldwide.

## Author contributions

GB: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Writing – original draft. MR: Project administration, Supervision, Validation, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



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