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TITLE PAGE

Ethical and Social Issues in Research and Technology Development: Global Context and Implications for Latin American Countries

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Abstract

As Latin American (Latam) countries advance in research and technology development, it becomes imperative to integrate ethical and social concerns into their innovation processes. Several frameworks have addressed these concerns, including ethical, legal, and social issues (ELSI), responsible research and innovation (RRI), and responsible innovation (RI). However, their discourse has been criticized by some as being highly focused on developed countries, often neglecting the unique contexts of developing countries. Therefore, ethically and socially driven frameworks are required that consider the needs, expectations, and realities of developing countries. This chapter explores the challenges and opportunities associated with the implementation of responsibility-driven research and innovation perspectives, particularly in the Latam region. First, we present an overview of the global literature incorporating ELSI, RRI, and RI frameworks using bibliometric and visualization approaches. Second, we discuss the characteristics of the contexts surrounding developing countries. Finally, building on these insights, we propose a simplified conceptual model for the adoption and use of ethically and socially driven frameworks within the Latam region. Our findings support the idea that no one-size-fits-all approach to social responsibility exists. Contrastingly, countries and regions should adopt adaptive and flexible frameworks suitable for their unique realities and localities as they strive towards inclusive, creative, and sustainable societies.

Keywords: emerging technologies, ethical and social issues, responsible innovation, Latin American, ELSI, RRI

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Abstract

As Latin American (Latam) countries advance in research and technology development, it becomes imperative to integrate ethical and social concerns into their innovation processes. Several frameworks have addressed these concerns, including ethical, legal, and social issues (ELSI), responsible research and innovation (RRI), and responsible innovation (RI). However, their discourse has been criticized by some as being highly focused on developed countries, often neglecting the unique contexts of developing countries. Therefore, ethically and socially driven frameworks are required that consider the needs, expectations, and realities of developing countries. This chapter explores the challenges and opportunities associated with the implementation of responsibility-driven research and innovation perspectives, particularly in the Latam region. First, we present an overview of the global literature incorporating ELSI, RRI, and RI frameworks using bibliometric and visualization approaches. Second, we discuss the characteristics of the contexts surrounding developing countries. Finally, building on these insights, we propose a simplified conceptual model for the adoption and use of ethically and socially driven frameworks within the Latam region. Our findings support the idea that no one-size-fits-all approach to social responsibility exists. Contrastingly, countries and regions should adopt adaptive and flexible frameworks suitable for their unique realities and localities as they strive towards inclusive, creative, and sustainable societies.

Introduction

It is widely recognized that the world is marked by unprecedented turbulence, uncertainty, novelty, and ambiguity (Ramírez & Wilkinson, 2016), and so are the problems facing humanity, such as climate change, poverty, food security, migration, global health, and resource scarcity (Pakkan et al., 2023). Effectively addressing these challenges requires societies to be capable of consistently creating and capturing value through innovation (Stahl, 2013), which often involves the development of new scientific and technological knowledge.

Recently, the anticipation of the unintended or undesirable consequences of such emerging knowledge through alignment with ethical and social concerns is relevant in science, technology, and innovation (STI) policy and practice (Biggi & Giuliani, 2021; Kendal, 2022; Rotolo et al., 2015), because it is a prerequisite for sustainable and inclusive paths of growth (Reichardt et al., 2016). Several frameworks have been developed to make STI more responsive to society's needs and expectations (Mikami et al., 2021), of which three main frameworks have stood out in the

literature: ethical, legal, and social issues (ELSI); responsible research and innovation (RRI); and responsible innovation (RI), which are the focus of this chapter.

Over the years, the knowledge underlying these frameworks has been created, used, and diffused across several geographies, academics, practitioners, and policy communities (Liu et al., 2022; Wiarda et al., 2021). Although these frameworks have been widely discussed, the discourse surrounding them has predominantly emerged from a developed-country perspective (Vasen, 2017). Thus, there is a need for further research characterizing ethically and socially driven frameworks in the context of developing countries. This chapter addresses this gap by exploring how developing countries, particularly those in the Latin American (Latam) region, can leverage these frameworks to align their STI efforts with ethical and social concerns. As developing countries continue to intensify their research and technology development efforts, it is imperative to consider the needs and expectations of society according to local realities and particularities (Vasen, 2015, 2017).

We begin our analysis by describing the global context of knowledge creation, use, and diffusion that underlie the ELSI, RRI, and RI frameworks across geographical, technological, and cognitive dimensions. Subsequently, we characterize the realities and particularities of developing countries, which form the basis for the development of a conceptual model for the adoption of an ethically and socially driven framework aligned to the sociocultural motivations and aspirations of the Latam region. We used bibliometric data to evaluate the geographical, technological, cognitive, and intellectual dimensions of the ELSI/RRI/RI frameworks. Additionally, we used scientific publications, gray literature, and policy reports related to the implementation of ethically and socially driven frameworks in relevant Latam countries. These findings provide a foundation for defining the challenges and opportunities in implementing actions to align STI, in its broadest sense, with social values and expectations in developing countries, particularly Latam countries.

The remainder of this chapter is organized as follows: The “Literature Review” section provides background information on the three frameworks included in this analysis, namely, ELSI, RRI, and RI, and relevant research on Latam countries. The section “Methods” enumerates research methods and data. The section “Results” describes the findings obtained in our analyses. Finally, the section ‘Discussions and Conclusions’ presents a conceptual model depicting the components of an ethical and socially driven framework for Latam countries.

Literature Review

Frameworks integrating ethical and social issues

Several frameworks have been developed to better align emerging STI with the needs and expectations of society (Shanley, 2021). Various alternative frameworks have been proposed, including pioneering technology assessment (TA) approaches (Coates, 1976), and their derivatives such as participatory (Hennen, 1999) and constructive (Rip et al., 1995) TAs, as well as more recent approaches such as inclusive innovation (Foster & Heeks, 2013). Furthermore, the literature presents other frameworks, such as ELSI (Fisher, 2005), RRI (Owen et al., 2012), and RI (Owen et al., 2013), which are the primary focus of this chapter.

These frameworks face similar governance challenges related to uncertainties derived from the long-term safety, environmental and socio-economic effects, and value-added impacts of emerging technologies (König et al., 2021). They also have common origins, including science and technology studies, anticipatory governance, applied ethics, and TA (Liu et al., 2022; Reijers et al., 2018); however, in practice, they follow different trajectories.

Ethical, legal, and social issues

The ELSI framework focuses on analyzing the social implications of technological advancements, particularly in the field of biomedical research (Ogbogu & Ahmed, 2022). This framework originated in the ELSI Research Program established in the Human Genome Project in 1990 and has since expanded internationally (Dolan et al., 2022; Morrissey & Walker, 2012). It is also commonly known as ELSA in Europe because of its ethical, legal, and social aspects (Ryan & Blok, 2023). Illes et al. (2017) outline the actionable priorities of this framework in six key areas: capacity building, policy, engagement with industry, research ethics, communication, and community building. Moreover, Kendal (2022) describes a series of concepts involved in any ELSI approach, including privacy, informed consent, the impact of scientific discoveries, minimizing harm and maximizing benefits, transparency and confidentiality, professional codes of ethics, dignity, and confidentiality, which are highly in line with the strong influence of research integrity and ethics within this framework.

Responsible research and innovation

RRI provides a broader way of thinking about innovation with an emphasis on open and transparent dialog across different stakeholders with diverse interests toward the anticipation of the benefits and negative consequences of emerging science and technologies (Komiya et al., 2022). RRI is characterized by strong policy development efforts mainly developed during the European Union's research framework Horizon 2020 (Rip, 2018). Over the years, RRI has been implemented in a top-down manner (Liu et al., 2022). Nevertheless, these efforts have been reoriented toward "Open Science" and "Open Innovation" (Shanley, 2021). This framework has been operationalized into six key principles: gender equality, public engagement, ethics, open access, science literacy, science education, and governance (Stahl, 2013). It has also been inferred that RRI positively impacts innovation by intervening in the early stages of technological development (Ko et al., 2020).

Responsible innovation

Although RI and RRI follow similar cognitive paths, clear and relevant distinctions exist between them that have sent these fields to various trajectories (Shanley, 2021). RI is derived from the concept of responsible development, which was first used in the nanotechnology field in the early 2000s (Von Schomberg, 2019). RI has a more significant academic background than RRI, including anticipatory, ELSI/ELSA, and TAs (Owen & Pansera, 2019). The RI framework emphasizes future-oriented and sustainable innovation, stressing the inclusion and participation of all innovation stakeholders. The framework integrates specific approaches such as anticipation, reflexivity, inclusive deliberation, responsiveness, and openness into the innovation process while addressing uncertainty (Stilgoe et al., 2013).

ELSI/ELSA, RRI, and RI frameworks-related research in Latam countries

Table 1 presents a list of representative scientific publications by authors in Latam countries using the ELSI, RRI, and RI frameworks as the basis of their studies.

This table shows that the contributions from Latam countries are still small. However, we observed a diverse range of contexts in which these frameworks have been used, including genetics, entrepreneurship, nanotechnology, gender studies, and science and technology policy. Notably, some of these efforts go beyond the mere application of these frameworks and include theory-building adapted to the respective countries. Nonetheless, these efforts are limited to certain areas,

suggesting that the diffusion and adoption of ethical and social frameworks are still in the early stages in this region.

Table 1. Total of scientific publications from Latin American countries extracted from our search

Framework	Reference	Title	Country
ELSI	(Penchaszadeh, 2015)	Ethical, legal and social issues in restoring genetic identity after forced disappearance and suppression of identity in Argentina	Argentina
RI	(Vargas Martínez et al., 2018)	Responsible innovation: new entrepreneurship strategy for MSMES (in Spanish)	Brazil
RI	(Bahena-Álvarez et al., 2019)	Social entrepreneurship in the conduct of responsible innovation: Analysis cluster in Mexican SMEs	Mexico
RI	(Ligardo-Herrera et al., 2019)	Application of the ANP to the prioritization of project stakeholders in the context of responsible research and innovation	Colombia
RI	(Macnaghten & Guivant, 2020)	Narrative as a resource for inclusive governance: a UK–Brazil comparison of public responses to nanotechnology	Brazil
RI	(Silva et al., 2023)	From woman to woman: consumption vulnerability and responsible innovation in transport network companies	Brazil
RRI	(Matías Herrera & García Fronti, 2019)	Criteria for the responsible management of nanotechnology financing in Argentina (in Spanish)	Argentina
RRI	(Giovanetti et al., 2021)	Promoting responsible research and innovation (RRI) during Brazilian activities of genomic and epidemiological surveillance of arboviruses	Brazil
RRI	(Barton et al., 2019)	Responsible research and innovation (RRI) in Chile: from a neostructural productivist imperative to sustainable regional development?	Chile
RRI	(Di Giulio et al., 2016)	Communicating through vulnerability: knowledge politics, inclusion and responsiveness in responsible research and innovation	Brazil
RRI	(Reyes-Galindo et al., 2019)	'Opening up' science policy: engaging with RRI in Brazil	Brazil

Note: ANP: Analytical Network Process; SME: Small and medium-sized enterprise; MSME: Micro-, Small and Medium-sized Enterprise

Methods

We collected scientific publications from the Web of Science (WoS) bibliographic database using search queries relevant to the ELSI/ELSA, RRI, and RI frameworks in titles, abstracts, and keywords in articles, proceedings papers, review articles, and book chapters of documents published in English from 1990 to 2023, as shown in Table 2. We used all editions of the WoS

Collection, including the Emerging Sources Citation Index, which includes peer-reviewed publications of regional importance.

Table 2. Total of documents extracted from our search, 1990–2023 (in parentheses, 2015–2023)

Type	Frameworks		
	ELSI	***RRI***	***RI***
Article	474 (244)	532 (501)	528 (449)
Review article	140 (82)	30 (30)	58 (46)
Proceeding paper	60 (18)	91 (84)	67 (54)
Book chapter	48 (22)	34 (33)	43 (33)
Others	35 (13)	21 (8)	46 (15)
Total	734 (375)	697 (657)	735 (618)

Note: ELSI: Ethical, legal and social issues; RRI: Responsible research and innovation; RI: Responsible innovation

Publications in English are used as proxies for the global knowledge base underlying each framework. We also used the bibliographic database SciELO to collect scientific publications in Spanish from journals not indexed in the WoS database.

We used geographical, technological, and cognitive dimensions based on bibliometric data and graphical approaches, such as networks and ternary maps, to analyze the contents of the knowledge bases underlying the ELSI, RRI, and RI frameworks. For the geographical and technological dimensions, we used rates of growth and ternary plots, which graphically assess these dimensions in an equilateral triangle depicted by the three frameworks based on the Revealed Scientific Advantage (RSA) values. RSA indicates the specialization of countries in selected domains (Radosevic & Yoruk, 2014). For the cognitive dimension, we built a two-mode network, which was defined by two distinct types of variables, namely the three frameworks and keywords extracted from the titles, abstracts, and authors' keywords of the collected publications. We used the UCINET/Netdraw software to visualize the network (Borgatti et al., 2013).

To investigate relevant research efforts in Latam and aspects that impact the implementation of ethically and socially driven frameworks in developing countries, we analyzed scientific publications, gray literature, and policy reports related to ELSI, RRI, and RI frameworks in developing countries.

Results

Characterization of ELSI/RRI/RI knowledge bases

Longitudinal trends

Figure 1 demonstrates the longitudinal trends in the number of publications across the frameworks and their co-occurrence in these documents. The inset in this figure lists the number of publications by Latam and Caribbean countries during 1990–2023.

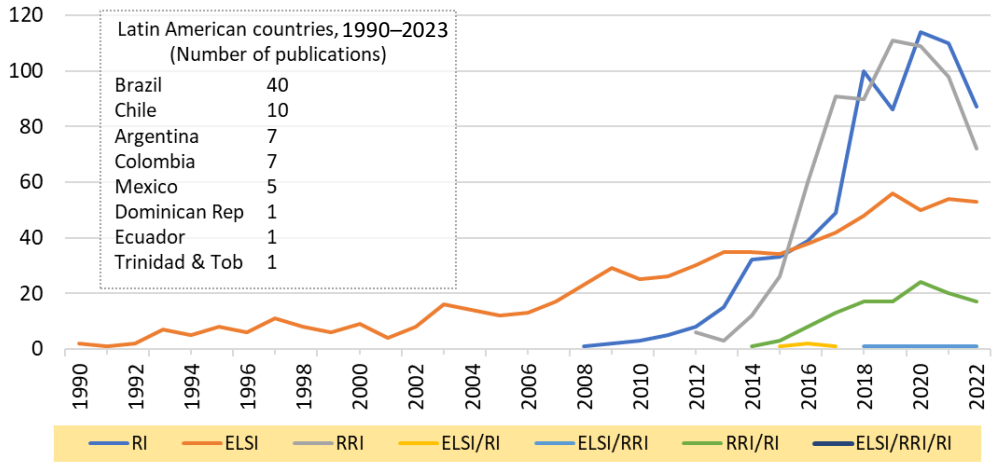

Figure 1. Longitudinal trends for ELSI, RRI, and RI (Source: own elaboration).

Figure 1 depicts that research on ELSI/ELSA has been published for the longest period (~ 1990), followed by RI (~ 2008) and RRI (~ 2012). Notably, the number of publications on RI and RRI surpassed that on ELSI/ELSA in 2015. After a period of rapid growth, the number of publications on RI and RRI peaked and began to decline in 2018. Contrastingly, publications on ELSI/ELSA maintained a steady growth rate, albeit significantly lower. Although these three frameworks share similar knowledge bases (Liu et al., 2022), we did not find any publications that integrated ELSI, RRI, and RI into a single study. Only RRI and RI appeared in the publications; however, their numbers were insignificant. As observed in the inset of Figure 1, the contribution of Latam and Caribbean countries to the international knowledge bases surrounding these frameworks remains negligible, except for Brazil, which has 40 scientific publications.

Geographical measure

Figure 2 assesses publications across relevant countries for the three frameworks. Figure 2a displays the recent publication growth rates during 2015–2018 and 2019–2022. Figure 2b shows the comparative advantage values during 2015–2022 based on the co-authors' country of

affiliation for the three frameworks. We focused on countries that accumulated over 20 publications during 2015–2022.

a)

Country	ELSI	RRI	RI
Australia (AUS)	0.65 (38)	2.00 (21)	2.38 (27)
Germany (DEU)	1.31 (**60**)	1.59 (**96**)	**6.57** (**53**)
Italy (ITA)	0.45 (29)	1.89 (**55**)	**6.50** (30)
Netherlands (NLD)	0.45 (42)	1.54 (**137**)	0.95 (**166**)
Switzerland (CHE)	0.67 (20)	1.50 (20)	2.29 (23)
UK (GBR)	0.51 (**83**)	1.22 (**149**)	**6.67** (**138**)
USA	0.38 (**303**)	3.31 (**56**)	**4.38** (**142**)
Austria (AUT)	-	1.35 (47)	**5.50** (26)
Belgium (BEL)	-	1.00 (30)	**29.00** (30)
Canada (CAN)	0.40 (**109**)	-	**6.88** (**63**)
France (FRA)	-	1.38 (31)	**10.67** (35)
Norway (NOR)	-	2.87 (**58**)	**22.00** (23)
Spain (ESP)	-	1.55 (**79**)	**5.25** (25)
China (CHN)	0.82 (20)	-	-
Denmark (DNK)	-	1.37 (45)	-
India (IND)	-	-	**9.50** (21)
Ireland (IRE)	-	2.50 (21)	-
Japan (JPN)	0.47 (28)	-	-
Romania (ROM)	-	0.09 (36)	-

b)

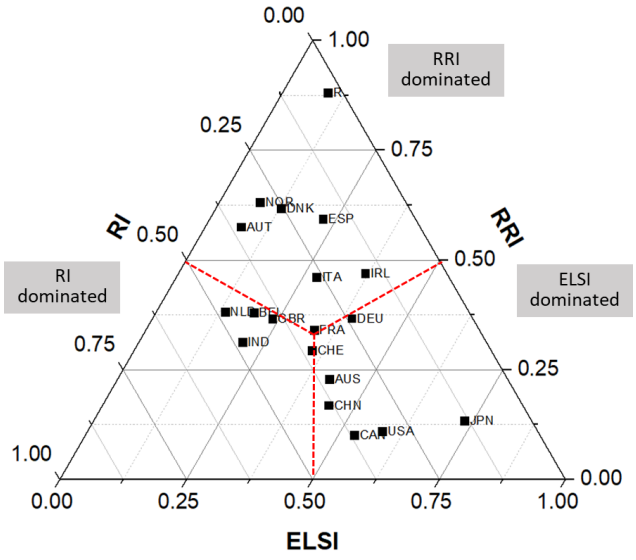

Figure 2. Assessment of geographies across frameworks. (a) Growth rates and number (in parentheses) of publications by relevant countries across frameworks and (b) Ternary plot visualization of revealed comparative advantages for countries across frameworks (Source: own elaboration).

Figure 2a indicates that most of the countries on the list are from Europe, suggesting a greater interest in and diffusion of these topics in this region. The only non-European countries included are Australia, the United States, Canada, China, India, and Japan. The United Kingdom and the Netherlands are the leading countries in the RRI and RI fields, accounting for approximately 20% of all publications. The United States has the most significant influence on the ELSI field, with over 40% of the total publications. Notably, apart from India, China, and Romania, no other developing countries appeared on our list, including Latam countries. Figure 2b illustrates the high level of specialization among countries across the three frameworks. Although Japan focuses on ELSI research, other countries, such as the United States and Canada, highlight ELSI and RI. The Netherlands is characterized by strong RRI and RI competencies, whereas the United Kingdom and Germany show balanced shares among the three frameworks.

Technological measure

Using a list of 23 technological domains extracted from the titles, abstracts, and authors' keywords of the collected documents, Figure 3 outlines the growth rates of publications and the levels of specialization of countries across the ELSI, RRI, and RI frameworks.

a)

Technological domain	ELSI	RRI	RI
Agriculture/Food	0.50 (15)	**3.79** (**67**)	**2.31** (**86**)
AI	**6.0** (14)	**2.86** (27)	**2.92** (51)
Biotech/Life Sciences	0.37 (**180**)	1.37 (**64**)	1.25 (54)
Blockchain	- (1)	- (3)	- (1)
Chemistry	N/A	0.56 (14)	1.00 (2)
Construction Tech	0.60 (8)	**3.50** (9)	**4.00** (25)
Education	0.42 (**78**)	1.00 (**186**)	1.67 (**72**)
Energy/Environment	1.00 (16)	**2.48** (**167**)	1.73 (**169**)
Engineering	1.00 (4)	1.31 (30)	2.00 (36)
Gene editing	1.13 (17)	**2.33** (30)	**2.50** (21)
Genetics/Genomics	0.39 (**334**)	**6.00** (7)	0.26 (24)
Healthcare/Medicine	0.47 (**486**)	**2.12** (**103**)	1.09 (**157**)
ICT	0.63 (**122**)	1.80 (**112**)	**2.50** (**112**)
Manufacturing	N/A	**2.50** (7)	0.38 (11)
Nanotech	0.13 (27)	0.35 (50)	0.59 (46)
Neuroscience/-tech	1.06 (35)	0.69 (27)	1.00 (18)
Others	1.14 (47)	1.13 (17)	2.00 (6)
Pharma	0.20 (53)	**5.00** (6)	1.00 (6)
Precision medicine	0.55 (**107**)	N/A	0.36 (15)
Quantum	- (1)	- (2)	- (4)
Regenerative medicine	0.38 (**106**)	0.75 (7)	0.36 (15)
Robotics	0.86 (13)	3.00 (28)	1.92 (38)
Synthetic biology	0.13 (9)	1.13 (32)	1.14 (15)

b)

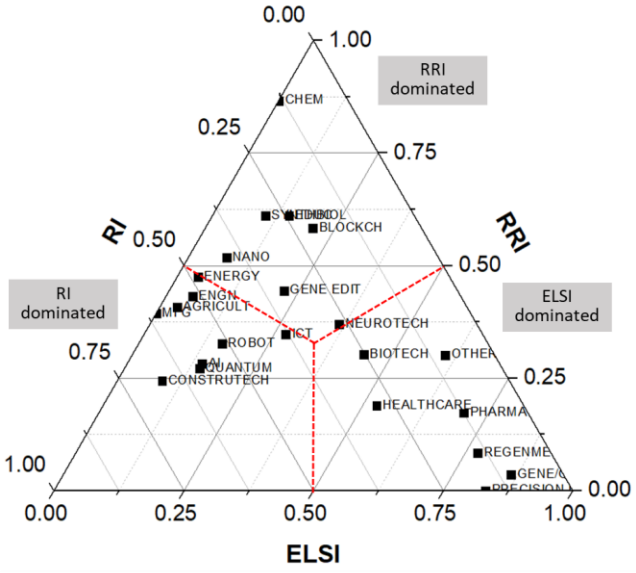

Figure 3. Assessment of technological domains across frameworks. (a) Growth rates and number (in parenthesis) of publications by technological domains across frameworks and (b) ternary plot visualization of technological domain specialization across frameworks (Source: own elaboration).

Figure 3a depicts that the technological domains that experienced the greatest growth across the three frameworks are agriculture/food technology, energy/environment, AI, construction technologies, and gene editing. The lowest-growing technological domains included nanotechnology and regenerative medicine. Figure 3b displays the distribution of technological domains across the three frameworks. The fields of healthcare, biotechnology, pharmaceutical, precision medicine, and genomic testing are dominated by the ELSI framework, whereas robot technologies, quantum construction technologies, and AI fall within the realm of RI. Synthetic biology, blockchain technology, educational technologies, and chemistry are located in regions dominated by RRI. Other technologies, such as energy, engineering, and agriculture, share RRI and RI dominance, whereas ICT and neurotechnology closely balance their shares among the three frameworks.

Cognitive measure

Figure 4 presents the two-mode network that relates the ELSI, RRI, and RI frameworks to keywords extracted from the abstracts, titles, authors' keywords of the collected documents, and a series of tables associated with the cognitive contents of the knowledge bases underpinning these frameworks.

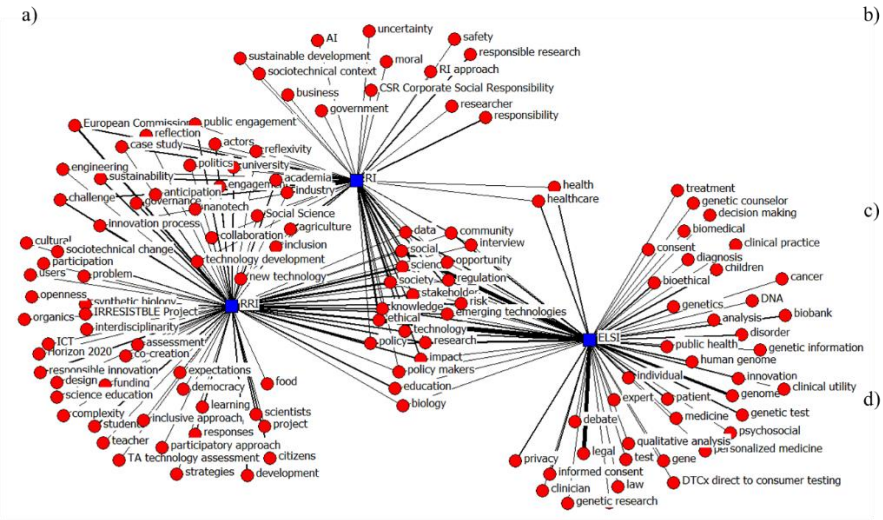

Figure 4. Cognitive contents of the knowledge bases underpinning the three frameworks. a) Two-mode network relating each framework with relevant keywords; b) Percentage of overlapping references between frameworks based on Ávila-Robinson et al. (2023); c) Percentage of publications for each framework with business-related keywords; and d) Percentage of publications for each framework with applied-related research (Source: own elaboration).

Consistent with the findings in previous sections, Figure 4a illustrates the distinct influence of human genome-related keywords on the development of the ELSI framework, including topics such as patients, public health, genetic testing, bioethics, and clinical practice. The RI framework includes responsibility-related terms and a series of terms related to sustainability and business. The RRI framework includes unique collaboration-related topics such as participatory approaches, interdisciplinarity, cocreation, and learning. It also includes a series of nontraditional stakeholders, such as citizens and teachers. Both RRI and RI are cognitively connected by principles of responsible research, including anticipation, reflexivity, governance, the multi-stakeholder approach, and public engagement. The three frameworks share interests in ethics, social issues, stakeholder perspectives, communities, emerging science, technologies, innovations, and policies. RRI and mainly RI show more significant interest in business-related contexts (Figure 4b). These frameworks differ in their intellectual bases as each presents a self-standing body of knowledge,

as depicted by the extent of the cognitive overlap among frameworks (Figure 4c). In contrast to ELSI research, which tends to focus on the application of this framework in specific contexts, RRI and RRI develop the theoretical knowledge that underpins both frameworks (see Figure 4d).

Overall, the analyses in this section indicate that developing countries, with the exception of India and China, have made limited contributions to the discourse surrounding the ELSI/ELSA, RRI, and RI frameworks. Additionally, we observed a strong correlation between the frameworks and geographical, technological, and cognitive dimensions. The following section describes the realities of developing countries in terms of general characteristics, knowledge generation and innovation, governance, and culture and institutions.

Realities of developing countries vs. developed countries

Previous literature has highlighted that developing countries should adapt and reconceptualize ethical and social frameworks to their unique characteristics and realities rather than blindly emulating them to avoid implementation failures (Pandey et al., 2020; Sjøtun & Solheim, 2023; Vasen, 2017; Wakunuma et al., 2021). In this section, we describe the general characteristics of the contexts surrounding developing countries, which will be instrumental in defining the features of an ethically and socially driven framework for the Latam region.

General characteristics of developing countries

Developing countries often encounter economic constraints, inadequate and restrictive governance mechanisms, and an imperative to survive in vulnerable settings, leading to slower growth (Nagarajah, 2023). This situation is compounded by significant socioeconomic disparities, informality, resource constraints, knowledge hierarchies, and power asymmetries experienced by these countries (Pandey et al., 2020). However, not all developing countries are equal; there is a high level of inter- and intra-diversity in these countries (Wakunuma et al., 2021), which is evident in the various country classification schemes based on income levels (Hamadeh et al., 2023) and additional aspects such as well-being and sustainability (OECD, 2021). There are also large disparities between rural and urban regions in developing countries. Recognizing these realities is crucial for the implementation of ethical and social frameworks. Thus, we explore three key dimensions—knowledge generation and innovation, governance, and culture and institutions—

encompassing the differentiating characteristics of developing countries from those of developed countries in the implementation of ethically and socially driven frameworks as follows.

Knowledge generation and innovation

Developing countries are characterized by emerging STI ecosystems with limited capacity for the development of science and technology-based innovations. These initial research and technology development efforts coexist with the creation, diffusion, and use of indigenous knowledge (Vasen, 2017). The latter type of informal knowledge encompasses new social practices, institutions, designs, and technologies arising from local needs in the context of social exclusion and inequality. Therefore, there is particular interest in the intercultural dialog between indigenous people and other traditional knowledge holders (Vasen, 2015, 2017). Additionally, compared with developed countries, developing countries prioritize rural perspectives, local and community-driven issues, and social and frugal innovation efforts aimed at solving life struggles toward sustainable and communitarian practices (Pandey et al., 2020; Wakunuma et al., 2021).

Furthermore, the limited capacity of developing countries to develop high-value-added knowledge places them in the role of knowledge adopters rather than creators, placing them at the periphery of global value chains, away from design processes (Vasen, 2017). The reliance on knowledge adoption and, therefore, the lack of technological ownership complicates the adaptation of these new technologies to the diverse local contexts of developing countries.

Governance

Developing countries often lack an appropriate regulatory framework to effectively monitor, enforce, and manage ethical and social concerns related to emerging science and technology. Governance practices in these countries are less formal (Wakunuma et al., 2021) owing to the limited financial and human resources. Pandey et al. (2020) highlight that bureaucrats, policymakers, and top-level agents lead the decision-making process in developing countries, as it is often assumed that the public and communities lack the necessary information and knowledge to make appropriate decisions. This type of governance contradicts the prevalent bottom-up, community-led, and locally-oriented innovation processes informally conducted in developing countries (Pandey et al., 2020; Wakunuma et al., 2021). This situation often overlooks the specific needs and concerns of marginalized communities, which, concurrently, are disproportionately

affected by technological change (Nagarajah, 2023). Consequently, the benefits of new technologies may not be equally accessible to the entire population, exacerbating socioeconomic disparities between less-advantaged regions and countries.

Culture and institutions

The ethnic, linguistic, social, and cultural diversity of developing countries requires the creation of inclusive frameworks that are sensitive to local contexts. Failure to address cultural concerns may result in resistance to innovations, particularly because of the stronger desire for protest groups in developing countries, as described by Vasen (2017). He observed that these countries tend to overemphasize the potential socioeconomic benefits of new research and technology development, while overlooking the associated risks and negative externalities, as evidenced by various cases of environmental and social injustices. Moreover, Macnaghten et al. (2014) provided a comprehensive list of aspects related to the political economy and power relations in developing countries. These include "(local, national, or regional) questions of effectiveness and efficiency, representative democracy, accountability, strategic focus, environmental sustainability, equity and fairness, respect to the rule of law, the limits of capitalism, the need to consume less, as well as to ethical and public desirability and acceptability…institutions and their organizational capacities, their political and regulatory culture, their social climate and risk culture…."

These characteristics indicate that developing countries need to reassess their approach to implementing ethical and socially driven frameworks. The following section outlines a framework tailored to the specific needs of developing countries, with a special emphasis on Latam countries. Key aspects of this framework include an integrated and adaptive nature, the role of stakeholders and capacity-building approaches, and a challenge-based orientation.

Discussions and Conclusions

Toward an ethically and socially driven framework for Latam countries

This study indicates that the global literature on ethical-social frameworks is dominated by developed countries, except for China and India. The latter can be attributed to the stronger internal STI competencies of both countries, as described by Neto et al. (2021). There have been calls to expand and "open up" the focus of these frameworks beyond scientific and technological

development to include diverse geographies, contexts, and knowledge (Macnaghten & Guivant, 2020; Sjøtun & Solheim, 2023; Wakunuma et al., 2021). The necessity of new development models, as described by Gao et al. (2019), is still a topic of debate. However, existing frameworks must be reconceptualized to better suit the specificities and realities of developing countries (Gao et al., 2019; Pandey et al., 2020; Vasen, 2017; Wakunuma et al., 2021), including Latin America. Figure 5 presents an attempt at a conceptual model that enumerates the development of an ethical and socially driven framework for Latam countries.

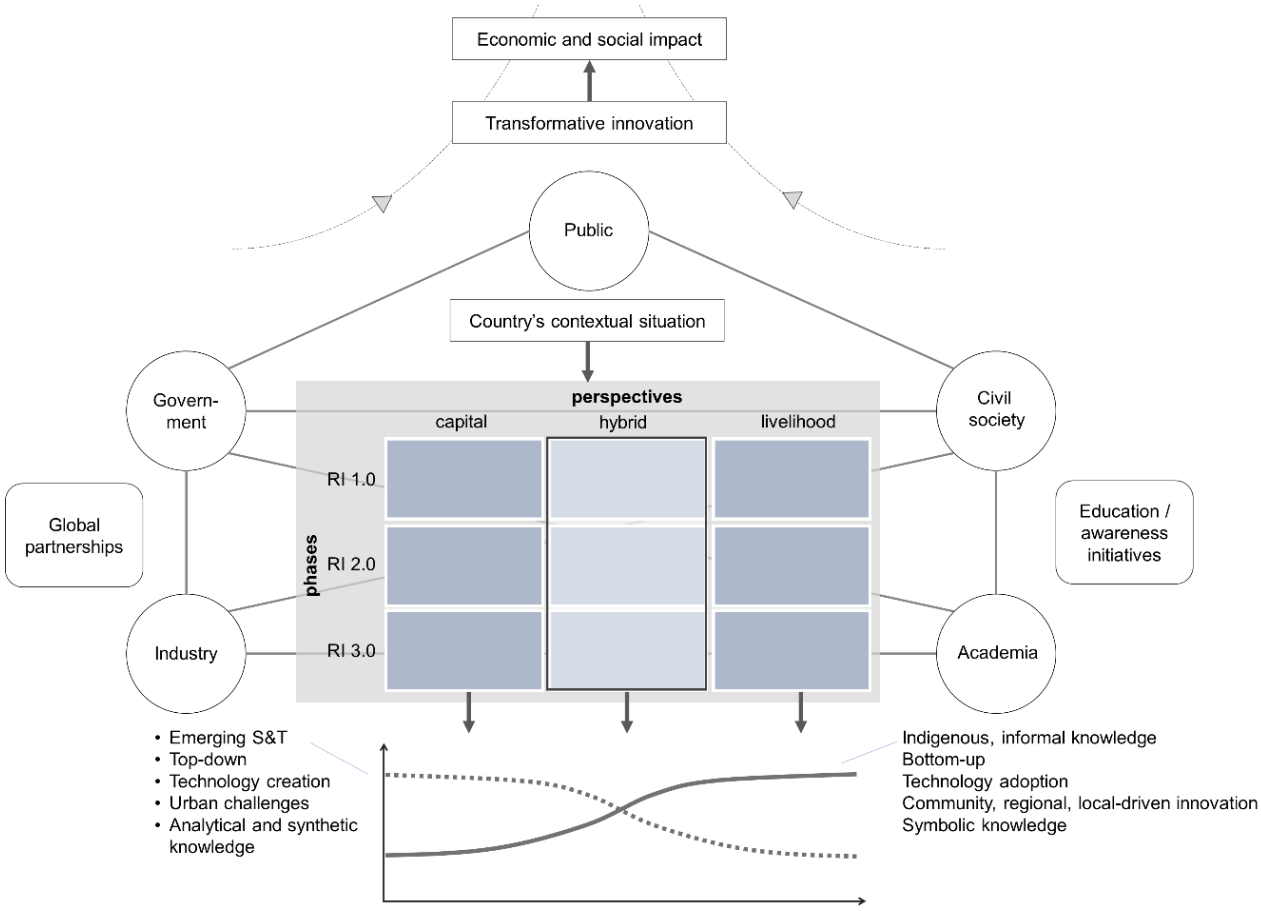

Figure 5. Conceptual model for Latam countries.

Disaggregation and adaptability

Thus, what type of framework is required? Two complementary approaches are required. Although we considered the three frameworks independently, they can reinforce and align with each other to create a more solid ethically and socially driven framework (Ryan & Blok, 2023). Furthermore, owing to the inherent diversity between and within countries, regardless of their level of

development, we would expect the coexistence of various mechanisms to achieve ethically and socially responsible and sustainable development. For some, the creation of agglomerated supra-models with narrow foci on research is futile (Sjøtun & Solheim, 2023). Several discussions highlight the need to disaggregate existing frameworks and adapt them to the specific contexts of countries (Macnaghten & Guivant, 2020; Sjøtun & Solheim, 2023; Wakunuma et al., 2021). It is important to identify the complementarities, differences, symmetries, and harmonies between perspectives (Pandey et al., 2020). According to Sjøtun and Solheim (2023), citing Jakobsen et al. (2019), research and technological specificities, sectoral characteristics, regional conditions, institutional and sociocultural dimensions, and policy regulations are all crucial contextual aspects.

Framework integration and knowledge nature

The latter requires a shift from fixed, all-inclusive frameworks to adaptive, flexible frameworks encompassing distinct types of innovation and processes customized to the contextual characteristics of Latam countries, as illustrated in Figure 5. This figure shows this approach by integrating the models proposed by Sjøtun and Solheim (2023) and Wakunuma et al. (2021). Sjøtun and Solheim (2023) describe three co-existing phases of RI: RI 1.0, RI 2.0, and RI 3.0. RI 1.0 focuses on innovation in research teams and laboratories, ethical values, and analytical knowledge, whereas RI 2.0 emphasizes innovation in industries, economic value, and analytical and synthetic knowledge. However, RI 3.0 describes innovation in cultural-creative sectors, which involves social value and well-being, and encompasses analytical, synthetic, and symbolic knowledge. According to Sjøtun and Solheim (2023), these phases are interwoven, that is, not independent, following one after the other. Wakunuma et al. (2021) define two contrasting perspectives regarding the RRI: capital- and livelihood-oriented approaches. The capital-oriented perspective is formal and top-down, fueled by private and public funding for emerging STI development directed toward urban challenges, and is composed of triple-helix partners with the inclusion of civil society. Contrastingly, the livelihood-oriented perspective is context-based and informal, encompassing bottom-up strategies driven by non-profit and grassroots organizations and often oriented toward local and community-driven social innovations. Barton et al. (2019) provide a similar perspective.

Developed and developing countries should strive for a hybrid perspective involving three phases and two perspectives on responsibility. However, the weight placed by each type of country

in terms of knowledge generation, types of organization, innovation locus, technology development and creation, and targeted regions varies depending on the context of each country (see Figure 5). In this case, we are dealing with a mixture or "hybridity" across phases and perspectives, in which values, knowledge, and technology related to economic, social, and esthetic values closely interact (Sjøtun & Solheim, 2023) depending on each country's contextual situation.

Similarly, knowledge creation in developing countries may be composed of a knowledge spectrum running from indigenous or informal knowledge (technology adoption) to emerging S&T (technology creation), as described in Figure 5 (bottom). For Latam countries, the "center of gravity" of their knowledge portfolio tends toward the former rather than the latter due to the still emerging nature of the innovation ecosystems underpinning these countries. New knowledge is thus created in-house by establishing formal STI ecosystems that consider both global challenges and communities' local needs and requirements.

The role of stakeholders and capacity-building

The roles of different types of organizations involved in STI activities also have adaptive characteristics. Although decision-making should consider the nuances of all stakeholders (represented by circles in Figure 5) (Stilgoe et al., 2020), stakeholders' roles may vary depending on the activity at hand, as the agency is interconnected in complex networks at multiple scales (Macnaghten & Guivant, 2020). For the case of Latam countries, civil society, the public in general, and non-profit organizations, such as NPOs and NGOs, should take relevant positions. It is also crucial to increase public trust by demonstrating commitment to transparent research and innovation practices for the acceptance and adoption of new technologies (Harsanto et al., 2020; Lubberink et al., 2017). Paredes-Frigolett et al. (2021) provide an additional framework that describes the dynamic processes emerging from the decisions made by multiple stakeholders in innovation ecosystems.

Moreover, educational and capacity-building programs are necessary to improve the understanding of ethical frameworks and RI principles among policymakers, regulators, researchers, and the general public. Gao et al. (2019)'s description of the requirements for building ethically and socially driven capacities in China could be beneficial for the Latam region. The latter involves the participation of governments, enterprises, and scientific communities. The government must have an active technology assessment-driven policy mindset, foster scientific

communication, and promote sustainable development in official discourse. Enterprises must prioritize social and ethical affairs, encompassing aspects such as social responsibility, social prestige, social participation, responsible business strategies, business ethics, civil responsibility, business integrity, and good corporate governance. Various frameworks exist to foster business ethical and social issues, including Corporate Social Responsibility (CSR); Environmental, Social and Governance (ESG); green financing; and business sustainability. Similarly, the scientific community must embrace social responsibility and public engagement in research, focusing on research integrity, research ethics, and responsible research practices.

Proactive risk management helps stakeholders identify and address potential risks and challenges early in the innovation process, mitigates negative consequences, and promotes long-term success (Guston et al., 2014). In this regard, global partnerships with international organizations, research institutions, and developed countries could exchange knowledge and leverage global expertise to enhance the capacity for ethical governance.

Challenge-based orientation

According to Schot and Steinmueller (2018), both developed and developing countries should prioritize transformative innovation that addresses environmental and social challenges, with a focus on socio-technical systems that meet basic human needs, as described in Figure 5. Transformative innovation is in line with the goal of linking STI with the UN's Sustainable Development Goals, focusing on specific needs and cultures, local challenges with global impact, and contributing simultaneously to social equity, environmental sustainability, and economic development (Sjøtun & Solheim, 2023).

The way forward for Latam countries

In the end, both developed and developing countries, including Latam countries, should aim for the development and implementation of more inclusive, creative, socially acceptable, and sustainable solutions (Sjøtun & Solheim, 2023). Nevertheless, the routes toward sustainability goals are unique and require adaptation to each Latam country's particularities and localities. The adoption of these frameworks is certainly a time-intensive and painstaking process, particularly challenging due to the economic, social, and cultural diversity of countries in the Latam region. However, in the end, STI, in its broadest sense, is and will be a necessity for achieving inclusive

and sustainable innovation, hence the paramount necessity to adopt and institutionalize ethically and socially driven frameworks in our region.

References

Ávila-Robinson, A., Miyashita, S., & Sengoku, S. (2023). Characterizing ELSI/RRI/RI Frameworks and their Links to Innovation Management Theory. 2023 Portland International Conference on Management of Engineering and Technology (PICMET),

Bahena-Álvarez, I. L., Cordón-Pozo, E., & Delgado-Cruz, A. (2019). Social entrepreneurship in the conduct of responsible innovation: Analysis cluster in Mexican SMEs. *Sustainability*, *11*(13), 3714.

Barton, J. R., Román, Á., & Rehner, J. (2019). Responsible research and innovation (RRI) in Chile: from a neostructural productivist imperative to sustainable regional development? *European planning studies*, *27*(12), 2510-2532.

Biggi, G., & Giuliani, E. (2021). The noxious consequences of innovation: what do we know? *Industry and Innovation*, *28*(1), 19-41.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. SAGE Publications Limited.

Coates, J. F. (1976). The role of formal models in technology assessment. *Technological forecasting and social change*, *9*(1-2), 139-190.

Di Giulio, G., Groves, C., Monteiro, M., & Taddei, R. (2016). Communicating through vulnerability: knowledge politics, inclusion and responsiveness in responsible research and innovation. *Journal of Responsible Innovation*, *3*(2), 92-109.

Dolan, D. D., Lee, S. S.-J., & Cho, M. K. (2022). Three decades of ethical, legal, and social implications research: Looking back to chart a path forward. *Cell genomics*, 100150.

Fisher, E. (2005). Lessons learned from the Ethical, Legal and Social Implications program (ELSI): Planning societal implications research for the National Nanotechnology Program. *Technology in Society*, *27*(3), 321-328.

Foster, C., & Heeks, R. (2013). Conceptualising inclusive innovation: Modifying systems of innovation frameworks to understand diffusion of new technology to low-income consumers. *The European Journal of Development Research*, *25*, 333-355.

Gao, L., Liao, M., & Zhao, Y. (2019). Exploring complexity, variety and the necessity of RRI in a developing country: the case of China. *Journal of Responsible Innovation*, *6*(3), 368-374.

Giovanetti, M., Alcantara, L. C. J., Dorea, A. S., Ferreira, Q. R., Marques, W. d. A., Junior Franca de Barros, J., . . . Iani, F. C. d. M. (2021). Promoting responsible research and innovation (RRI) during Brazilian activities of genomic and epidemiological surveillance of arboviruses. *Frontiers in Public Health*, *9*, 693743.

Guston, D. H., Fisher, E., Grunwald, A., Owen, R., Swierstra, T., & Van der Burg, S. (2014). Responsible innovation: motivations for a new journal. In (Vol. 1, pp. 1-8): Taylor & Francis.

Hamadeh, N., Van Rompaey, C., & Metreau, E. (2023). World Bank Group country classifications by income level for FY24 (July 1, 2023- June 30, 2024) (In: https://blogs.worldbank.org/opendata/new-world-bank-group-country-classifications-income-level-fy24).

Harsanto, B., Kumar, N., Zhan, Y., & Michaelides, R. (2020). Responsible research and innovation (RRI) in emerging economies: a preliminary review. 2020 IEEE International Conference on Engineering, Technology and Innovation (ICE/ITMC),

Hennen, L. (1999). Participatory technology assessment: a response to technical modernity? *Science and Public Policy*, *26*(5), 303-312.

Illes, J., Sipp, D., Kleiderman, E., Benjaminy, S., Isasi, R., Lomax, G., . . . Ravitsky, V. (2017). A blueprint for the next generation of ELSI research, training, and outreach in regenerative medicine. *npj Regenerative Medicine*, *2*(1), 1-4.

Jakobsen, S.-E., Fløysand, A., & Overton, J. (2019). Expanding the field of Responsible Research and Innovation (RRI)–from responsible research to responsible innovation. In (Vol. 27, pp. 2329-2343): Taylor & Francis.

Kendal, E. (2022). Ethical, Legal and Social Implications of Emerging Technology (ELSIET) Symposium. In (pp. 1-8): Springer.

Ko, E., Yoon, J., & Kim, Y. (2020). Why do newly industrialized economies deter to adopt responsible research and innovation?: the case of emerging technologies in Korea. *Journal of Responsible Innovation*, *7*(3), 620-645.

Komiya, K., Shineha, R., & Kawahara, N. (2022). Practice of responsible research and innovation in the formulation and revision of ethical principles of molecular robotics in Japan. *SN Applied Sciences*, *4*(11), 305.

König, H., Baumann, M. F., & Coenen, C. (2021). Emerging technologies and innovation—hopes for and obstacles to inclusive societal co-construction. *Sustainability*, *13*(23), 13197.

Ligardo-Herrera, I., Gómez-Navarro, T., & Gonzalez-Urango, H. (2019). Application of the ANP to the prioritization of project stakeholders in the context of responsible research and innovation. *Central European Journal of Operations Research*, *27*(3), 679-701.

Liu, J., Zhang, G., Lv, X., & Li, J. (2022). Discovering the Landscape and Evolution of Responsible Research and Innovation (RRI): Science Mapping Based on Bibliometric Analysis. *Sustainability*, *14*(14), 8944.

Lubberink, R., Blok, V., Van Ophem, J., & Omta, O. (2017). Lessons for responsible innovation in the business context: A systematic literature review of responsible, social and sustainable innovation practices. *Sustainability*, *9*(5), 721.

Macnaghten, P., & Guivant, J. S. (2020). Narrative as a resource for inclusive governance: a UK–Brazil comparison of public responses to nanotechnology. *Journal of Responsible Innovation*, *7*(sup1), 13-33.

Macnaghten, P., Owen, R., Stilgoe, J., Wynne, B., Azevedo, A., de Campos, A., . . . Frow, E. (2014). Responsible innovation across borders: tensions, paradoxes and possibilities. *Journal of Responsible Innovation*, *1*(2), 191-199.

Matías Herrera, P., & García Fronti, J. (2019). Criterios para la gestión responsable del financiamiento nanotecnológico en Argentina. *Gestión Joven*, *20*(2).

Mikami, K., Ema, A., Minari, J., & Yoshizawa, G. (2021). ELSI is Our Next Battlefield. *East Asian Science, Technology and Society: An International Journal*, *15*(1), 86-96.

Morrissey, C., & Walker, R. L. (2012). Funding and forums for ELSI research: who (or what) is setting the agenda? *AJOB primary research*, *3*(3), 51-60.

Nagarajah, N. (2023). Determinants of responsible innovation for sustainability transition in a developing country: Contested narratives for transition in the Sri Lankan power sector. *Norsk Geografisk Tidsskrift-Norwegian Journal of Geography*, *77*(1), 35-46.

Neto, J. F. C., Froehlich, C., & Gonçalves, M. A. (2021). PESQUISA E INOVAÇÃO RESPONSÁVEL EM ECONOMIAS EMERGENTES: UMA REVISÃO SISTEMÁTICA. *Revista Gestão e Desenvolvimento*, *18*(2), 72-89.

OECD. (2021). *How's Life in Latin America? : Measuring Well-being for Policy Making*.

Ogbogu, U., & Ahmed, N. (2022). Ethical, Legal, and Social Implications (ELSI) Research: Methods and Approaches. *Current Protocols*, *2*(1), e354.

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. *Science and public policy*, *39*(6), 751-760.

Owen, R., & Pansera, M. (2019). Responsible innovation: process and politics. *International Handbook on Responsible Innovation: A Global Resource*, 35-48.

Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., & Guston, D. (2013). A framework for responsible innovation. *Responsible innovation: managing the responsible emergence of science and innovation in society*, 27-50.

Pakkan, S., Sudhakar, C., Tripathi, S., & Rao, M. (2023). A correlation study of sustainable development goal (SDG) interactions. *Quality & Quantity*, *57*(2), 1937-1956.

Pandey, P., Valkenburg, G., Mamidipudi, A., & Bijker, W. (2020). Responsible research and innovation in the global south: Agriculture, renewable energy and the pursuit of symmetry. In (Vol. 25, pp. 215-222): SAGE Publications Sage India: New Delhi, India.

Paredes-Frigolett, H., Singer, A. E., & Pyka, A. (2021). A framework for ethical research and innovation. *Science and engineering ethics*, *27*, 1-40.

Penchaszadeh, V. B. (2015). Ethical, legal and social issues in restoring genetic identity after forced disappearance and suppression of identity in Argentina. *Journal of community genetics*, *6*(3), 207-213.

Radosevic, S., & Yoruk, E. (2014). Are there global shifts in the world science base? Analysing the catching up and falling behind of world regions. *Scientometrics*, *101*, 1897-1924.

Ramírez, R., & Wilkinson, A. (2016). *Strategic reframing: The Oxford scenario planning approach*. Oxford University Press.

Reichardt, K., Negro, S. O., Rogge, K. S., & Hekkert, M. P. (2016). Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, *45*(8), 1620-1635.

Reijers, W., Wright, D., Brey, P., Weber, K., Rodrigues, R., O'Sullivan, D., & Gordijn, B. (2018). Methods for practising ethics in research and innovation: A literature review, critical analysis and recommendations. *Science and engineering ethics*, *24*, 1437-1481.

Reyes-Galindo, L., Monteiro, M., & Macnaghten, P. (2019). 'Opening up'science policy: engaging with RRI in Brazil. *Journal of Responsible Innovation*, *6*(3), 353-360.

Rip, A. (2018). The past and future of RRI. *Futures of Science and Technology in Society*, 115-133.

Rip, A., Schot, J., & Misa, T. J. (1995). Constructive technology assessment: a new paradigm for managing technology in society. In *Managing technology in society: The approach of constructive technology assessment* (pp. 1-12). Pinter Publishers.

Rotolo, D., Hicks, D., & Martin, B. R. (2015). What is an emerging technology? *Research Policy*, *44*(10), 1827-1843.

Ryan, M., & Blok, V. (2023). Stop re-inventing the wheel: or how ELSA and RRI can align. *Journal of Responsible Innovation*, *10*(1), 2196151. https://doi.org/10.1080/23299460.2023.2196151

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy: R&D, systems of innovation and transformative change. *Research Policy*, *47*(9), 1554-1567.

Shanley, D. (2021). Imagining the future through revisiting the past: the value of history in thinking about R (R) I's possible future (s). *Journal of Responsible Innovation*, *8*(2), 234-253.

Silva, L. M. C., Vieira, K. C., Grützmann, A., & Rezende, D. C. D. (2023). From woman to woman: consumption vulnerability and responsible innovation in transport network companies. *Innovation: The European Journal of Social Science Research*, *36*(4), 739-756. https://doi.org/10.1080/13511610.2023.2215956

Sjøtun, S. G., & Solheim, M. C. (2023). Exploring the geographies of responsible innovation. In (Vol. 77, pp. 1-9): Taylor & Francis.

Stahl, B. C. (2013). Responsible research and innovation: The role of privacy in an emerging framework. *Science and Public Policy*, *40*(6), 708-716.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568-1580.

Stilgoe, J., Owen, R., & Macnaghten, P. (2020). Developing a framework for responsible innovation. In *The Ethics of Nanotechnology, Geoengineering, and Clean Energy* (pp. 347-359). Routledge.

Vargas Martínez, E. E., Bahena Álvarez, I. L., & Pozo Cordón, E. C. (2018). Responsible innovation: new entrepreneurship strategy for MSMES. *Innovar*, *28*(69), 41.

Vasen, F. (2015). Innovación responsable: un marco aún demasiado europeo. *SciDev. Net*.

Vasen, F. (2017). Responsible innovation in developing countries: an enlarged agenda. *Responsible innovation 3: A European agenda?*, 93-109.

Von Schomberg, R. (2019). Why responsible innovation. *International handbook on responsible innovation: a global resource*, 12-32.

Wakunuma, K., Castro, F. d., Jiya, T., Inigo, E. A., Blok, V., & Bryce, V. (2021). Reconceptualising responsible research and innovation from a Global South perspective. *Journal of Responsible Innovation*, *8*(2), 267-291.

Wiarda, M., van de Kaa, G., Yaghmaei, E., & Doorn, N. (2021). A comprehensive appraisal of responsible research and innovation: From roots to leaves. *Technological Forecasting and Social Change*, *172*, 121053.