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Programa de Doctorado en Desarrollo Local y Cooperación Internacional

TÍTULO:

Interacción de actores en los mecanismos de monitorización y evaluación de Ciencia e Innovación Responsable: un estudio exploratorio de la técnica AHP

Actors' engagement in monitoring and evaluation mechanisms for Responsible Research and Innovation: an explorative study of the AHP technique

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Prefacio

El inicio del desarrollo de este trabajo se remonta a finales del año 2015, en el marco de una reunión para programar el desarrollo de un trabajo de fin de master con mi entonces profesora de posgrado, la Dra. Mónica García Melón. En aquel momento, buscaba un tutor y barajaba dos temas en los que iniciar una investigación: las estrategias de Responsabilidad Social Corporativa en eventos musicales y el tema que nos ocupa. Por aquel entonces, acababa de publicarse el documento "*Report from the Expert Group launched by the European Commission on Policy Indicators for Responsible Research and Innovation*" (Strand et al., 2015) y el concepto de *Responsible Research and Innovation* tenía un gran protagonismo en la estrategia europea de financiación de ciencia e innovación.

La Dra. García Melón me había impartido recientemente unas clases sobre las técnicas AHP y ANP en el marco del Master en Responsabilidad Social Corporativa que imparte la *Universitat Politècnica de València*. En vista de que presentaba dos temas adecuados para aquel trabajo, me propuso elegir qué criterios eran importantes a la hora de elegir un tema de investigación. Tras unos minutos de reflexión e intercambio de ideas, identifiqué los tres criterios que consideraba que debían regir la elección del tema. A continuación, me hizo comparar la importancia de cada criterio con respecto a los otros dos y asignarles una puntuación: ¿Cómo de importante es el criterio A respecto al criterio B a la hora de elegir un tema de investigación para tu trabajo? Por último, me preguntó cómo puntuaría en una escala del 0 al 9 cada uno de los temas de investigación respecto a cada uno de los criterios. De este modo, aplicando la técnica AHP, de la que hablaremos más adelante, a la elección del tema de mi trabajo iniciamos un camino de más de un lustro que alcanza un hito con la redacción de este documento.

El diseño y la ejecución de mi proyecto de investigación, como intuyo que muchos otros, está lleno de elecciones y renuncias, de oportunidades y de casualidades que han configurado el resultado final del proceso investigador. La elección del tema de investigación, fue sin lugar a duda un hito importante en este camino, que motivó, además, la inclusión del Dr. José Félix Lozano en el grupo de trabajo, quien también me había impartido clase sobre filosofía y ética en el marco del citado master.

Así, a partir de los aportes teóricos que desarrollaremos en la primera sección de este documento y de otros provenientes de la gestión de organizaciones, toma de decisiones y filosofía, definimos el objetivo general de nuestro trabajo y de esta tesis doctoral. Nuestro objetivo era explorar y testear una metodología participativa para involucrar a diferentes grupos de interés en el desarrollo, selección y priorización de criterios e indicadores de *Responsible Research and Innovation* en un contexto específico. Definimos un estudio exploratorio que nos permitiera adentrarnos en la materia y del cual obtuvimos tres resultados relevantes para esta tesis doctoral. En primer lugar y fruto del interés que despertó el tema, decidí matricularme en octubre de 2016 como estudiante de doctorado en el programa de Desarrollo Local y Cooperación Internacional de la Universitat Politécnica de València. En segundo lugar, desarrollamos una primera propuesta metodológica dando como resultado el trabajo presentado en el capítulo 4, publicado en noviembre del año 2017. Y, por último, la Dra. García Melón y el Dr. Jiménez-Saez coordinaron a un grupo de investigadores para desarrollar un proyecto de investigación que permitiese coordinar un mayor número de acciones que las que podría llevar a cabo como una estudiante de doctorado a tiempo parcial. Nuestra incipiente línea de investigación recibió un espaldarazo en 2017 con la financiación del Plan Nacional de Investigación del proyecto "Propuesta de indicadores para impulsar el diseño de una política orientada al desarrollo de Investigación e Innovación Responsable en España" (INPERRI) (ref.: CSO2016-76828-R). La concesión del proyecto de investigación permitió también mi contratación como investigadora predoctoral (ref.:

BES-2017-081141). En julio de 2018, me incorporé al equipo del Instituto de Gestión de la Innovación y del Conocimiento (INGENIO) para realizar mi tesis doctoral a tiempo completo. En el instituto INGENIO, un instituto mixto del CSIC y la *Universitat Politècnica de València* con una consolidada trayectoria en estudios de innovación, he tenido la oportunidad de integrar conocimiento y reflexiones fruto de las actividades formales e informales participadas por personal del instituto y visitantes. Así, durante los últimos cinco años la estrategia metodológica de este trabajo se ha ido nutriendo y actualizando con aportes muy diversos como consecuencia de la red de conocimiento generada alrededor de INGENIO. Además, la obtención de financiación para el desarrollo del proyecto INPERRI y para la realización de estancias a través del contrato predoctoral han tenido también un fuerte impacto en el diseño de la investigación. Especialmente destacable ha sido la posibilidad de realizar una estancia de investigación en la *Wageningen University and Research*. Durante esta estancia, el Dr. Vincent Blok y la Dr. Edurne Iñigo me acompañaron en el diseño de la investigación cuyos resultados se incluyen en el capítulo 3 de este documento y que son una bisagra importante entre la investigación de carácter normativo del capítulo 2 y la investigación experimental de los capítulos 4 a 6.

El repaso cronológico que introduce este documento no puede obviar dos hitos que han afectado de forma notable a los plazos y ejecución de las tareas de investigación durante los tres últimos años. Por un lado, en abril de 2019 me quedé embarazada y di a luz en enero del 2021. El proceso de embarazo y crianza de un bebé ha supuesto una modificación de planes de trabajo y cronogramas y una reconsideración sobre alternativas posibles en el desarrollo de ciertas actividades. Por otro lado, la crisis sanitaria provocada por el virus del SARS-CoV-2, el confinamiento y las posteriores las restricciones a la movilidad han tenido un impacto directo sobre las posibilidades de desarrollar actividades íntimamente relacionadas con el trabajo investigador. A nivel colectivo y en nuestro entorno de investigación se ha puesto a prueba la resiliencia para crear nuevas formas de comunicación y colaboración. A nivel individual, ha sido necesario reconfigurar los espacios de trabajo, repensar planes de trabajo y cronogramas y gestionar la incertidumbre generada por la crisis y sus consecuencias sociales y psicológicas. Por otro lado, la pandemia ha supuesto un interesantísimo campo de observación. Hemos podido observar en tiempo real los efectos de numerosos conceptos manejados en la literatura sobre RRI y el papel de diversos actores en los procesos de toma de decisiones y de comunicación política y divulgación científica. Sin lugar a duda, la crisis generada por el COVID ha permitido profundizar sobre las relaciones entre diferentes conceptos y aproximaciones teóricas relacionadas con el tema de esta tesis doctoral.

Sirva este prefacio para evidenciar que el proceso de investigación en esta tesis doctoral ha incorporado elementos que han permitido enriquecer el diseño metodológico y exigido, también, su modificación. La profundización en la comprensión del tema abordado ha supuesto la reconsideración de ciertos abordajes a lo largo del trabajo, viéndose profundamente modificada desde las primeras reuniones de trabajo sobre un futuro trabajo de final de master hasta el momento en el que integro los diferentes capítulos de esta tesis doctoral.

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Resumen

La capacidad del ser humano de modificar las condiciones de vida en el planeta se ha incrementado de forma notable en el último siglo. Así, dos fenómenos aparentemente opuestos concurren respecto al potencial destructivo y constructivo de nuestras sociedades. Por un lado, la humanidad se enfrenta al reto de articular procesos que permitan gestionar con responsabilidad los productos resultantes del desarrollo de la ciencia e innovación y evitar el colapso social, económico y medioambiental que puede resultar de los mismos. Por otro lado, la humanidad mira a las ciencias y al potencial innovador para responder a los retos globales que requieren abordajes y coordinación entre diferentes niveles de acción y desde una perspectiva inter y transdisciplinar.

En este marco, surge el término "Investigación e Innovación Responsable" (RRI por sus siglas en inglés) con el objetivo de integrar aspectos éticos y demandas de participación de diferentes actores en los procesos de investigación e innovación con el fin de que los productos resultantes de los mismos estén alineados con las expectativas de la sociedad. Bajo el paraguas del término RRI o *Responsible Innovation* (RI), se han articulado una serie de propuestas teóricas y esfuerzos empíricos para operacionalizar la necesidad de integrar una perspectiva ética y promover la participación de nuevos actores en los procesos de investigación e innovación que permitan modular el potencial constructivo y destructivo de los resultados de la ciencia y la innovación.

Para la consolidación del interés por el término RRI ha sido determinante la inclusión del mismo en los programas de investigación de la Comisión Europea. El programa Horizonte 2020 impulsó el uso del término en Europa, destinando fondos de investigación para promover su operativización, desarrollo de herramientas para su fomento, así como de herramientas de evaluación y monitorización.

En este trabajo exploraremos los procesos de diseño de herramientas de monitorización y evaluación de la RRI. Para ello, propondremos la ética cívica como teoría que se ajusta a la fundamentación filosófica del concepto RRI, revisaremos cómo se han incorporado los valores y expectativas de agentes ajenos al proceso científico e innovador en el desarrollo de herramientas de monitorización y evaluación de la RRI y exploraremos cómo la técnica AHP (*Analytic Hierarchy Process*) puede contribuir a los procesos de desarrollo de dichas herramientas alineando los mismos a los requerimientos de la ética cívica.

El trabajo parte de la hipótesis de que los procesos de desarrollo de metodologías y herramientas para la evaluación y monitorización de la RRI pueden ser considerados como procesos de investigación e innovación en sí mismos. En consecuencia, este trabajo analizará los procesos de investigación e innovación hacia herramientas de evaluación y seguimiento de la RRI bajo la óptica propia de la RRI. Se centrará especialmente en explorar el papel de los actores en tales procesos de investigación e innovación y en la potencialidad de la técnica AHP para facilitar la integración de actores en los procesos de desarrollo de herramientas de evaluación y monitorización de la RRI.

Resum

La capacitat de l'ésser humà de modificar les condicions de vida en el planeta ha incrementat de manera notable en l'últim segle. Així, dos fenòmens aparentment oposats concorren respecte al potencial destructiu i constructiu de les nostres societats. D'una banda, la humanitat s'enfronta al repte d'articular processos que permeten gestionar amb responsabilitat els productes resultants del desenvolupament de la ciència i innovació i evitar el col·lapse social, econòmic i mediambiental que pot resultar d'aquests. D'altra banda, la humanitat mira a les ciències i al potencial innovador per a respondre als reptes globals que requereixen abordatges i coordinació entre diferents nivells d'acció i des d'una perspectiva inter i transdisciplinar.

En aquest marc, sorgeix el terme "Investigació i Innovació Responsable" (RRI per les seues sigles en anglés) amb l'objectiu d'integrar aspectes ètics i demandes de participació de diferents actors en els processos d'investigació i innovació amb la finalitat que els productes resultants dels mateixos estiguen alineats amb les expectatives de la societat. Sota el paraigua del terme RRI o Responsible Innovation (RI), s'han articulat una sèrie de propostes teòriques i esforços empírics per a operacionalizar la necessitat d'integrar una perspectiva ètica i promoure la participació de nous actors en els processos d'investigació i innovació que permeten modula el potencial constructiu i destructiu dels resultats de la ciència i innovació.

Per a la consolidació de l'interés pel terme RRI ha sigut determinant la inclusió del mateix en els programes d'investigació de la Comissió Europea. El programa Horitzó 2020 impulsà l'ús del terme a Europa, destinant fons d'investigació per a promoure la seua operativització, desenvolupament d'eines per al seu foment, així com d'eines d'avaluació i monitoratge.

En aquest treball explorarem els processos de disseny d'eines de monitoratge i avaluació de la RRI. Per a això, proposarem l'ètica cívica com a teoria que s'ajusta a la fonamentació filosòfica del concepte RRI, revisarem com s'ha incorporat els valors i expectatives d'agents aliens al procés científic i innovador en el desenvolupament d'eines de monitoratge i avaluació de la RRI i explorarem com la tècnica AHP (*Analytic Hierarchy Process*) pot contribuir als processos de desenvolupament d'aquestes eines alineant els mateixos als requeriments de l'ètica cívica.

El treball parteix de la hipòtesi que els processos de desenvolupament de metodologies i eines per a l'avaluació i monitoratge de la RRI poden ser considerats com a processos d'investigació i innovació en si mateixos. En conseqüència, aquest treball analitzarà els processos d'investigació i innovació cap a eines d'avaluació i seguiment de la RRI sota l'òptica pròpia de la RRI. Se centrarà especialment a explorar el paper dels actors en tals processos d'investigació i innovació i en la potencialitat de la tècnica AHP per a facilitar la integració d'actors en els processos de desenvolupament d'eines d'avaluació i monitoratge de la RRI.

Summary

The capacity of humanity to modify the conditions of life on the planet has increased dramatically in the last century. Thus, two opposing phenomena concur concerning our societies' destructive and constructive potential. On the one hand, humanity faces the challenge of articulating processes to responsibly manage the products resulting from the development of science and innovation and to avoid the social, economic and environmental collapse that can result from them. On the other hand, humanity looks to the sciences and innovative potential to respond to global challenges that require approaches and coordination between different levels of action and from an inter- and transdisciplinary perspective.

In this framework, the term "Responsible Research and Innovation" (RRI) arises intending to integrate ethical aspects and demands for the participation of different actors in research and innovation processes so that the resulting products are aligned with society's expectations. Under the umbrella of the term RRI or Responsible Innovation (RI), a series of theoretical proposals and practical efforts have been articulated to operationalise the need to integrate an ethical perspective and promote the participation of new actors in research and innovation processes to modulate the constructive and destructive potential of the results of science and innovation.

Including the term RRI in the European Commission's research programmes has been decisive in consolidating interest in RRI. The Horizon 2020 programme has boosted its use in Europe, allocating research funds for its operationalisation, promotion, evaluation and monitoring tools.

In this work, we will explore the design processes of RRI monitoring and evaluation tools. To do so, we will propose civic ethics as a theory that fits the philosophical foundation of the RRI concept, we will review how the values and expectations of agents outside the scientific and innovative process have been incorporated into the development of RRI monitoring and evaluation tools, and we will explore how the AHP (Analytic Hierarchy Process) technique can contribute to the development processes of these tools by aligning them with the requirements of civic ethics.

The work stems from the hypothesis that developing methodologies and tools for RRI assessment and monitoring can be considered research and innovation processes. Consequently, this paper will analyse the processes of research and innovation towards RRI assessment and monitoring tools through the lens of RRI. It will primarily focus on exploring the role of actors in such research and innovation processes and on the potential of the AHP technique to facilitate the integration of actors in developing RRI assessment and monitoring tools.

Capítulo 1 . Introducción

> *"From the perspective of 2019, it seems that although the concept of RRI might not survive for long -this we cannot know- the underlying structural challenges it was made to address will not go away any time soon. In other words, the future might be in the past when it comes to the basic ideas of RRI."* (Strand & Spaapen, 2020:42)

> *"To make a decision we need to know the problem, the need and purpose of the decision, the criteria of the decision, their subcriteria, stakeholders and groups affected and the alternative actors to take. We then, try to determine the best alternative , or in the case of resource allocation, we need priorities for the alternatives to allocate their appropriate share of the resources"* (Saaty, 2008:84)

Este capítulo presenta la introducción a la tesis doctoral. En la sección 1.1 se presenta el tema del trabajo, su relevancia y su justificación. En la sección 1.2 introducimos la ética cívica como fundamento teórico de la tesis y el concepto de *Responsible Research and Innovation* como objeto de estudio de la tesis doctoral. La sección 1.3 incluye los objetivos y preguntas de investigación abordadas en este trabajo. A continuación, se incluye en la sección 1.4 en la que se presenta el diseño de la investigación y de la metodología utilizada en la tesis doctoral. Por último, la sección 1.5 presenta la estructura de la tesis doctoral e incluye una guía de lectura de los capítulos.

1.1 Presentación y justificación: evaluación de la aportación de la ciencia, tecnología e innovación a los retos del siglo XXI

La capacidad del ser humano de modificar las condiciones de vida en el planeta se ha incrementado de forma notable desde la última mitad del siglo XX, y con ella, el concepto de responsabilidad ha adquirido una nueva dimensión (Jonas, 1979). Así, dos fenómenos aparentemente opuestos concurren respecto al potencial destructivo y constructivo de nuestras sociedades. Por un lado, la humanidad se enfrenta al reto de articular procesos que permitan gestionar con responsabilidad los productos resultantes del desarrollo de la ciencia e innovación y evitar el colapso social, económico y medioambiental que puede resultar de los mismos. Por otro lado, la humanidad mira a las ciencias y al potencial innovador para responder a los retos globales que requieren abordajes y coordinación entre diferentes niveles de acción y desde una perspectiva inter y transdisciplinar.

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Bajo el paraguas del término RRI o *Responsible Innovation* (RI), se han articulado una serie de propuestas teóricas y esfuerzos empíricos para operacionalizar la necesidad de integrar una perspectiva ética y promover la participación de nuevos actores en los procesos de investigación e innovación. Diferentes autores coinciden en que los estilos de gobernanza propuestos bajo el término RRI en la última década se superponen a otros estilos y narrativas previas, introduciendo nuevas perspectivas y estrategias a las propuestas teóricas y las prácticas promovidas anteriormente (la evolución del término será presentada con detalle en la sección 2.2).

Para la consolidación del interés por el término RRI ha sido determinante la inclusión del mismo en los programas de investigación de la Comisión Europea. El programa Horizonte 2020 impulsó el uso del término en Europa, destinando fondos de investigación para promover su operativización, desarrollo de herramientas para su fomento, así como de herramientas de evaluación y monitorización.

En este trabajo exploraremos los procesos de diseño de herramientas de monitorización y evaluación de la RRI. Para ello, propondremos la ética cívica como teoría que se ajusta a la fundamentación filosófica del concepto RRI, revisaremos cómo se ha incorporado los valores y expectativas de agentes ajenos al proceso científico e innovador en el desarrollo de herramientas de monitorización y evaluación de la RRI y exploraremos cómo la técnica AHP puede contribuir a los procesos de desarrollo de dichas herramientas alineando los mismos a los requerimientos de la ética cívica.

El trabajo parte de la hipótesis de que los procesos de desarrollo de metodologías y herramientas para la evaluación y monitorización de la RRI pueden ser considerados como procesos de investigación e innovación en sí mismos.

En 2014, Ariel Rip afirmó que su enfoque era "considerar la RRI como una innovación social que se va articulando paulatinamente", considerando así que la innovación introducida por el concepto RRI se refería "a los roles de los actores y stakeholders en la investigación y la innovación" (Rip, 2014:2). En la misma línea, este trabajo parte de la siguiente proposición: los procesos de desarrollo de metodologías y herramientas para la evaluación y seguimiento de la RRI pueden ser considerados como procesos de investigación e innovación en sí mismos. En consecuencia, este trabajo analizará los procesos de investigación e innovación hacia herramientas de evaluación y seguimiento de la RRI bajo la óptica propia de la RRI. Se centrará especialmente en explorar el papel de los actores en tales procesos de investigación e innovación.

[1] Las citas originales en inglés presentadas en este documento han sido traducidas al castellano por la autora.

1.2 Introducción a los fundamentos teóricos y objeto de estudio de la tesis

El trabajo se presenta en la modalidad de compendio de artículos, de forma que en cada uno de ellos se profundiza en un aspecto relevante de los fundamentos teóricos. Por este motivo, en esta sección presentamos brevemente los fundamentos teóricos y conceptos clave sobre los que se articula la tesis doctoral y que serán abordados con mayor o menor profundidad en cada uno de los artículos.

1.2.1. Ética cívica

El presente trabajo utiliza la ética cívica como marco normativo adecuado desde una perspectiva filosófica para abordar los procesos de evaluación y monitorización de la RRI. La ética cívica es una aproximación dialógica y procedimental que se basa en la existencia de unos valores mínimos que deben ser respetados en las sociedades plurales. Se nutre de las éticas del diálogo desarrolladas por Apel y Habermas, así como de las modificaciones propuestas por A. Cortina quien defiende la necesidad de integrar la pluralidad de valores de nuestras sociedades en el proceso dialógico. Esta característica de la ética cívica es especialmente relevante para el abordaje de la RRI. Existiendo diferentes aproximaciones epistemológicas sobre la RRI (Timmermans & Blok, 2021), todas las definiciones de RRI tienen en común el considerar como un elemento clave la participación (en mayor o menor grado) de los grupos de interés. Así, la ética cívica, nutriéndose de la ética del discurso, aboga por el diálogo con los grupos de interés como elemento nuclear.

Otro componente relevante de la ética cívica es la consideración de unos mínimos que deben guiar el proceso dialógico. La consideración de estos mínimos se fundamenta en el hecho de que nuestras sociedades son plurales y por tanto necesitamos tener en cuenta la coexistencia de valores y normas diferentes en nuestras sociedades.

La RRI ha sido definida como un proceso que tiene connotaciones políticas (Strand & Spaapen, 2020). Del mismo modo, los procesos evaluativos tienen un componente técnico, pero también político (García Sánchez, 2009). En ellos se toman decisiones que afectan a las personas y esto también va alineado con los procesos con la ética procedimental y con la necesidad de integrar las necesidades y expectativas de diferentes grupos de interés en estos procesos de toma de decisiones.

Sobre estos temas en la sección 2.3 analizamos el concepto de responsabilidad desde la perspectiva de la ética cívica y las implicaciones que tienen la ética cívica para la RRI.

1.2.2. Responsible Research and Innovation

La presente tesis doctoral explora los procesos de desarrollo de herramientas de evaluación y monitorización de "Responsible Research and Innovation". Pero, ¿qué es la ciencia e innovación responsable y en qué se diferencia de otras propuestas teóricas? En la sección 2.2, se desarrolla una revisión del concepto RRI, pero en este punto introduciremos algunas ideas que faciliten la lectura del documento.

El concepto *Responsible Research and Innovation* así como *Responsible Innovatio*n surgen de forma cuasi simultánea a principio de la década pasada. En una revisión sobre las diferentes definiciones y dimensiones conceptuales del término, Burget et al. (2017) clasifican las definiciones en administrativas y académicas. Las definiciones administrativas del término son aquellas propuestas en el marco de administraciones públicas, principalmente, la Comisión Europea. Las definiciones

académicas provienen de investigadores interesados en las relaciones entre ciencia y sociedad. Burget et al. (2017:15) concluyen que "la RRI es esencialmente un intento de gobernar la investigación y la innovación para incluir a todas las partes interesadas y al público en las primeras etapas de investigación y desarrollo. La inclusión de diferentes actores y del público, a su vez, pretende aumentar las posibilidades de anticipar y discernir cómo la investigación y la innovación pueden beneficiar a la sociedad, así como evitar que se produzcan consecuencias negativas."

Así, el objeto de estudio de este trabajo se refiere al cuerpo teórico forjado alrededor de los términos Responsible Research and Innovation y Responsible Innovation. Se trata pues, de unos términos relativamente recientes (Timmermans, 2017), con un gran poder tractor por parte de organismos financiadores en Europa, principalmente la Comisión Europea (Burget et al., 2017; Rip, 2016; Timmermans, 2017) y con un claro carácter normativo cuyo contenido debe ser continuamente cuestionado en el marco de sociedades plurales (Lindner et al., 2016).

Desde el ámbito académico, la RRI se interpreta como una propuesta de gobernanza de la ciencia e innovación que sigue la estela de diferentes narrativas y propuestas previas que se preocupan la integración de aspectos éticos y de responsabilidad para abordar el potencial constructivo y destructivo de la ciencia, que tratan de mejorar la relación de ciencia y sociedad, o que reflexionan sobre el rol de diferentes grupos en la toma de decisiones y la gestión de incertidumbre que envuelve muchos campos de desarrollo de la ciencia y la innovación.

Así desde la integración de aspectos éticos en la ciencia e innovación, Landeweerd et al. (2015) enmarca la RRI como el tercer y más reciente estilo de gobernanza. El primer estilo, basado en la gestión y evaluación de riesgos (*Risk Assessment* en inglés) conllevaría el análisis de qué es aceptable o no y se operacionalizaría a través de normativa y legislación. El segundo estilo supondría la colaboración con expertos en ética aplicada y bioética, así como otros científicos sociales en los procesos de toma de decisiones. En tercer lugar, el estilo basado en "*public participation*", en el que se incardinaría la RRI, propone la participación pública para asegurar una correcta integración de las preocupaciones éticas.

Arnaldi et al. (2016) proponen considerar la RRI como un enfoque de gobernanza emergente en el ámbito europeo. Sus colegas Randles et al. (2016) ofrecen un recorrido por seis narrativas a través de las cuales se han articulado visiones sobre el rol de los actores en la gobernanza de la ciencia respecto a qué es considerado o no responsable. Bajo el nombre de "*Research and innovation with /for society*" (Ciencia e innovación por y para la sociedad) se presenta la más reciente narrativa en la que se enmarca el concepto de RRI. Esta narrativa tiene como argumento central la consideración de que el potencial de la ciencia e innovación tiene tal calado que las decisiones sobre hacia donde deben dirigirse no puede ser dejado sólo en manos de grupos reducidos de personas. La participación de diferentes grupos y públicos se convierte en un requisito de justicia en esta narrativa.

La definición del concepto de RRI está lejos de ser única y hay diferentes aproximaciones que se han evidenciado en diferentes estudios. Lo cierto es que diferentes análisis sobre las aproximaciones teóricas muestran divergencias en aspectos fundamentales a nivel epistémico, ontológico y axiológico (Timmermans & Blok, 2021).

Así pues, a lo largo del trabajo se reconocerá el carácter abierto de la RRI y la necesidad de consensuar su contenido y alcance con los diferentes actores que participen en la definición de su contenido.

1.3 Objetivos y preguntas de investigación

El trabajo responde a los siguientes objetivos y preguntas específicas de investigación.

Tabla 1 *Objetivos y preguntas de investigación*

Objetivos	Preguntas de investigación
1. Definir las implicaciones de la ética cívica como marco normativo para la RRI	1. ¿Cuáles son las implicaciones para la Investigación e Innovación Responsable (RRI) de una concepción dialógica de la responsabilidad? 2. ¿Cuáles son las implicaciones para la RRI de utilizar la ética cívica como marco normativo?
2. Describir en qué medida y cómo se integra o se prevé la participación de actores en las actividades de investigación e innovación para el desarrollo de mecanismos para la monitorización y la evaluación de la RRI.	3. ¿En qué medida la RRI informa el diseño de mecanismos de monitorización y evaluación respecto a la participación de actores? 4. ¿Cómo están previstas e integradas las estrategias de contextualización y participación en el diseño de los mecanismos de monitorización y evaluación de la RRI?
3. Explorar la contribución potencial de la técnica AHP para contextualizar y promover la participación de los actores en el diseño de mecanismos de monitorización y evaluación de la RRI	5. ¿Cómo puede la técnica AHP contribuir a priorizar un conjunto específico de indicadores de RRI en un contexto específico? 6. ¿Cómo puede AHP contribuir a identificar y priorizar temas (ambientales) relevantes a nivel de proyecto y programa para promover la anticipación y la reflexividad? 7. ¿Cómo puede AHP contribuir a identificar nuevos criterios para la monitorización y evaluación de la RRI?

1.4 Diseño de la investigación y metodología

> "*Sometimes action precedes understanding. Sometimes doing things catalyses new ideas. Feedback loops also exist between every stage, which make real innovations more like multiple spirals than straight lines*" (Mulgan, 2006:155)

He querido iniciar este documento con un prefacio que describiese ciertos hitos del desarrollo de la tesis doctoral para evidenciar que el diseño y la ejecución de mi proyecto de investigación, como intuyo que muchos otros, está lleno de elecciones y renuncias, de oportunidades y de casualidades que han configurado el resultado final del proceso investigador. En las siguientes subsecciones presentaremos el diseño metodológico utilizado en la tesis doctoral, pero antes, consideramos relevante reflexionar sobre la posicionalidad de la autora como investigadora y posicionamiento teórico-metodológico que informa la tesis doctoral, así como sus implicaciones en el desarrollo de la estrategia de investigación desarrollada.

Posicionalidad académica y profesional

Consideramos relevante presentar una reflexión sobre la posicionalidad de la autora que permita contextualizar el interés por el desarrollo de esta tesis doctoral y ciertas características de la misma.

El tema de esta tesis doctoral es un punto de intersección entre mi formación académica y mi experiencia profesional. Me licencié en Derecho y posteriormente cursé estudios de organización y dirección de empresas y de sostenibilidad y responsabilidad social corporativa. Durante mi formación académica reflexioné sobre la gestión de organizaciones, la responsabilidad de las mismas en la gestión y mejora de impactos económicos, sociales y medioambientales, los procesos de gestión de necesidades y expectativas de los grupos de interés de las organizaciones y las herramientas de *reporting* y comunicación de impactos, principalmente a través de los informes de sostenibilidad propuestos por el *Global Reporting Initiative*.

En paralelo, tuve diversas experiencias profesionales, pero sin duda la más significativa para contextualizar este trabajo fue mi rol en tareas de apoyo a la investigación y gestión de proyectos transnacionales de I+D. Adquirí experiencia práctica en actividades de investigación y trabajé en el diseño, ejecución, y justificación de proyectos dirigidos a dar respuesta a los retos sociales y medioambientales tanto a nivel local como global. En este rol, participé en proyectos de I+D y licitaciones nacionales e internacionales relacionados con diferentes retos sociales, en muchos casos mediante el uso de las nuevas tecnologías de la información y comunicación. Las propuestas y proyectos en los que participé se desarrollaron en el marco de programas de financiación europeos, especialmente de la Comisión Europea, así como iniciativas y foros multi-stakeholder relacionados con diferentes retos sociales y medioambientales. Este periodo supuso una interacción constante con equipos investigadores, *practicioners*, *policy-makers*, emprendedores y personal técnico de organizaciones europeas de diversa naturaleza. Igualmente, supuso un contacto constante con ciertas políticas de financiación de la ciencia y estructuras de política científica de la Comisión Europea. Durante este periodo inicié colaboraciones con diferentes organismos de financiación y proyectos europeos en los que participé como experta evaluadora.

En el momento en el que iniciaba el diseño del estudio que posteriormente se convertiría en mi tesis doctoral, participé en el programa de prácticas Blue Book de la Comisión Europea. En febrero de 2016 me trasladé a Bruselas para incorporarme durante cinco meses en la Unidad de Materias Primas de la Dirección General de Mercado Interior, Industria, Emprendimiento y Pymes. Este periodo fue especialmente enriquecedor para la comprensión de las dinámicas en las que se desarrollan las políticas científicas de la Comisión Europea.

De este modo, el interés por el tema de la tesis doctoral surge por el interés en combinar los conocimientos académicos sobre la gestión organizacional para la mejora de impactos económicos, sociales y medioambientales mediante la integración de procesos dialógicos con los grupos de interés con la experiencia profesional en la gestión de proyectos de investigación europeos.

Los años en los que he trabajado en el desarrollo de la tesis doctoral, han sido un proceso de aprendizaje sobre la profesión investigadora y, éste ha sido el elemento motivador para enfrentarme al conocimiento de los procesos de investigación y participar en tareas relacionadas con la docencia y la comunicación científica.

Posicionalidad metodológica

Es común en los manuales de metodologías de investigación encontrar referencias sobre la oportunidad y practicidad de reflexionar sobre la filosofía o paradigmas de investigación sobre los que construimos el diseño de una investigación (e.g. Lincoln et al., 2011; Saunders et al., 2007).

El término paradigma fue inicialmente acuñado por Kuhn en 1962 y se ha aplicado de formas diferentes en el ámbito de los estudios de metodología en las ciencias sociales (Morgan, 2007; Timmermans & Blok, 2021). Los marcos de análisis más extendidos en el estudio de los paradigmas de investigación los consideran posturas epistemológicas definidas por su dimensión ontológica, de la que derivan las dimensiones epistemológicas y metodológicas (Morgan, 2007). La ontología se refiere a las asunciones sobre "la forma y naturaleza de la realidad y, por lo tanto, qué es lo que podemos conocer de ella"; la epistemología se refiere a "la naturaleza de la relación entre quien conoce o busca conocer y lo que puede ser conocido", es decir, la relación entre sujeto y objeto de investigación; la metodología se refiere a "cómo puede el investigador (o el que busca conocer) arreglárselas para averiguar si lo que él o ella cree puede ser conocido" (Guba & Lincoln, 2002:120). La literatura sobre los paradigmas como posturas epistemológicas ha ido incorporando diferentes clasificaciones en las últimas décadas, hablándose del paradigmas positivista, post-positivista, la teoría crítica, el constructivismo o el paradigma participativo o cooperativo en el caso de Lincoln et al. (2011) o de humanismo radical, estructuralismo radical, paradigma interpretativo o funcionalista, en el caso de Saunders et al. (2007).

A este respecto, en esta tesis doctoral se parte de una aproximación pragmática respecto a las cuestiones epistemológicas. Para el pragmatismo, el foco no se pone en una postura ontológica de la que derivan de forma escalonada y consecuente una serie de implicaciones epistemológicas y metodológicas (Morgan, 2007). El pragmatismo en una posición que pone el foco "argumenta el que el determinante más importante de la filosofía de la investigación adoptada es la pregunta de investigación: un enfoque [positivismo o interpretativismo] puede ser mejor que el otro para responder a preguntas particulares" (Saunders et al., 2007:110; traducción propia).

La aproximación al pragmatismo en la metodología propuesta por Morgan (2007) inspira el diseño metodológico de esta tesis doctoral por diferentes motivos. En primer lugar, la pregunta de

investigación que articula este trabajo ha inspirado el diseño de la investigación a lo largo de los años, si bien, este diseño ha estado condicionado por las posibilidades temporales y económicas durante el transcurso de la tesis doctoral. Podríamos, así pues, decir, que las decisiones y elecciones que hemos ido tomando a lo largo de los años han estado centradas en cómo responder de forma adecuada a dicha pregunta de investigación.

A lo largo de los años en los que se ha desarrollado este trabajo se han producido cambios en el diseño de la investigación. Las decisiones tomadas a lo largo del proceso se han visto sin lugar a duda condicionados por mi trayectoria personal y profesional y por mis asunciones culturales y axiológicas. La axiología se refiere "a rama de la filosofía que estudia los juicios sobre valores" (Saunders et al., 2007:110). La dimensión personal y axiológica en el diseño de la investigación ha sido, sin lugar a duda, relevante. Por este motivo en la sección anterior incluimos una reflexión sobre la posicionalidad académica y profesional que permite una mejor contextualización del trabajo.

El trabajo presentado se enmarca en las tres principales características propuestas por Morgan (2007) como definitorias de la aproximación pragmática. Por un lado, la relación establecida entre la teoría y los datos de este trabajo transitan entre lo deductivo e inductivo. Esta aproximación se evidencia principalmente en el capítulo 3. Por otro lado, consideramos que la relación entre la investigadora y el proceso de investigación tiene un carácter intersubjetivo. El diseño de la investigación ha sido iterativo durante las diferentes fases del proyecto y se ha ido nutriendo de los resultados producidos durante la investigación y la rica interacción con la comunidad científica con la que se ha ido discutiendo estos resultados. Por último, la aproximación a la tesis doctoral tiene un interés intrínseco en la posibilidad de transferencia de los resultados de la investigación, sobre la que reflexionaremos especialmente en las conclusiones de este trabajo.

Diseño general de la investigación

La tesis doctoral se presenta mediante un compendio de artículos que presentan los resultados de tres procesos de investigación complementarios. La tesis responde a la motivación general de explorar y testear una metodología participativa para involucrar a diferentes grupos de interés en el desarrollo, selección y priorización de criterios e indicadores de *Responsible Research and Innovation* en un contexto específico. La motivación inicial se ha traducido en un diseño de la investigación para responder a la pregunta central de investigación de este trabajo: ¿Cómo puede una metodología para la toma de decisiones basada en la técnica AHP apoyar la participación de las partes interesadas en los procesos de investigación e innovación hacia la monitorización y la evaluación de la RRI?

Así, el trabajo se estructura alrededor tres procesos de investigación que responden a objetivos específicos (ver Tabla 1 en la sección anterior). El primero consiste en una investigación de carácter normativo, el segundo de carácter descriptivo y el tercero y último, de carácter exploratorio. Cada uno de estos procesos de investigación ha llevado aparejadas sus propias preguntas de investigación y diseño metodológico y cuyos resultados se presentan en el compendio de artículos (ver Figura 1).

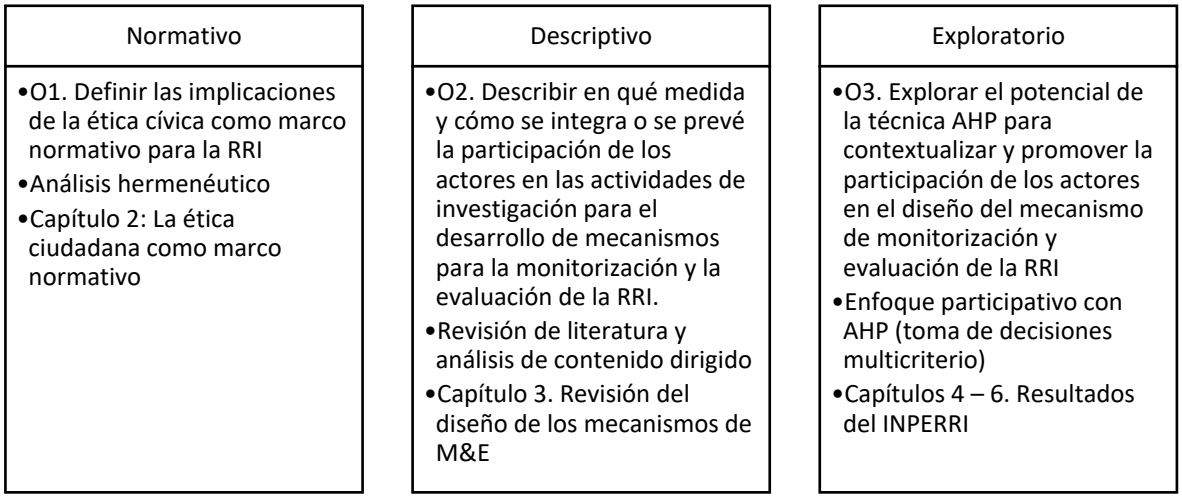

Figura 1 *Tipo de investigación: objetivos, metodología y capítulos*

La estrategia de investigación utilizada ha sido principalmente cualitativa, intercalando el análisis documental (capítulo 2 y 3), revisión sistemática de la literatura (capítulo 3) con el estudio de caso sobre la aplicación de la técnica AHP (capítulos 4 a 6). En cada uno de los artículos que conforman el compendio se describe el uso de los distintos métodos, recogida de datos y análisis de los mismos.

En esta sección queremos presentar con mayor detalle algunos elementos del diseño metodológico de los capítulos 3 a 6. Concretamente, respecto al capítulo 3 presentamos una descripción completa de la metodología utilizada que tuvo que ser reducida para su publicación por limitación de caracteres. Respecto a los capítulos 4 a 6, presentaremos una síntesis de la evolución del diseño metodológico a lo largo del desarrollo de la tesis doctoral.

1.4.1 Revisión sistemática de la literatura y análisis de contenido dirigido (Capítulo 3)

En el capítulo 3 se presenta una revisión sistemática de literatura para identificar artículos e informes sobre el desarrollo de mecanismos de monitorización y evaluación de la RRI. En el análisis del texto de esta revisión se aplicó el método de análisis de contenido dirigido. Como se describe por Tranfield et al. (2003), el proceso de revisión sistemática proporciona rigor metodológico y una base de conocimiento confiable de una variedad de estudios y, a través de una revisión de la literatura, los investigadores pueden "mapear y evaluar el territorio intelectual existente" (Tranfield et al., 2003:208). El análisis de contenido dirigido es un método de investigación deductivo para analizar datos de texto en el que "existe una teoría o una investigación previa sobre un fenómeno que está incompleta o podría beneficiarse de una descripción más detallada" (Hsieh & Shannon, 2005:1281).

Consideramos que la revisión sistemática y el método de análisis de contenido dirigido eran adecuados para responder a la pregunta de investigación formulada en este capítulo. Posteriormente, se adaptaron los procesos descritos por Tranfield et al. (2003) para realizar una revisión sistemática así como los pasos propuestos por Kaid (1989) para el análisis de contenido dirigido tal y como se describe a continuación.

En primer lugar, llevamos a cabo una serie de tareas de planificación para diseñar nuestro estudio. A través de un proceso iterativo, los autores discutimos la necesidad del estudio, los enfoques teóricos y la delimitación de la revisión de la literatura. Este proceso fue crucial para formular nuestro modelo de estructuración conceptual presentado en el capítulo 3.

En esta etapa, comenzamos las tareas para realizar la selección de datos. Habiendo identificado los primeros intentos de diseño del tipo de herramientas a analizar en el año 2014, nuestro objetivo fue identificar todo el universo de publicaciones científicas existente para analizar el grado de contextualización y participación realizado hasta el momento. Para localizar los estudios relevantes diseñamos un protocolo de revisión (Ver Anexo B) que combinaba una estrategia de búsqueda en bases de datos, una estrategia de bola de nieve de referencia y seguimiento de citas y una estrategia de búsqueda en el *Journal of Responsible Innovation*, revista científica dedicada a la RRI.

Obtuvimos nuestro conjunto inicial de datos de citas de búsquedas en ISI Web of Science (WoS) y Scopus. Elegimos estas dos bases de datos electrónicas para identificar la literatura revisada por pares. La búsqueda, realizada el 10 de junio de 2020, empleó la siguiente combinación de palabras clave: "responsible innovation" OR "responsible research" OR "responsible research and innovation" AND "account*" OR "assess*" OR "evaluat*" OR "indicator*" OR "monitor*". En nuestra búsqueda solo se seleccionaron documentos publicados a partir de 2003, lo que permitió identificar cualquier artículo publicado desde la aparición temprana del concepto hasta la atención exponencial en la última década en línea con estudios previos y revisiones de literatura sobre RRI (Thapa et al., 2019; Timmermans, 2017). Se realizó una búsqueda manual para identificar artículos relevantes del *Journal of Responsible Innovation* y capítulos de libros de un libro relevante publicado en 2021. Los cuatro conjuntos de datos resultantes, incluidos el título y el resumen de cada publicación, se fusionaron, lo que arrojó 948 resultados. Los duplicados y ciertos tipos de documentos (libros y reseñas de conferencias, documentos de conferencias, materiales editoriales o resúmenes de reuniones) se eliminaron de la lista integrada. Con el conjunto de datos resultante de 443 artículos, realizamos una revisión por etapas. En primer lugar, se leyeron los títulos y los resúmenes. Diecisiete artículos fueron descartados por su tipología documental y 367 documentos fueron descartados por no cumplir con los criterios de inclusión: artículos que propongan un mecanismo de M&E de la RRI de cualquier tipo, propósito y nivel de agregación.

Después de la lectura del texto completo, el conjunto de datos resultante de 59 artículos se redujo a veintiséis. Doce artículos fueron descartados por no abordar el tema de la investigación y diecisiete más por no desarrollar mecanismos de M&E de la RRI. Se descartaron cuatro documentos más, tres de ellos por presentar información duplicada de otros documentos, en estos casos los criterios utilizados para seleccionar el documento a permanecer en la revisión de literatura priorizaron las revistas de artículos y los documentos con información más detallada sobre la investigación. Un documento fue descartado por no brindar información suficiente para realizar el análisis. Durante la lectura del texto completo, llevamos a cabo un proceso de bola de nieve para identificar fuentes altamente relevantes, incluidos informes financiados por la UE, para incluirlos en el conjunto de datos. La muestra final incluyó treintaisiete artículos, capítulos de libros y reportajes. La muestra final incluyó algunos documentos que hacían referencia al mismo mecanismo, por lo que creamos grupos para analizar los veinticinco mecanismos identificados en la búsqueda bibliográfica.

Una vez seleccionados los documentos para la revisión bibliográfica, definimos la estrategia de análisis de contenido. Como durante las fases iniciales de nuestro estudio construimos el marco analítico basado en la teoría y la investigación previa, optamos por desarrollar un análisis de contenido dirigido ya que su principal fortaleza es que "la teoría existente puede ser apoyada y extendida" (Hsieh & Shannon, 2005:1283). Nuestra estrategia de codificación incluyó estos pasos:

- Primero, leímos los artículos y resaltamos todo el texto que parecía ser relevante para cualquier elemento de nuestro modelo analítico.

- Luego, codificamos todas las citas destacadas utilizando los códigos deductivos. Creamos un libro de códigos (ver Anexo C) que incluye todos los elementos de nuestro marco analítico, con definiciones operativas y subcategorías, provenientes de la teoría relevante.
- Cuando nuestros códigos deductivos no eran adecuados para aprehender la información de la cita, creamos un código inductivo y lo incluimos en el libro de códigos.
- Después de codificar todos los datos, revisamos los códigos inductivos y discutimos si deberían ser una nueva categoría o subcategoría en nuestro marco analítico.

Los resultados de este proceso se incluyeron en el libro de códigos. Esta estrategia se considera la más adecuada "Si el objetivo de la investigación es identificar y categorizar todas las instancias de un fenómeno particular […]" (Hsieh & Shannon, 2005:1281), en nuestro caso, una comprensión profunda de cómo la contextualización y la participación fueron previstas e integradas en los procesos de desarrollo de mecanismos de M&E en nuestro caso.

1.4.2 Técnicas participativas y de toma de decisiones multicriterio mediante la técnica AHP (Capítulos 4 a 6)

El proceso de investigación exploratorio diseñado para responder al objetivo 3 "Explorar el potencial de la técnica AHP para contextualizar y promover la participación de los actores en el diseño del mecanismo de monitorización y evaluación de la RRI" se ha desarrollado especialmente en el marco del proyecto INPERRI. En esta tesis doctoral se incluyen tres estudios exploratorios sobre el uso de técnicas participativas y de toma de decisiones multicriterio mediante la técnica AHP para la priorización de instrumentos de monitorización y evaluación de la RRI.

La técnica AHP (*Analytic Hierarchy Process*) es una técnica de decisión multicriterio (MCDM, por sus siglas en inglés) que permite tomar decisiones sobre problemas complejos en los que existen múltiples factores y sub-factores de influencia (Saaty, 2008). En la aplicación práctica de la técnica AHP los factores de influencia han recibido diferentes denominaciones (Russo & Camanho, 2015) y en este documento hablaremos de criterios y, específicamente en el capítulo 5, de elementos. La técnica requiere el desarrollo de una serie de pasos que permitan la construcción de un modelo jerárquico para la asignación pesos de importancia de los diferentes criterios a utilizar en la toma de una decisión y posteriormente, evaluar el grado de contribución de alternativas al objetivo fijado (ver Tabla 2). En este caso, la técnica fue aplicada a la priorización de los criterios, sin utilizarse posteriormente para la toma de decisiones sobre alternativas. El uso de la técnica AHP con el objetivo de identificar y evaluar indicadores ha sido utilizada previamente (Russo & Camanho, 2015). De este modo, mediante el uso del AHP, exploramos la capacidad de la técnica para identificar listados priorizados de indicadores o elementos a considerar para la monitorización y evaluación de la RRI aplicada a diferentes casos mediante la definición de una jerarquía de toma de decisión y priorización por un grupo de expertos o grupos de interés, a los que denominamos participantes.

Tabla 2 *Pasos para la generación de prioridades (criterios) en AHP*

#	Pasos
1	Definición del problema y del conocimiento esperado.
2	Estructurar la jerarquía para la toma de decisión incluyendo el objetivo en la parte superior y los objetivos desde niveles intermedios (criterios) hasta los inferiores (generalmente alternativas)-
3	Construir matrices de comparaciones por parejas. Los elementos del nivel superior se utilizan para comparar los elementos del nivel inmediatamente inferior con respecto a este.
4	Utilizar las prioridades obtenidas de la comparación para asignar pesos a las prioridades en el nivel inmediatamente inferior, haciéndose así para cada elemento. Entonces, para cada elemento en el nviel inferior se le asignan los pesos y se obtiene la pririodad global.

Nota: Elaboración propia a partir de Saaty (2008)

La metodología aplicada en este proceso de investigación consta de tres fases cuyo contenido ha ido variando y enriqueciéndose a lo largo del proceso de desarrollo de la tesis doctoral (ver Tabla 3). La fase preparatoria consiste en una serie de actividades necesarias para poder diseñar y ejecutar las siguientes fases y requiere la participación de los investigadores (doctoranda y coautores) en tareas de preparación de materiales y selección de participantes. La fase de construcción del modelo consiste en la organización de una sesión presencial donde se presenta a los participantes el objetivo que motiva una toma de decisión. Los participantes consensuan un modelo jerárquico de criterios para la toma de decisiones que posteriormente priorizarán. El modelo es el resultado necesario para poder iniciar la tercera fase de priorización. En esta fase los participantes aportan su conocimiento experto sobre la importancia que tienen los diferentes componentes del modelo jerárquico para la toma de decisión. Durante la tercera fase los facilitadores tienen un papel clave analizando y tratando las posibles inconsistencias y retroalimentando a los participantes con los resultados del proceso. Así, con el análisis de la priorización de los expertos se analizan los resultados y se comparten con los mismos para recibir retroalimentación y confirmar si están de acuerdo con los resultados obtenidos.

Tabla 3 *Metodología y de toma de decisiones: fases y actividades*

Fase	Actividades
Preparatoria	1.1. Revisión de literatura e indicadores
	1.2. Selección e invitación de participantes
	1.3. Envío de material de lectura previa para los participantes
Construcción	2.1 Presentación de objetivos y definiciones clave
del modelo	2.2 Reflexión sobre las críticas y precauciones en el uso de indicadores
	2.3 Discusión y construcción conjunta del modelo jerárquico para la toma de decisiones
	2.4 Informe con el modelo final para confirmación con los participantes
Priorización	3.1 Priorización individual de los indicadores
	3.2 Análisis de los datos
	3.3 Revisión de inconsistencias
	3.4 Informe final con los resultados para confirmación por los participantes

En los siguientes epígrafes, se detalla el contenido de las diferentes fases y los métodos utilizados en las mismas presentando con detalle aquellas actividades que fueron evolucionando y enriqueciéndose

a lo largo del proyecto. La Tabla 4 presenta las particularidades en la aplicación de la metodología participativa y de toma de decisiones mediante la técnica AHP en los capítulos 4 a 6.

Tabla 4 *Resumen de la aplicación de la metodología en los capítulos 4 a 6*

Fase	Actividades	Capítulo 4	Capítulo 5	Capítulo 6
Preparatoria	1.1 Revisión de literatura e indicadores	X	X	X
	1.2 Selección e invitación de participantes	X	X	X
	1.3 Envío de material de lectura previa para los participantes			X
Construcción del modelo	2.1 Presentación de definiciones clave		X	X
	2.2 Reflexión sobre las críticas y precauciones en el uso de indicadores			X
	2.3 Discusión y construcción conjunta del modelo jerárquico para la toma de decisiones		X	X
	2.4 Informe con el modelo final para confirmación con los participantes			X
Priorización	3.1 Priorización individual de los indicadores	X	X	X
	3.2 Análisis de los datos	X	X	X
	3.3 Revisión de inconsistencias	X	X	Incluye informe individual
	3.4 Informe final con los resultados para confirmación por los participantes		X	X

Fase preparatoria

Tal y como hemos introducido, en la fase preparatoria se desarrollaron una serie de acciones tendentes a poder diseñar y ejecutar las siguientes fases. En estas actividades participaron principalmente los investigadores (doctoranda y coautores) y consistieron en las tareas que se describen a continuación.

La revisión de literatura e indicadores previos existentes fue la primera actividad planificada y consistió en identificar sets de indicadores y dimensiones del fenómeno a estudiar. Estos sets serían un punto de partida para la construcción de un modelo para la toma de decisiones en la fase siguiente.

Cada uno de los tres casos en los que se aplicó la técnica AHP requirió el manejo de literatura diferente para dar respuesta a las diferentes preguntas de investigación que se planteaban. La descripción detallada de la literatura revisada se presenta en las secciones correspondientes de los capítulos 3, 4 y 5. A continuación, detallamos las particularidades de cada proceso que consideramos relevante explicar en esta sección.

El proceso de investigación desarrollado en el capítulo 4 pretendía explorar la posibilidad de utilizar la técnica AHP para priorizar indicadores de RRI en un contexto específico. El diseño de la investigación comenzó en octubre de 2015, momento en el que existía escasa literatura sobre la monitorización y evaluación de la RRI. Unos meses antes, en junio de 2015 se publicó el texto de referencia en este ámbito "*Report from the Expert Group launched by the European Commission on Policy Indicators for Responsible Research and Innovation*" [Informe del Grupo de Expertos promovido por la Comisión Europea sobre Indicadores de Política para la Investigación e Innovación Responsable] (Strand et al., 2015). Este informe se presentaba 82 indicadores para las seis áreas de la RRI tal y como habían sido

formuladas por la Comisión Europea (2012): gobernanza, public engagement, igualdad de género, educación para la ciencia, ciencia abierta/acceso abierto y ética. Igualmente, los autores proponían incluir nuevos indicadores en dos nuevas áreas: sostenibilidad medioambiental y justicia social, para los cuales no propusieron indicadores concretos. Además, el informe incidía en que "Los actores nacionales y regionales, las universidades y los institutos de investigación, las organizaciones de la sociedad civil, las agencias de financiación y otros [actores] deben diseñar su propio proceso de deliberación para elegir y adaptar los indicadores propuestos en el Capítulo 2, y agregar sus propios indicadores de acuerdo con sus propias necesidades, objetivos y preocupaciones" (Strand et al., 2015:7). Concretamente, la motivación para plantear la pregunta de investigación del capítulo 4 surgía de esta recomendación. Durante el proceso de revisión de la literatura se identificó que existía una licitación por parte de la Comisión Europea que resultaría en un nuevo set de indicadores, el proyecto MORRI, pero cuyos resultados definitivos no estaban disponibles en aquel momento. De este modo, se optó por seleccionar el listado de indicadores de Strand et al. (2015) tal y como estaban presentados en el informe para el desarrollo de la investigación presentada en el capítulo 4.

Respecto al capítulo 5, el proceso de investigación pretendía explorar la dimensión de sostenibilidad medioambiental propuesta pero no desarrollada por Strand et al. (2015). En este caso, el uso de la técnica AHP se utilizaría para explorar cómo se podían priorizar los aspectos medioambientales a tener en cuenta para poder anticipar posibles impactos ambientales de proyectos que no tuviesen por objeto de investigación aspectos medioambientales. Concretamente se utilizó el caso de las Tecnologías de la Información y Comunicación para el Envejecimiento Activo y Saludable (*ICT for AHA*, por sus siglas en inglés) que estaban recibiendo creciente atención en el Séptimo Programa Marco y Horizonte 2020 de la Comisión Europea. En este caso, dado que no existían sets de indicadores de sostenibilidad ambiental desde una perspectiva de RRI, la revisión de la literatura consistió en identificar posibles marcos que permitiesen arrancar una discusión de partida para la construcción de un modelo propio. Como resultado de la revisión de la literatura se optó por utilizar el esquema de impactos medioambientales propuestos por el estándar GRI (Global Reporting Initiative, 2016).

Finalmente, respecto al capítulo 6, la revisión de la literatura respondía a dos objetivos. En primer lugar y como ocurrió para los capítulos 4 y 5, los autores analizaron el contenido de informes disponibles sobre indicadores de ética desde una perspectiva de la RRI para poder diseñar la estructura de la fase participativa. Por otro lado, los autores identificaron literatura relevante para ser compartida entre los expertos para adquirir una base de conocimiento adecuada para participar en la discusión durante la construcción del modelo participativo. La inclusión de lecturas previas por parte de los participantes en la construcción del modelo fue una mejora en la metodología que se llevó a cabo tras la ejecución de diferentes procesos similares durante la ejecución del proyecto INPERRI. Dado que este proceso de investigación se produjo en el año 2019, ya existía una mayor disponibilidad de recursos y los resultados del proyecto MORRI estaban disponibles. Así, los documentos revisados incluyeron ya algunos informes relevantes sobre indicadores de ética en RRI del proyecto MORRI.

La estrategia consistente en seleccionar los factores de influencia de la estructura jerárquica directamente de la literatura (capítulo 4) o mediante la discusión de aquellos considerados relevantes por los participantes en la fase de creación de la estructura jerárquica (capítulo 5 y 6) han sido utilizados en igual medida en estudios previos (Russo & Camanho, 2015).

La siguiente actividad fue la selección de los participantes, que se llevó a cabo considerando las recomendaciones para la aplicación de la técnica AHP ajustadas a los objetivos y contenido de cada uno de los tres casos. Los criterios comunes a los tres estudios aplicado en la selección de los participantes fueron: (i) que contases con la experiencia académica o profesional necesaria para

participar en los estudios, y (ii) que tuviesen conocimiento o experiencia profesional en el ámbito de la investigación o innovación en España.

En el estudio exploratorio del capítulo 4 se seleccionaron a doce expertos, cada uno de los cuales participó en la priorización de los indicadores de una de las seis dimensiones de RRI. Así, se seleccionaron dos expertos para cada una de las siguientes áreas: *public engagement,* igualdad de género, educación para la ciencia, acceso abierto, ética y gobernanza.

El estudio presentado en el capítulo 5 incluyó un grupo de cinco expertos que participaron en la construcción del modelo y la priorización de elementos. Todos ellos contaban experiencia en el desarrollo y gestión de proyectos de investigación o innovación, así como con conocimientos sobre sostenibilidad, evaluación ambiental o educación medioambiental.

Finalmente, en el estudio incluido en el capítulo 6, se seleccionaron once expertos (inicialmente fueron 12 pero uno de ellos excusó su ausencia en el último momento) que participaron en la construcción del modelo y priorización de indicadores. Los participantes cubrían cinco categorías: experiencia o conocimientos en ética aplicada, en RRI, en investigación e innovación en diferentes áreas de conocimiento, en participación en comités de ética en instituciones académicas o en política de ciencia e innovación en administraciones públicas.

La invitación de los participantes se realizó mediante correo electrónico y llamadas telefónicas, en el caso de que algún participante rechazase la invitación, se revisó el listado de posibles participantes para asegurar que el grupo final de participantes cubría con representación de todas las categorías establecidas en la metodología de los respectivos estudios.

El envío de material de lectura previa para los participantes fue una actividad que se realizó únicamente en el estudio presentado en el capítulo 6 y fue fruto del aprendizaje desarrollado durante la ejecución del proyecto INPERRI. El contenido de las lecturas a enviar fue un resultado de la revisión de la literatura al inicio de la fase preparatoria.

Fase de construcción de un modelo para la toma de decisiones

La construcción del modelo jerárquico o *problem modelling* en AHP requiere la participación dos grupos de personas con los roles de (i) facilitador y (ii) personas que participan en la toma de decisiones. La construcción del modelo consiste en estructura el problema sobre el que hay que tomar una decisión alrededor de tres partes: un objetivo, una serie de criterios y subcriterios y las posibles alternativas.

La fase de construcción del modelo se produjo en las investigaciones de los capítulos 5 y 6. La construcción del modelo se realizó en sendas sesiones presenciales. Durante estas sesiones se presenta a los participantes el objetivo que motiva una toma de decisión y los participantes consensuan un modelo jerárquico de criterios para la toma de decisiones que posteriormente priorizarán. La priorización se realizará utilizando la técnica de decisión multicriterio AHP (*Analytical Hierarchy Process*) (Saaty, 1980) que requiere de la construcción de una jerarquía compuesta por un objetivo a cumplir y una serie de niveles de criterios para la consecución del objetivo. La técnica se utiliza tradicionalmente para la toma de decisiones entre distintas alternativas de acción tras la priorización de los criterios para el logro del objetivo. En este caso, la técnica fue aplicada a la priorización de los criterios, sin utilizarse posteriormente para la toma de decisiones sobre alternativas.

Las sesiones presenciales para la construcción del modelo jerárquico se iniciaron con la presentación del proyecto INPERRI y los objetivos de la sesión y definiciones clave a tener en cuenta. En la sesión referida en el capítulo 6, se introdujo una reflexión sobre las críticas y precauciones al uso de indicadores que considerábamos relevante aportar a la reflexión. Se programaron entonces una serie de actividades de reflexión y discusión entre los participantes. En ambos casos la sesión presencial finalizó con una actividad para consensuar el modelo jerárquico construido conjuntamente para la toma de decisiones.

Tras la reunión presencial, los investigadores a cargo de la sesión, redactaron las conclusiones de las mismas, así como notas aclaratorias. En el estudio definido en el capítulo 5, estas notas fueron incluidas en el cuestionario de priorización mientras que en el estudio del capítulo 6 se enviaron previamente a los participantes para que confirmasen su conformidad o hiciesen los apuntes que considerasen oportunos.

Fase de priorización

La priorización de los indicadores (capítulo 4 y 6) y elementos de la estructura jerárquica propuesta en cada estudio se realizó mediante la aplicación de la técnica AHP. Como hemos indicado, AHP requiere la construcción de un modelo para la toma de decisiones basado en una estructura jerárquica que incluya el objetivo de la toma de decisión y los criterios y subcriterios para la misma. Una vez construida la jerarquía, los participantes individualmente llevan a cabo la comparación por parejas de criterios o *pairwise comparisons*. En los diferentes niveles o nodos jerárquicos se realizan comparaciones por pares para determinar la importancia de un criterio sobre otro. La técnica usa una escala de juicio o *judgement scale* de 1 a 9 para valorar los pesos de cada elemento, en la que 1 significa que los elementos son igualmente importantes y 9 que uno de ellos es extremadamente más importante. La escala de juicio puede ser presentada a los participantes de forma cualitativa o cuantitativa, esto es, mediante escalas numéricas, verbales o gráficas (Ishizaka & Labib, 2009). En nuestra investigación las comparaciones por parejas se presentaron utilizando la escala fundamental de 1 a 9 de Saaty (2008). En esta escala se utiliza el valor 1 para la comparación de un elemento frente a sí mismo y se vinculan los valores enteros 3, 5, 7 y 9 a los juicios verbales “moderadamente dominante”, “fuertemente dominante”, “muy fuertemente dominante” y “extremadamente dominante” (Saaty & Ozdemir, 2003:239). Además, se utilizaron los colores azul y rojo para diferenciar los elementos a comparar. Así, se solicitó a los participantes que comparasen los elementos por parejas (de dos en dos) respecto a la importancia que tiene uno frente a otro. En la Figura 2, se incluye un extracto del cuestionario utilizado en el capítulo 6 en el que se detalla cómo debe realizarse la comparación.

Para llevar a cabo el proceso, a los participantes en los tres procesos investigativos se les envió por correo electrónico un cuestionario. En el caso del capítulo 4 en el que no se realizó una sesión presencial de construcción del modelo, los cuestionarios fueron realizados mediante una entrevista personal presencial o por video conferencia). El cuestionario incluía una descripción sobre el uso de la técnica. En el cuestionario se incorporaron también notas aclaratorias sobre los elementos a comparar, así como información adicional elaborada tras la sesión presencial. Durante el proceso de relleno de los cuestionarios no surgieron dudas significativas por parte de los participantes.

Una vez recibidos los cuestionarios se procedió al análisis de los resultados de la priorización de cada uno de los participantes mediante el uso de software Superdecisions©.

Las comparaciones por pares permiten la obtención de matrices a partir de las cuales se obtienen escalas en base a vectores de peso, es decir, el peso obtenido por cada uno de los elementos comparados que permiten la priorización de los mismos.

Los elementos han de ir comparándose dos a dos preguntándose cómo de importante es el indicador I_A frente al indicador I_B, utilizando la siguiente escala, donde R_{AB} es la respuesta dada por Ud. a la pregunta.

	EX	MF	F	MO	=	MO	F	MF	EX	
Indicador I_A	9	7	5	3	1	3	5	7	9	**Indicador I_B**

- R_{AB} = 1: se considera **igualmente importante** el indicador A que el indicador B (**=**)
- R_{AB}= 3: se considera **moderadamente más importante** el indicador A que el indicador B (**MO**)
- R_{AB} = 5: se considera **bastante más importante** el indicador A que el indicador B (**F. Fuerte**)
- R_{AB} = 7: se considera **mucho más importante** (o demostrablemente más importante) el indicador A que el indicador B (**MF. Muy Fuerte**)
- R_{AB} = 9: se considera **absolutamente más importante** el criterio A que el criterio B (**EX. Extremo**)

Si por ejemplo se le pregunta:

Desde su punto de vista, qué GRUPO DE INDICADORES es más importante y en qué grado para **MONITORIZAR Y VALORAR LA RELEVANCIA SOCIAL Y ACEPTABILIDAD ÉTICA DE LOS RESULTADOS DE LA CIENCIA E INNOVACIÓN** en España

Y Ud. responde:

	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	~~3~~	1	3	5	7	9	**Participación de grupos de interés**

Para Ud. esto significa que el grupo de indicadores sobre la colaboración entre áreas de conocimiento es moderadamente más importante que el grupo de indicadores sobre la participación de grupos de interés.

En el caso de que un elemento o indicador presente subindicadores se le preguntará asimismo sobre la importancia de dichos SUB-INDICADORES en relación con el indicador al cual estén ligados.

Figura 2 *Extracto de cuestionario explicando las comparaciones mediante AHP*

Una vez introducidos los datos y obtenidas las matrices, se analizaron los niveles de inconsistencia de las respuestas. El uso de la técnica AHP requiere que las comparaciones "caigan en un rango admisible

de consistencia" (Saaty, 1994:19). Siguiendo a Saaty, "la inconsistencia es inherente al proceso de juicio" (Saaty, 1994:27). En la aplicación de AHP se consideran niveles tolerables de inconsistencia aquellos inferiores al 10% o al 0,1% (Ishizaka & Labib, 2009; Saaty & Ozdemir, 2003) y deben ir aparejados a un límite máximo de comparación de elementos igual a 7 (Saaty & Ozdemir, 2003). Las inconsistencias altas pueden producirse bien por un error en las comparaciones o por la existencia de incompatibilidades entre los juicios. Cuando se produce un nivel de inconsistencia superior al tolerable se propone resolver la inconsistencia identificando el juicio con mayor inconsistencia de la matriz, determinando el rango de valores que permitiría la eliminación de la inconsistencia y preguntando al participante si quiere modificar su juicio a uno incluido en el rango, repitiendo la misma operación sucesivamente con el siguiente juicio con mayor inconsistencia hasta que o bien se resuelva, o bien se deba posponer la decisión (Saaty & Ozdemir, 2003).

El estudio del capítulo 4 incluía los listados de indicadores propuestos por Strand et al. (2015) que incluían en ciertas áreas elementos a comparar superiores a 20. Por tanto, en algunos casos se observaron inconsistencias superiores al límite de 0.10 establecido para las comparaciones AHP. En este caso se descartó la revisión de las inconsistencias dado que el nivel de perturbación (el cambio numérico necesario para eliminar la inconsistencia) sería tan bajo debido al alto número de elementos a comparar que comprendería un nivel muy alto de dificultad tanto para eliminar la inconsistencia como para mejorar la validez del resultado (Saaty & Ozdemir, 2003).

En los estudios de los capítulos 5 y 6 la construcción del modelo jerárquico se realizó por parte de los participantes en una reunión presencial y se estableció la necesidad de limitar los elementos a comparar a 7 (Saaty & Ozdemir, 2003) y crear clústeres con subcriterios en los casos en que fuese necesario. Este aspecto es relevante tanto respecto al análisis de consistencia como para asegurar que la estructura es adecuada para evitar concentraciones de elementos que pudiesen afectar a la asignación de pesos por parte de los participantes (Ishizaka & Labib, 2009).

En la revisión de inconsistencias en los capítulos 5 y 6 se identificaron aquellos que tenían inconsistencias superiores al 10%. Se definió un proceso para la revisión de inconsistencias con los participantes siguiendo los pasos propuestos por Saaty & Ozdemir (2003). En el caso del capítulo 5, se contactó con los participantes que habían presentado respuestas inconsistentes, se explicó cómo operaba el concepto de inconsistencia en la técnica y se revisaron las respuestas. En el capítulo 6 se quiso enriquecer el proceso de retroalimentación sobre las inconsistencias y se prepararon informes detalladas para cada participante tal y como se describe en el capítulo 6.

Una vez revisadas las inconsistencias, se calcularon los resultados grupales. La obtención de los resultados globales puede realizarse de dos maneras: mediante la agregación de prioridades individuales (AIP) o mediante la agregación de los juicios individuales (AIJ) generando una matriz grupal (Saaty, 2008). En ambos casos, la agregación requiere el uso de la media geométrica para mantener las propiedades matemáticas de la matriz. La agregación de juicios conlleva un mayor grado de identidad grupal en la priorización final dado que la identidad individual se pierde con la agregación de los juicios (Russo & Camanho, 2015). En cambio, la agregación de prioridades se utiliza cuando las personas que toman las decisiones son expertos y no desean combinar sus juicios sino únicamente los resultados finales de su priorización (Saaty, 2008). Ambos métodos han sido utilizados en las aplicaciones prácticas de la técnica, si bien es más frecuente la agregación de juicios individuales (Russo & Camanho, 2015). En nuestro caso, utilizamos la agregación de prioridades individuales (AIP) mediante media geométrica en el capítulo 4 mientras que en los capítulos 5 y 6 utilizamos la agregación de juicios individuales creando nuevas matrices grupales a partir de la media geométrica de los juicios individuales. Esta decisión se tomó en base a dos elementos. Por un lado, los

participantes en el capítulo 4 no construyeron por si mismos la estructura jerárquica a priorizar mientras que sí lo hicieron los participantes del capítulo 5 y 6. Así, consideramos que el trabajo desarrollado en los capítulos 5 y 6 tenía un componente grupal fuerte que debía ser considerado en la agregación de resultados. Por otro lado, los participantes del capítulo 4 lo hicieron en calidad de expertos de su área de conocimiento específica y cada uno de ellos completó únicamente el cuestionario sobre el área de conocimiento de la que eran expertos. En el extremo contrario, en el capítulo 6 se trabajó con una combinación de expertos en el área de ética y de personas pertenecientes a grupos de interés (stakeholders en la terminología utilizada en el capítulo) con el propósito específico de combinar ambas visiones.

Tras la obtención del resultado grupal, los participantes de los capítulos 5 y 6 recibieron un informe detallado con los resultados de su priorización individual y los resultados de la agregación de los juicios del grupo.

El diseño de la metodología aplicada durante los tres estudios, se fue enriqueciendo con mejoras metodológicas e incluyendo mayores niveles de retroalimentación de los participantes. Por este motivo, los capítulos 4, 5 y 6 se presentan en orden cronológico tal y como se fueron ejecutando para que se pueda observar la evolución del uso de la técnica a lo largo del proceso.

1.5 Guía de lectura de los capítulos

En esta sección se presenta una guía para la lectura de la tesis doctoral que introduce los diferentes capítulos que la componen y su relación con los objetivos y preguntas de investigación. El documento está estructurado en un primer capítulo introductorio, un segundo capítulo teórico, un tercer capítulo descriptivo consistente en una revisión sistemática de la literatura, tres capítulos exploratorios en los que se presentan tres casos de aplicación de la técnica AHP y el séptimo y último capítulo en el que se presentan las conclusiones del trabajo. Al final de esta sección se presenta una figura resumen en la que se visualiza la relación de los capítulos con los objetivos y preguntas de investigación (ver Figura 3).

Capítulo 1. Introducción.

El primer capítulo de la tesis doctoral consiste en una introducción general. En ella se aborda una introducción al tema de estudio y apuntes teóricos, definiciones clave y apuntes metodológicos necesarios para la lectura de la tesis en su conjunto. Se utiliza la introducción general para exponer aspectos que, debido a los límites de extensión en las revistas científicas, no pudieron detallarse en más profundidad en los siguientes capítulos. Igualmente, se pone en relación conceptos y aproximaciones metodológicas de los diferentes capítulos y se presenta el proceso que ha llevado a la toma de decisiones a lo largo del diseño y ejecución de la tesis doctoral.

Capítulo 2. Civic ethics as normative framework for Responsible Research and Innovation.

Autores: José Félix Lozano e Irene Monsonís Payá.

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El segundo capítulo presenta un estudio sobre la consideración de la ética cívica propuesta por Adela Cortina como fundamento teórico para la RRI. En este artículo se presenta la evolución del término RRI, la concepción dialógica del concepto de responsabilidad, así como las implicaciones de considerar la ética cívica como marco normativo para la RRI. En él se exploran la fundamentación ética para superar el utilitarismo y deontologismo como teorías filosóficas en las que sustentar el concepto de RRI y se aboga por considerar las éticas del discurso incorporando los valores de la ética cívica para fundamentar la participación de actores en los procesos de RRI.

Capítulo 3. Participation in monitoring and evaluation of RRI: a review of research approaches towards the development of monitoring and evaluation mechanisms.

Autores: Irene Monsonís Payá, Edurne A. Iñigo y Vincent Blok

Actualmente el contenido de este capítulo está en proceso de revisión en el *Journal of Responsible Innovation*

El tercer capítulo presenta un estudio descriptivo en el que se revisa cómo se ha integrado o previsto la participación de actores en los procesos para el diseño de mecanismos de evaluación y monitorización de la RRI. Este artículo presenta una revisión sistemática mediante la cual se han

identificado 25 procesos cuyo objetivo incluía el desarrollo de mecanismos con un propósito de evaluación o monitorización en RRI. El artículo explora los momentos en los que la participación ocurre, los argumentos esgrimidos para incorporar la participación de actores, la relación entre los propósitos de evaluación y la existencia o previsión de participación. Se trata de una investigación novedosa dado que explora por primera vez cómo opera o se prevé la participación de actores en estos procesos.

Capítulo 4. Indicators for Responsible Research and Innovation: A Methodological Proposal for Context-Based Weighting.

Autores: Irene Monsonís Payá, Mónica García-Melón y José Félix Lozano

Publicado en el año 2017 en la revista *Sustainability*, 9:12, 2168

El cuarto capítulo presenta un estudio en el que se explora la potencialidad de la técnica AHP en la priorización de indicadores pertenecientes a un set preexistente propuesto a nivel europeo. El estudio presenta los resultados de un proceso de priorización por expertos en diferentes áreas que mediante el uso de cuestionarios llevan a cabo de forma individual. Se presentan los resultados de la priorización por parte de los expertos y se proponen cuatro estrategias para establecer sets reducidos de indicadores.

Capítulo 5. Anticipating Environmental Burdens in Research and Innovation Projects. Application to the Case of Active and Healthy Ageing.

Autores: Irene Monsonís Payá, Tomás Gómez Navarro y Mónica García-Melón

Publicado en el *International Journal of Environmental Research and Public Health* 2020, *17*(10), 3600

El quinto capítulo presenta la aplicación de una metodología en la que expertos en temas medioambientales construyen un modelo jerárquico sobre el que identificar aquellos elementos que son prioritarios para anticipar posibles impactos medioambientales en el uso los resultados de investigación de proyectos no centrados en la mejora medioambiental. Un grupo de expertos desarrolla una propuesta de elementos a considerar en cualquier proyecto y posteriormente prioriza aquellos que deberían ser considerados en proyectos de investigación sobre tecnologías de la información y la comunicación aplicadas al envejecimiento activo y saludable.

Capítulo 6. Deliberative participation and the AHP technique: a process to identify and prioritise Responsible Research and Innovation's challenges on ethical issues in Spain.

Autores: Irene Monsonís Payá y José Félix Lozano

Actualmente el contenido de este capítulo está en proceso de redacción para su envío a una revista científica

El sexto capítulo presenta el último estudio exploratorio del proyecto INPERRI en el que se aplicó una metodología participada por expertos y grupos de interés para explorar posibles indicadores de evaluación de la ética desde una perspectiva de la RRI en España. Durante una reunión presencial, los

participantes desarrollaron identificaron los problemas y retos a los que se enfrenta la ética desde una perspectiva de la RRI en nuestro entorno. Posteriormente, identificaron indicadores que pudiesen favorecer el seguimiento y evaluación de dichos retos. Tras la sesión participativa, los participantes priorizaron aquellos indicadores que consideraban más relevantes en el contexto español. El proceso de desarrollo de la investigación se diseñó considerando los valores de la ética cívica propuestos en el capítulo 2.

Capítulo 7. Conclusiones.

Finalmente, el séptimo capítulo presenta las conclusiones del trabajo. Encontramos este capítulo duplicado dado que se incorpora una versión en castellano y otra en inglés.

A continuación, se incluye la figura resumen en la que se visualiza la relación de los capítulos con los objetivos y preguntas de investigación (ver Figura 3).

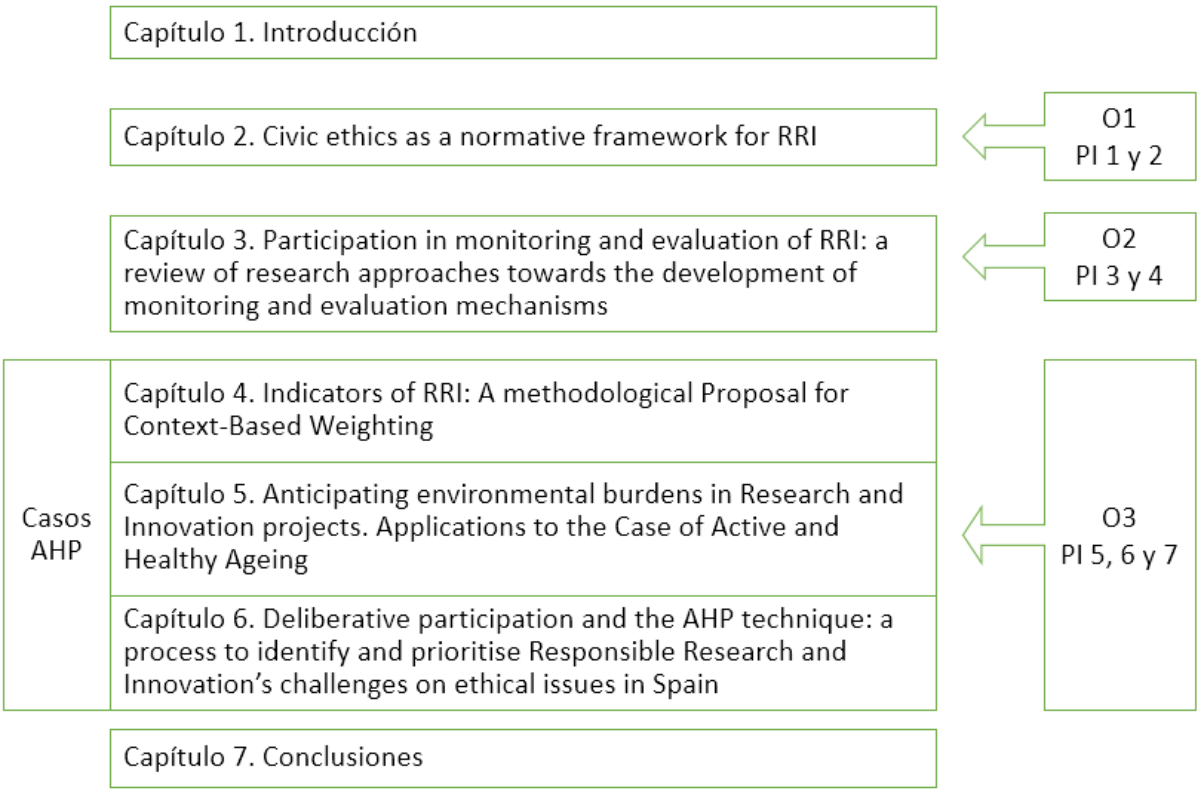

Figura 3 *Estructura de la tesis*

Capítulo 2 . Civic ethics as a normative framework for responsible research and innovation

Félix Lozano & Irene Monsonís-Payá (2020) Civic ethics as a normative framework for responsible research and innovation, Journal of Responsible Innovation, 7:3, 490-506, DOI: 10.1080/23299460.2020.1816024

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Abstract

Responsible Research and Innovation (RRI) is a term used in Europe to advance in the consideration of societal and ethical dimensions of research and innovation. RRI involves two main challenges: its rationale its practical development. The legitimacy of RRI is based on its ethical foundation. Different ethical traditions, such as procedural ethics, have been identified as underpinning the RRI conceptualizations so far. The objective of this article is to examine the evolution of discursive ethics proposed by J. Habermas and K.O. Apel, and civic ethics as a normative framework for RRI, and to explore their development and feasibility and how they are affected by the tensions that such a paradigmatic change might imply.

Keywords: Responsible Innovation; Civic Ethics, Discourse Ethics

2.1 Introduction

Dilemmas about controlling the outputs of scientific knowledge and innovation were traced back by von Schomberg (2013) and Rip (2014) on Responsible Research and Innovation (RRI). Concern about establishing some ethical limits to scientific experimentation has continued to grow. In the 1970s, K. O. Apel (1973, vol 2:361) made the statement that: “the result of science is a challenge for the humankind” and, as a consequence, moral developments alongside technological developments were essential for the future of society. Also, during the same period, Jonas (1979) declared that the paradise promised by technology had become a threat.

Both warnings were based on recognitions of the growing power of science and technology and that this power implied the risk of destruction for the whole of humanity. Four decades later, these warnings remain valid and even more urgent in the face, especially, of grand challenges (Blok 2014) such as climate change, and innovations such as genetic manipulation, the neurosciences and artificial intelligence, among others. Since the outcomes of science and innovation could have enormous and unprecedented impacts, there is a practical need and urgency for the construction of a post-conventional moral conscience and an institutional system based on universal ethical principles to guide those processes (Apel, 1973; Habermas, 1983). More recently, in the area of RRI, some scholars have contributed both theoretically and conceptually, to the notion of ethical considerations as part of the research and innovation process and less emphasis in its outcomes (Cuppen et al., 2019).

Attempts to introduce social and ethical considerations into the governance of science and innovation have been evolving since the second half of the 20th century (Landeweerd et al., 2015; Zwart et al., 2014). The term RRI is part of the attempt, particularly in Europe, to integrate these considerations. Several different narratives have emerged around the term (and responsible innovation), constituting a nuanced set of approaches to what, how and by whom science and innovation processes might be guided. Different ontological and axiological assumptions have been identified regarding the inclusion or not under the science and innovation umbrella of the type of innovation (mainly technological innovation) referred to, and the role of non-traditional actors in the governance of science and innovation (Timmermans & Blok, 2021). Thus, the conceptual proposals around RRI deal with its practical implications in different ways in order to address three major challenges related to our technological civilization: a risk of potentially catastrophic dimensions; the persistent problem of inequality; and the meaning and value of nature, especially human nature (Jasanoff, 2016).

The most immediate issue is how to steer scientific and technological developments (or other types of innovation) towards improving life on earth. The fundamental question is: what should be the key ethical principles orienting science and technology management and assessment? We share Landeweerd and colleagues' (2015) premise that: "For a just approach to governance and technology, we need to define what we owe to each other, and on what basis". Our article also stresses the importance of the normative foundation for RRI. Legitimation is crucial in normative ethics, which requires us to justify why we propose certain norms, values and actions. As Brand & Blok (2019:4) point out that some RRI approaches focus on the question of whether and how it is possible to direct technology and innovation towards socially desirable ends, understood as something that is given or achieved through de facto dialogue among the primary stakeholders. Questioning the reasons why some and not other ends are considered or giving voice to certain should not be the strategy in ethics arguments, because otherwise: "the dominance of strategic considerations could undermine taking social and ethical aspects seriously" (Brand & Blok, 2019:17).

The necessity for a solid philosophical foundation for RRI has been emphasized by several authors from different philosophical traditions (Blok, 2014, 2018; Sophie Pellé, 2016; Timmermans & Blok, 2021). Such a foundation is essential for RRI legitimacy and social acceptance. Pellé and Reber (2015; 2016) acknowledged that the discussion on the normative foundation has implications for the governance of RRI. They identified three main responsibility perspectives aligned to the mainstream traditions of moral philosophy - deontology, utilitarianism and Aristotelism (virtues) - and proposed an RRI approach based on virtue ethics. Although we agree on the need for a normative foundation, we agree with (Blok, 2019) that virtue ethics is a less appropriate to innovation ethics. Also, Timmermans and Blok (2021:27) provide a rigorous critical hermeneutic analysis of the ontological and axiological assumptions of the four most relevant RRI definitions and conclude that: "In addition,

the assumed feasibility and the legitimacy of the accounts currently still suffer from a lack underpinning. It is, therefore, recommended that the assumptions and claims of RI are substantiated further via reasoned argument and empirical evidence".

In the present paper, we explore the potential of discursive ethics (Apel, 1973, 1988; Habermas, 1981) as a foundation for RRI and, more specifically, the civic ethics developed by Adela Cortina (1986, 1990, 1995) as a source of normative legitimation. Civic ethics overcomes some of the limitations of the virtue approach (paternalism, a metaphysical conception of "good" and relativism), the utilitarian approach (individualism, materialism/ positivism and output calculation) and the discursive approach (proceduralism and idealism), while retaining a cognitive and universalistic perspective, the idea of strong justice, autonomy and consideration of the emotional dimension of human beings.

Our objective is to contribute to the debate on how RRI can be conceptualized by: 1) exploring how a civic ethics normative foundation, derived from the discourse ethics of Habermas and Apel and proposed by Adela Cortina, could nourish the narrative around the governance of RRI; and 2) reflecting on the implied challenges and tensions regarding the legitimacy and feasibility of the concept. To do this, in what follows we a) discuss how the notion of RRI has evolved; b) explore the dialogical conception of responsibility; and c) investigate the contribution of civic ethics as a normative framework for RRI. We provide a review of the work on discursive ethics and their implications for the RRI framework.

2.2 Evolution of the term RRI

Landeweerd et al. (2015) identify three styles to address deficiencies in the governance of science and innovation that appeared gradually in response to specific demands over the last 70 years up to the present. First, a technocratic style focused on risk assessment that would translate the knowledge of scientists and technologist into what should be acceptable or not for normative and regulation. Initial efforts to constrain certain scientific practices were inscribed in hard legislation and international regulation (soft law).

This style of governance led to the drafting of principles, especially in the field of medicine, such as the Nuremberg Code in 1947. Based on the assumptions in the technocratic approach, scientific knowledge is considered neutral, rational and well informed (Landeweerd et al., 2015); parliamentary science advisory offices could respond to this type of governance style. Its deficiencies (Landeweerd et al., 2015) do not imply that they do not play an essential role in the assessment and development of legislation and regulation. Some examples of their current validity are the drafting of the Helsinki Declaration in 2012, the 1997 Oviedo Convention - "the only international legally binding instrument on the protection of human rights in the biomedical field" (Council of Europe, n.d.), and the recent announcement of the creation of a parliamentary scientific advisory office as a result of a successful grassroots scientist movement "Ciencia en el Parlamento" in Spain (Catanzaro, 2018). These strategies have been moderately successful, but have some intrinsic limitations (slow process versus speed of advances; standardization of regulation versus dynamism and particularism of scientific practice) which have led to the development of theoretical proposals that go beyond the ex-post corrective control approach.

Second, the decision makers in the applied ethics governance style include "ethical experts from the fields of applied ethics and bioethics as well as socially engaged scientists" (Landeweerd et al., 2015:7).

Examples of this style are the ELSI - Ethical, Legal and Social Implications and ELSA - Ethical, Legal and Social Aspects approaches which gained relevance in the 1990s in the US and Europe respectively, and whose "golden years" were between 2002 and 2012 (Zwart et al., 2014).

The limitations of the first and second styles (normative load and lack of neutrality of technical knowledge and ethical expertise for prescriptive recommendations) led to the emergence of a third governance type, the public participation style (Landeweerd et al., 2015). The public participation style demands further integration of ethical concerns and social dimensions and reinforced legitimacy through democratic exercises in the governance of science and technology, sometimes described post-ELSI approaches (Balmer et al., 2015). Among all these approaches, the one that attracted the most attention in Europe was RRI or responsible innovation depending on the author. Among the several reasons why this term gained such popularity in Europe was its adoption by the European Commission, and its integration as a cross-cutting issue in the EC Horizon 2020 research programme and the various related funded projects (Burget et al., 2017; Rip, 2016; Timmermans & Blok, 2021).

The diffusion of the term RRI term during the last 10 years in Europe, led to a "rapid expansion of the RRI discourse", which resulted in a "proliferation of RRI approaches and projects" that "made it harder to maintain an overview of the discourse" (Timmermans, 2017:1). It was during 2011 to 2013 that the more influential definitions of RRI were formulated. One of the earliest came from von Schomberg (2011:9) and refers to both the process and product dimensions of RRI:

> Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society).

The European Commission (2012:1) proposed an alternative definition: "RRI means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes, with the values, needs and expectations of European society", while Stilgoe et al. (2013:1570), defined it as: "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present". In the same year, van den Hoven et al. (2013:3) described RRI as referring:

> "to the comprehensive approach of proceeding in research and innovation in ways that allow all stakeholders that are involved in the processes of research and innovation at an early stage (A) to obtain relevant knowledge on the consequences of the outcomes of their actions and on the range of options open to them and (B) to effectively evaluate both outcomes and options in terms of societal needs and moral values and (C) to use these considerations (under A and B) as functional requirements for design and development of new research, products and services."

The need to identify differences and similarities among definitions of RRI and their ethical foundations led a stream of work and analyses by various authors. The ethical foundations supporting the different RRI narratives are based on one or a combination of the following philosophical traditions: virtue or teleological ethics, deontologist, utilitarianism or consequentialism, procedural or discourse ethics (Burget et al., 2017; Sophie Pellé, 2016; Timmermans & Blok, 2021). The fact that the dominant narratives do not have common ontological and axiological assumptions (Timmermans & Blok, 2021) can be seen as positive and leaves space for other proposals and critical reflection. In Rip's (2016:3) words, "the present interest in the open-ended idea of RRI can be understood as RRI being an occasion for a number of threads of development and of challenges and debates coming together under what is essentially a blanket term".

Some of the features common to the definitions of RRI proposed so far refer to a combination between the different levels of actor (or stakeholder) involvement in the decision-making processes and consideration of the social and ethical dimensions of the outcomes of research and innovation, including ability to anticipate future impacts (anticipation as an original feature of RRI is discussed in Zwart et al. (2014)). It is relevant, also, to highlight the different attention given to the procedural and product dimensions of RRI, where the formers has received more analytical attention (Cuppen et al., 2019). The uncertainty around the outcomes from certain research fields has been proposed as a possible reason for this pattern in the RRI literature (Cuppen et al., 2019). The importance given to uncertainty of research outcomes is acknowledged by Thorstensen and Forsberg (2016:2): "How to tackle the inherent uncertainties generated by new technologies is therefore a main motivation for developing RRI approaches, but also a main challenge for RRI approaches in practice". The active participation of stakeholders in the assessment of technology, projects and products is seen by these authors as a possible way to improve the management of these uncertainties.

The relevance of public participation and the new roles for RRI actors have been considered pivotal to viewing RRI as a social innovation (Rip, 2014). The most influential definitions of RRI, some of which were included above, include references to public engagement, considering new stakeholders either as input providers or as essential actors in co-construction exercises (Timmermans & Blok, 2021).

In the case of integration of the social and ethical dimensions of science and innovation, we believe that there are two elements that should be differentiated. One is why the inclusion of those dimensions should be central to science and innovation policies – which suggests the need to examine the concept's ethical foundations. We address the question of their inclusion in Section 4. The second is would it could be done. Various proposals have been made about the operationalization of RRI and the challenges facing efforts by the scientific and innovation communities to integrate public participation in the social and ethical dimensions. The European Commission (2012) proposed six key areas of RRI: public engagement, gender equality, science education, open access, ethics and governance. Other have defined dimensions to characterize a responsible system of innovation: anticipation, reflexivity, inclusion, responsiveness (Stilgoe et al., 2013) and openness (Owen & Pansera, 2019). Other dimensions of RRI, such as sustainability and care, have been explored (Burget et al., 2017), but in our view, they should be part of the universal moral principles in a post-conventional moral order.

As a result of their analysis of these different definitions and conceptual dimensions of RRI, Burget et al. (2017:14) conclude that "RRI is fundamentally a cluster of ideas for promoting an idea of science governance that is essentially about responsible processes as opposed to processes that are not supervised responsibly". Describing these ideas as "responsible processes", requires further exploration of how responsibility should be understood in this normative framework. We discuss this in Section 3 where we also propose how civic ethics could contribute to the normative foundations of RRI.

2.3 From a utilitarian to a dialogic conception of responsibility

The notion of responsibility is relatively new to philosophy, but has provoked huge controversy and been subject to multiple interpretations (Corlett, 2016). In the RRI field, an analysis of the concept of responsibility can be found in Pellé and Reber (2015). The authors state that merely trying to describe

responsibility is not enough and does not suggest how it should be practised: "moral philosophy provides at least ten or eleven different meanings of the concept, offering a variety of pathways for practical implementation" (Pellé & Reber, 2015:111). In this section, we try to overcome this limitation by focusing on the philosophical interpretation of the concept of responsibility. This attention to normative foundations is not just an academic exercise, it has an essential impact on RRI governance (Sophie Pellé, 2016).

Focusing on responsibility in science and technology, Max Weber (1919) delivered a famous speech at Munich University, presenting the concept of the "ethics of responsibility" (Verantwortungsethik) in the context of politic and science (Wissenschaft als beruf). The main idea was that acting ethically involves not only acting according to principles or convictions (Gesinnungsethics) but also taking account of the probable consequences of our actions. The second idea proposed by Weber was that the world is not perfect, not foreseeable and not manageable and that, on many occasions, negative consequences result from good intentions.

Some 60 years later, the idea of responsibility gained centrality with the publication of Hans Jonas's (1979) book, Das Prinzip Verantwortung (The Responsibility Principle). The book starts from the thesis that "the promise of the modern technic has been transformed into a threat" (Jonas, 1979:1). Due to technology advances, humans have the capacity to change the world and human nature, quite radically and irreversibly which implies huge risk for future generations. Therefore, the Kantian moral imperative: "Act in such a way that you treat humanity, whether in your own person or in the person of any other, never merely as a means to an end, but always at the same time as an end" (Kant, 1785:BA67) should be about the moral imperative of responsibility. The responsibility imperative affirms that: "Act in that way that the effects of your actions can be compatibles with the permanence of an authentic human life on Earth" (Jonas, 1979:36). This concept of responsibility is aimed at ensuring the survival of the species and preservation of human freedom in a technological civilization where the borders between the artificial and the natural have disappeared. Jonas's responsibility principle starts from an awareness of our vulnerability and the real risk of human extinction. This idea of responsibility for the future should be understood as: "independent of whatever idea of law and idea of reciprocity" (Jonas, 1979:84). The main moral duty, then, is the duty to preserve the existence of humanity, which is a moral imperative.

A few years later, Apel, another German philosopher, also focused on this idea of responsibility for the future, but from a different philosophical perspective. Apel's (1988) book Diskurs und Verantwortung (Discourse and Responsibility) started from the same conviction of an urgent need for an ethical theory that takes account of the risk that humans could be extinguished as the result of human actions, and that the future of our species is at stake. In Apel´s words:

> "the results of the science represent a moral challenge for the humankind …. For the first time in the history of human species has the humankind the task to develop the solidarity responsibility as an indicator for the consequences their actions in a planetary perspective. … this obligation to solidarity responsibility implies an ethics of responsibility". (Apel, 1973:361)

The idea that we are in a situation of paradox which requires a universalistic ethics (to deal with global technological challenges), in parallel with the idea of a rational foundation for this ethics, became even more complex and triggered intellectual efforts to define a universalistic ethics (Apel, 1973:359). As Cortina (1995) points out, Apel stresses the idea that the final objective of responsibility is not assuring human survival, but an authentic human survival, which requires a robust philosophical foundation for the principles of responsibility ethics. In going further than Jonas (1979), Apel considered that it

was not sufficient to guarantee the mere material existence of human beings, but that we should consider the idea of human progress and prosperity. To this end, Apel proposed that the conventional idea of responsibility should be overcome with a post-conventional idea of the ethics of responsibility (Kolhberg, 1981).

This idea of post-conventional dialogic responsibility supposes overcoming the previously dominant idea of responsibility defended by utilitarianism (Bentham, 1780; Mill, 1879). The moral philosophy of utilitarianism maintains that a rule is fair if it brings great happiness to the greatest number of people. Based on the idea of the consequences of actions, utilitarianism puts responsibility at the centre of moral philosophy. Of course, utilitarian philosophy is much more complex and has been interpreted in diverse ways (action utilitarianism vs rule utilitarianism), but this moral philosophical tradition conceives responsibility as based on three, somewhat questionable, assumptions: it is possible to foresee, estimate and evaluate the possible consequences of our actions (forward-looking responsibility); concrete actions can be evaluated only ex-post (backward-looking responsibility); utilitarianism criteria are individual, subjective and unquestionable.

These weaknesses of the utilitarian philosophy limit its application to RRI. First, the idea that we can anticipate the consequences of an action or a rule (ex-ante evaluation) does not take account of human epistemic limitations related to foreseeing the future, and does not take account of the unpredictability of complex and dynamic contexts. This forward-looking understanding of responsibility can generate an illusion of control with catastrophic consequences "the false sense of security provided by the consequentialist calculation of future impacts" (Blok, 2019:5). Second, the idea of responsibility related only to ex post evaluation –we can evaluate the concrete consequences of an action– assumes that evaluation adheres to predefined rules and criteria, which assumes that consequences can be clearly identified, measured and evaluated. The idea of backward-looking or negative responsibility is: "insufficient when considering innovation (and research) because: (1) it fails to include a normative involvement; (2) it may dilute responsibility; (3) it is understood to be without an agent; and (4) it is restricted to the notion of external accountability" (Pellé & Reber, 2015:111). Third, the idea that justice is based on personal evaluation of happiness or positive consequences makes interpersonal comparison impossible and opens the way to relativism. The utilitarianism approach assumes that each individual has his or her own private interests and idea of happiness - ideas and aspirations which can be maximized by personal decisions and strategic negotiation. This individualistic perspective ignores the relevance of the social process in the formation of preferences.

To overcome the limitations of this utilitarianism perspective of responsibility, Blok (2017) drawing on Levinas's philosophy, makes an interesting proposal. Emmanuel Levinas conceived communication as conversation and understood the encounter with the other was the foundation of ethics: "The subject of discourse as conversation acknowledges the experience of the other as the very basis of his subjectivity" (Blok, 2014:181). This experience of the other implies sensitivity towards the other, interactive dialogue, responsiveness to the other's voice and submission of the self to the other.

Blok's interpretation of Levinasian ethics has four main characteristics: a) ethics, basically, is responsive to the demands of the other; b) the ethical orientation is found in the confrontation with the singularity of the other; c) the other is accessible through our physical proximity to the other; and d) "The face-to-face encounter with the other enables us to take unconditional responsibility for the other" (Blok, 2017:2). This idea of communication as conversation and the a priori assumption of a concrete physical experience (Leibapriori) (Lebenswelt) as opposed to the abstract rationality assumed in the deontology and utilitarianism views, opens a new perspective on human suffering and helps us to understand the concrete reality and biological conditions that influence people´s decision

making (Conill, 2006, 2019). Although these ideas have real implications for the concept of responsibility, we consider discursive ethics as providing the main criteria for responsibility and as more appropriate for a normative foundation of RRI, while integrating Levinasian theory ideas and concepts.

The discursive ethics presented by Karl Otto Apel (1973), Jürgen Habermas (1981) and Adela Cortina (1986, 1990, 1995) states that the process involved in the moral foundation of norms should be participatory discourse among all affected by these norms. This regulative idea or transcendental process for foundation of moral norms has two implications: inclusivity of every person affected and rational dialogue. "One moral duty is only justified if it is a consensus after a rational dialogue between all affected" (Cortina, 1995:166). From the a priori of the community of communication as a regulating principle, two conditions for the real community of communication can be observed: a) all people should be integrated into the dialogue (or no one can be excluded from dialogues which have an effect on the individual); b) we should work to create the conditions for a real rational dialogue (we need to work to achieve and the ideal communication community).

For the discursive ethics approach, responsibility is an essential concept in three senses: as responsibility for the actual conditions of the participants in the discourse (responsibility for the specific context; for the real situation of the people); responsibility for the arguments presented in the discourse (theoretical responsibility; responsibility for your ideas and opinions); and responsibility for the practical consequences of the eventual consensus (consequence responsibility).

Following the philosophical approach of discursive ethics (Apel, 1973; Cortina, 1986, 1990, 1995; Habermas, 1981), the dialogic understanding of responsibility overcomes the limitations of a unidimensional utilitarian approach to responsibility, which considers only consequences (Bentham, 1780; Mill, 1879) and the virtue ethics approach, which considers only how agents behave (Aristotle, 1986; MacIntyre, 1981).

The dialogical responsibility we propose as a critical component of RRI, has some essential traits that make it especially suited to the challenges of a sociotechnical civilization and overcomes some of the dominant capitalist ideas in the science-society relationship, that is, paternalism, self-interest and individualism.

- No paternalism. The dialogue between those affected is a legitimate process for deciding what to do in concrete situations. This process dismisses the idea of experts in a superior epistemological situation who make unilateral calculus based on causal logic without considering the opinions of those affected by the decision.

- No self-interest. Dialogical responsibility is aimed at achieving a consensus among those affected by norms and decisions. This approach transcends agreements based on the interests of those with the power to participate in negotiations, which, also, supposes that universal principles, values and common goals are prioritized over particular and private interests. (Brand & Blok, 2019:13) acknowledge that: "Negotiation is about finding a balance or compromise among different private interests. Deliberation (at least in the classic sense) is meant to go beyond private interests, towards arriving at a shared understanding about public issues, and making argumentatively agreed-on decisions about the common good".

No individualism. From a philosophical perspective, this dialogic responsibility assumes intersubjectivity and mutual acknowledgement as a basis for decision making and sees rationality as the capacity to deal not just with objects but also with people and to discuss not just means but also

ends. Apel insists in line with Levinas that awareness of being part of a human community, not an isolated subject, is an empirical fact and a logical precondition for reflection on ethics reflection: "In the community of argumentation is the reciprocal recognition of all participants as equal discussion partner a presupposition" (Apel, 1973:400).

2.4 Civic ethics as a normative framework for RRI

2.4.1 From Discursive Ethics to Civic Ethics

As discussed above, discursive ethics affirms that the legitimacy of moral norms can be based only on rational dialogue in conditions of symmetry among all affected by this norm. Habermas (1983) stated that when we say to someone "you must do something", there must be a good reason for doing so, and maintained that the only way to assess reasons is through dialogue between those affected. The factum of reason demands that whoever joins the discourse has assumed de facto that there is the possibility of reaching rational consensus on norm legitimacy.

This programme of discourse ethics has two levels (Zwei-Stufen-Ethik) that are highly relevant for determining responsibility in science and technology (Apel, 1988). The first level (level A in Apel's terminology) is the procedural principle of ultimate foundation that assumes that it is possible to reach a consensus among all potential participants in the discourse (including future generations) following a rational dialogue in conditions of symmetry. The transcendental pragmatic perspective of consensus building is a regulatory idea that guides the political institutionalization of practical discourses. The second level (level B in Apel's terminology) is the ethics of discourse understood as the ethics of responsibility in a scientific context, where the consciousness of moral duty must consider the utilitarian principles of the consequences of calculation. At the level of practical discourse, we need to consider not only the interests of all concerned but also how to improve knowledge of the expected consequences of grounded norms in concrete contexts with real limitations. The moral norms should apply in real situations, based on two main principles: survival of the speaking subject and those who depend on him or her and development of the material and cultural conditions to allow communicative action in the future. Dialogue cannot be understood only as a procedure for the exchange of subjective interests; it must be conceived as the only possible process for ascertaining correctness of norms.

This discursive approach has attracted two main criticisms related to its idealistic perspective and its unrealizability in specific contexts. Steinmann and Löhr (1994), based on Lorenzen's (1987) philosophical approach, suggested that the starting point of the dialogue is the experience of conflict and a universal aspiration for peace. The constructivism practised by the Erlangen Schule, the transcendental foundation, is based on the idea of communication as idealistic and unnecessary. Reflections on ethics should start from praxis and should develop for praxis ("aus der Praxis für die Praxis"). The second relevant criticism refers to the unrealizability of discursive ethics in concrete contexts. It is claimed that it is impossible for all affected persons to participate in a rational dialogue in symmetric conditions (Steinmann & Löhr, 1994). These critics do not have a proper understanding of either the difference or the complementarity between ideal speech situation and the real communication community, or the concept of a "regulative idea" or the transcendental normative foundation.

Blok (2014:178) critiqued Habermas´s discursive ethics theory and his criticisms relevant to the RRI field:

Habermas' theory of practical discourse also shows a tendency to harmony and alignment (consensus), conceptualizes the differences among stakeholders as a difference within the same, therefore not able to deal with fundamentally different interests and value frames that are at stake in RI processes in order to deal with the grand challenges of our time.

In our view, Blok´s interpretation of Habermas's dialogue as discursive rhetoric, aimed at reducing the differences among participants, can be reviewed. The discursive approach should not be understood as a disagreement and a fight to convince the others, but as the means of achieving a consensus about the correctness of a norm for action based on rational arguments. It should be understood as a regulative idea, for dealing with the foundation of ethical norms and only, indirectly, as providing an orientation for concrete dialogue.

Another critique of Apel's and Habermas's discursive ethics is that this perspective is procedural, is "too abstract" and assumes a logic focused reason. It does not take account of the emotional dimension or the influence of the historical context. The programme of civic ethics proposed by Adela Cortina tries to overcome these critiques and incorporate contributions from the hermeneutic tradition (Conill, 2006; Irrgang, 2007; MacIntyre, 1981). Cortina constructs a proposal which takes account of the deontological moment of the normative foundation while, at the same time, incorporating a sense of the ends of human activity, the complexity of the real world and responsibility for the future (Cortina, 1997, 2000, 2010, 2014). One of the main limitations of discourse ethics, according to Cortina, is the ignorance of human emotions in moral life. She acknowledges (Adela Cortina, 2014:35) that : "Discourse ethics, due to its eagerness to reach the level of intersubjectivity, places in parentheses the emotions, values and virtues that are, however, essential for moral life". The content of this civic ethics is coherent with a pluralist society with different conceptions of human nature and no predefined telos of humankind, but which, at the same, includes pretensions to universalistic justice. The essential values of civic ethics are: freedom, equality, solidarity, respect and dialogue. These are the nuclear values of a pluralistic society; the minimum to allow peaceful coexistence and human success (Cortina, 1994, 1997). Let us see more in detail to what she is referring:

- freedom. This is the first of the values defended by the Enlightenment and one of the most heavily debated since. Three senses of freedom can be distinguished. The first is freedom as participation, where participation means participation in public affairs, and the possibility and capacity to participate in the affairs and decisions that affect us. This is the concept of freedom that Benjamin Constant (1819) called "the freedom of the ancients" . The second is freedom as independence, where freedom is understood as the possibility to lead one's life without outside interference. This concept of freedom is typical of modernity and is linked closely to individualism and the primacy of private over public life. The third is freedom as autonomy, as proposed by the Enlightenment, which considers that the individual is free if he or she is capable of making his or her own rules;

- equality is the second of the values proclaimed by the French Revolution and, which, over time, has gained meaning. We can distinguish two essential meanings derived from the profound idea that all people are equal in dignity: equality of all citizens before the law which means that all people have the same legal rights and obligations, within an impartial legal system; and equality of opportunity which means that those in need can receive more help from society in order to allow their participation in social life (Parijs, 1997);

- solidarity, a value derived from the fraternity involved in the French Revolution, which we have inherited and transformed. Solidarity is one of the values most in demand in recent times and most needed to condition human existence. This value can be expressed in two types of personal and social reality. The first is solidarity of the common interest which "obliges" us to cooperate in order to achieve our objective; the second is solidarity of generosity, which means that help is given to those most in need and that this help is motivated by their misfortune which moves the aid giver. It should be noted that solidarity is not the same as tribalism, it does not refer to solidarity only with the members of a certain group. It refers to universal solidarity which takes account of the situations of the most vulnerable people;

- respect is a reformulation of the value of tolerance and has many interpretations (Lozano & Escrich, 2017). While tolerance can be the result of impotence, indifference or disinterest (passivity), respect involves an active interest in understanding the projects and ideas of others and helping them to realize them from a moral point of view. Active respect means positive appreciation and commitment;

- dialogue - since Socrates, dialogue has been a means not only of resolving disputes but also of finding truth and increasing knowledge. Dialogue does not involve the mere statement or communication of information; it involves expressing what is believed and taking responsibility for what is spoken. Dialogue refers to a shared search for truth and justice and, as Steinmann and Löhr (1994) state, is the only way to achieve peaceful resolution of conflict.

2.4.2 Implications of civic ethics for RRI

The contribution of civic ethics to RRI governance seems relevant at the levels of its normative foundation and practical realization. The civic ethics proposed by Cortina and built on by authors such as Crocker (2008), has its roots in the ethics of discourse, but presupposes the dismissal of pure proceduralism while avoiding the metaphysical essentialism of some comprehensive doctrines of good. "Civil ethics thus constitutes the ethical background of and creates the conditions for social cohesion in morally pluralist societies" (Cortina, 2000:41).

We are aware of the difficulties involved in realizing the ideal of dialogue in responsible innovation governance, that is, its inherent dynamics (Stilgoe et al., 2013) and the highly competitive business world in which it takes place (Brand & Blok, 2019). Stilgoe, Owen and Macnaghten suggest that traditional ethics evaluation was directed to the intentions and consequences of past actions (backward looking responsibility) applied "to the products of science and innovation" (Stilgoe et al., 2013:1568), while innovation involves the creation of something new and unexpected. We believe that civic ethics could provide a meaningful way to deal with such fundamental unpredictability because it proposes a deliberation process that satisfy the normative legitimation demands and, at the same time, is coherent with the innovation process.

Based on the levels suggested by Apel (1988), we believe that this dialogue perspective is adequate for RRI governance. These two levels have specific practical implications for the governance of science and technology. The first level of transcendental foundation is not just formal and abstract, it also demands ideal conditions for dialogue and concrete dispositions of the participants in that dialogue. As noted above, the ideal conditions for dialogue are a regulative idea that gives an orientation to concrete practical discourses. This regulatory idea has implications at two levels: the conditions for the process of participating in real dialogue and the underlying values which should be activated by

those who participate in the dialogue. Inspired by Habermas (1983) and the five essential values of Cortina's civic ethics, the four basic principles that a practical dialogue about RRI should consider are:

principle one: inclusion. Everyone has the right to participate in questions that affect his/her life, and nobody should be excluded from the rational discourse ex-ante. This means that the decision-making processes must consider the interests and opinions of everyone affected. Inclusion should be understood in a broad and not a restrictive sense: "not only those actors who have a direct stake or interest in the innovation process should have a voice, but also members from the wider public, whose stake might be much more indirect. It is held that when diverse stakeholders and lay people are involved in the innovation" (Brand & Blok, 2019:6). Although the inclusion principle has practical and strategic advantages (Eizagirre et al., 2017), it must be remembered that it is a moral imperative. Inclusion, as a regulatory idea, does not imply that we need to discuss every topic endlessly, but that we must be open to a pluralistic discourse and implies, clearly, that no one should be excluded from the outset. This principle offers the possibility for all those affected to ask as many questions as they deem appropriate and to express their opinions freely;

principle two: symmetry. Real symmetry is another ideal that has the power to guide real dialogue. Symmetry implies that everyone who participates in a rational dialogue has the knowledge and resources (material and time) and enjoys the conditions to allow appropriate participation. Clearly, it is not possible for everyone to have the same level of knowledge and resources. However, this regulative idea has two relevant implications for RRI governance: it delegitimates highly asymmetrical dialogue and provides the obligation to work to improve the participation conditions to achieve symmetry;

principle three: no coercion. Absence of coercion and respect for the strength of the best argument, reasoning and sound argument are the main criteria for evaluating ideas and interests and making decisions; neither economics nor political power, nor prestige, nor social background are legitimate sources of privileged consideration. This principle has two concrete implications: the first is the absence of any kind of violence, threat, or intimidation; and the second is that it supposes a revindication of reason and argumentation. The fact that everyone has the right to participate does not mean that every opinion has the same value; opinions and arguments are assessed according to intersubjective rational discourse criteria;

principle four. publicity and accountability. All arguments, ideas or interests must fulfil the public criteria or public use of reason (Habermas, 1981; Kant, 1784). This principle has two clear implications for RRI governance: one is that it must be open to external scrutiny and public control, it should not be secret or hidden information; and the other is that the decisions taken should be publicly disclosed. This public information should include not only the conclusions or decisions taken but also the procedure involved and the reasons why the conclusions or decisions were reached.

These normative principles are aligned to the RRI principles in the literature (Burget et al., 2017) and, in particular, are coherent with the vision of RRI proposed by von Schomberg (2007, 2013) and Stilgoe et al. (2013) and their four procedural dimensions of responsible innovation: anticipatory, reflexive, inclusive and responsive. However, we consider that the civic ethics principle offers a strong normative foundation to underpin and reinforce the dimensions presented by Owen and colleagues, and are developed from a descriptive (sociological) perspective.

2.5 Conclusions

This article discusses the implications of civic ethics as a normative foundation for RRI. The different narratives around RRI proposed so far present a combination of virtue ethics, utilitarianism, deontologism and procedural ethics foundations. They have in common consideration of public participation and the inclusion of the ethical and social dimensions in scientific and innovation decision-making. Civic ethics allows both features to be integrated in an enriching way and overcomes paternalism, selfishness and individualism and establishes the steering universal moral principles such as freedom, equality, solidarity, respect and dialogue. The inclusion of such principles in the ethical foundation of RRI, would put the focus on the contribution to human progress and prosperity based on legitimation of the post-conventional moral order. Also, its operationalization will need to consider four principles to assure dialogue with different actors and include consideration of future generations: that is, inclusion, symmetry, no coercion, disclosure and accountability.

Capítulo 3 . Participation in monitoring and evaluation of RRI: a review of research approaches towards the development of monitoring and evaluation mechanisms

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Abstract

There are three arguments supporting the involvement of different actors in the design and implementation of the Monitoring and Evaluation (M&E) of Responsible Research and Innovation (RRI). First, it strengthens the evaluation; second it allows taking advantage of the performative function and third, it is aligned with the concept of RRI. In Europe, the idea of RRI triggered an interest in developing M&E methods and tools of RRI, but how actors participate in these research processes is still being determined. This paper investigates the extent to which the participation of actors is considered in research on M&E of RRI by using the three stages of translation proposed by Callon and colleagues - problematization, development of the research and transfer to a real setting. Through a systematic review of 25 M&E research approaches, our findings show that participation occurs mainly in the later stages of research and is specially linked with learning and trust-related purposes.

Keywords: Responsible Research and Innovation; Evaluation; Monitoring; Participation; Inclusiveness

3.1 Introduction

The term Responsible Research and Innovation (RRI), or responsible innovation, has gained momentum in Europe, especially since 2009 (Timmermans, 2017). Its widespread use is due to its adoption by funding agencies, including the European Commission (Zwart et al., 2014), and recognition of the need to review the relations between science, innovation and society (Flink & Kaldewey, 2018). In turn, this sparked interest in the monitoring and evaluation (M&E) of RRI.

A common feature in the RRI literature is the inclusion of new types of knowledge facilitated by the involvement of societal actors in the research and innovation process (Timmermans & Blok, 2021). The challenges of societal engagement in public research, scientific governance and industry have been widely documented (Bauer et al., 2021; Brand & Blok, 2019).

Despite the general acknowledgement of the need for more inclusive governance of science and innovation in the RRI literature, it is still being determined if diverse actors participate in the research processes towards M&E mechanisms for RRI. By M&E mechanism, we refer to methods and tools designed for monitoring or evaluation purposes, such as procedures, evaluation grids and quantitative or qualitative indicators. This paper investigates when, how much and in what ways the participation of different actors is considered in the approaches followed in the research process towards M&E of RRI and their implementation in real settings. We will focus on contextualisation through participation to refer to strategies and processes that allow or call for actors' participation in designing these mechanisms to adapt them to a specific context. We examine whether: a) attempts to develop M&E mechanisms of RRI are approached from a participatory and inclusive perspective, where the principles of RRI inform the nature of M&E, and b) the strategies of contextualization through participation applied in M&E design of RRI.

We systematically reviewed the literature related to the research approaches towards M&E mechanisms of RRI. The literature review was designed to identify research processes where M&E mechanisms were developed to analyse whether and how participation was embedded in such processes or expected to occur in subsequent phases of implementation. Our research question is: why and how do different actors participate or are expected to participate in the design of M&E of RRI?

To address our research question, we propose to analyse these processes in three stages: problematization, research development and implementation in real settings, based on the theory of translation of Callon et al. (2009). We will use the term actors to refer to the broader range of possible publics and concerned groups interacting and cooperating with the research team in knowledge creation and decision-making.

Our work makes two main contributions. First, we provide the first systematic review of research on the participatory nature of M&E of RRI. Second, we discuss the results to allow reflection on the decisions about the involvement of actors in the M&E process for RRI. Our findings have relevance for policy-makers, practitioners, researchers and other actors interested in operationalising RRI at different levels.

3.2 Three arguments in favour of participation in the design of M&E for RRI

The reasons for fostering the participation of stakeholders and the publics in the governance of science have been widely discussed (Fiorino, 1990; Funtowicz & Ravetz, 1993; Stirling, 2007). Fiorino (1990) classified arguments for citizen participation into substantive, instrumental and normative arguments. Following this author and Stirling (2007), substantive arguments relate to assuring a better quality of the outputs of the research process; instrumental arguments refer to creating more legitimate and trustful outputs, while normative arguments refer to the right thing to do regarding the procedural research approach. We identified three relevant specific arguments for each category to justify participation in the design and implementation of M&E mechanisms of RRI.

First, a substantive argument refers to the fact that including different actors in designing M&E mechanisms and contextualized strategies for their implementation is likely to increase evaluation effectiveness and reduce the risks of negative impacts deriving from their implementation. For example, indicators are a standard instrument for M&E and were proposed in one of the early attempts to develop M&E mechanisms for RRI (Strand et al., 2015). However, using indicators and quantitative metrics for M&E purposes required special attention, as the research policy and evaluation literature advice. These instruments require caution regarding the nature and purposes of indicators (Heink & Kowarik, 2010) and the relation between purposes and specific methods and techniques (Molas-Gallart, 2012, 2015). The misuse of quantitative indicators and guidelines might result in unintended consequences (Wilsdon et al., 2017), such as goal displacement, biases against interdisciplinarity, reduction of task complexity and changes in institutional arrangements (Hicks et al., 2015; Rijcke et al., 2016). This is especially relevant to our study as strategies of participation (and contextualization) have been proposed to mitigate potential unexpected and unwanted impacts of indicators (Barré, 2010; Ràfols, 2019).

Second, the instrumental argument of reinforcing the participation of actors in the development of research on M&E of RRI might result in greater ownership of the process. Implementing M&E could lead to the adoption of strategic behaviours by researchers and changes to institutional arrangements (Rijcke et al., 2016). If these institutional changes work against the policy's objectives, they produce unwanted effects of implementing M&E mechanisms. Greater participation might increase the actors' sense of ownership and commitment to the policy objective, helping to avoid these undesirable effects.

Third, a normative argument would refer to the expectation that attempts to design M&E mechanisms for RRI consider the views of different stakeholders and actors and incorporate their values in the different phases of the design process. RRI involves developing research and innovation processes governed by anticipation, reflexiveness, inclusiveness and responsiveness (Stilgoe et al., 2013). The involvement of different actors in the research and innovation processes, especially in decision-making, is common to most RRI definitions and accounts (Burget et al., 2017; Timmermans & Blok, 2021; Wickson & Carew, 2014). Although some critical views have emerged against the practical consequences of putting participation and inclusiveness at the centre of the RRI perspective (Brand & Blok, 2019; van Mierlo et al., 2020), social engagement and inclusiveness are recognized as the key principle in RRI discourses.

This raises the question about the reasons found in our literature review to have actors participating in the design of M&E mechanisms. In the following section, we present how participation was presented in the initial proposes of M&E of RRI.

3.3 Participation in early attempts of M&E of RRI

The development of M&E mechanisms for RRI began in 2013. An early paper by Wickson & Carew (2014:270) proposed a set of quality criteria for M&E of RRI. It recommended the strategy of contextualization through the participation of actors as a way to adapt the outputs of the research to the specific context where the criteria would be used:

> Of course, both this rubric and the approach we have outlined should remain open to evolve and be adapted, critiqued and amended, as appropriate to different contexts. We specifically see scope for different research groups, innovation organizations, funding bodies and interested stakeholders to engage in analytic-deliberative processes to create their own criteria, and/or indicators for the quality criteria we present, and to articulate these statements across an evaluative scale.

Further development of the M&E of RRI was boosted by two calls issued by the European Commission (EC). In 2014, the EC appointed an expert group, which produced a report proposing a tentative set of indicators and asked users to "use this framework to pick and choose those indicators that fit their activities and those of their R & I network the best" (Strand et al., 2015:16). Strand and colleagues recommended the participation of actors to create specific sets of contextualized indicators:

> Our ambition has been to present the European Commission as well as other actors within the European Research Area with a toolbox from which they may choose and tailor sets of indicators for the monitoring, promotion and development of RRI. It is obvious that one cannot create a prioritised list of indicators without — explicitly or implicitly — prioritising the objectives to be achieved within a particular policy context.
>
> For this reason, we cannot offer a general prioritised list of indicators for actors in the European Research Area. National and regional actors, universities and research institutes, civil society organizations, funding agencies and others should devise their own process of deliberation in order to choose and tailor the indicators proposed in Chapter 2, and add their own indicators according to their own needs, goals and concerns. (Strand et al., 2015:41)

Also in 2014, the EC published a call for proposals for a four-year study on the "Monitoring Responsible Research and Innovation" (European Commission, 2013), the so-called MoRRI project. The MoRRI project resulted in a set of indicators to monitor key areas of policy related to RRI (Peter et al., 2018) to allow the identification of differences among European Union (EU) member states.

It is striking that the EC did not request input from actors involved in the research, especially considering that public engagement was one of the key policy areas proposed by its approach to RRI (European Commission, 2012). While the call for tenders did not specify specific inclusion requirements, academics involved in the MoRRI consortium stressed the "need for caution in the construction and application of indicators in general and for RRI specifically'' (Mejlgaard et al., 2019: 198). Mejlgaard et al. (2019) highlighted the need to consider the potential systemic effects of indicators (Hicks et al., 2015) and responsible use of metrics (Wilsdon et al., 2017).

We have seen now that there are three arguments to promote the participation of diverse actors in developing M&E mechanisms of RRI. We also have presented that in early attempts to develop them,

there were two approaches, one requesting such actor's inclusion and another focusing on purely technical development. This leads us to consider to what extent participation has been embedded or foreseen in the rest of the research processes towards the M&E of RRI.

3.4 Analytical framework and research questions

As previously mentioned, our analysis is structured using a framework based on Callon et al.'s (2009) theory of translation. This framework involves three stages of research, the translation 1, 2 and 3 in the nomenclature used by Callon et al. The early and first stage of the research involves the problematization phase, when the research approach is designed, and key decisions such as monitoring and evaluation purpose are taken. The second stage refers to the development of the research itself. The third stage refers to the implementation into real settings of the research outputs.

Regarding translation 3, our analysis will focus on the expected or foreseen participation of actors by the researchers carrying out the research process. A stage-based framework allows us to address the question of why and how the participation of actors occurs in existing studies developing M&E for RRI and identify the patterns of levels of cooperation between researchers and other actors in this literature (see Figure 4). This framework has been used successfully for similar analyses, such as Ràfols (2019), who uses it to identify how developing research evaluation metrics would benefit each research stage.

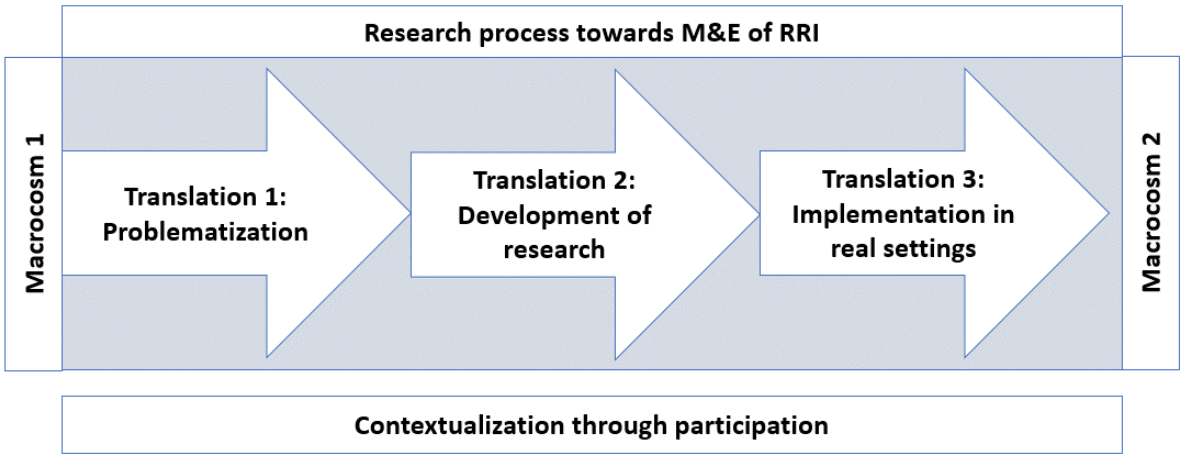

Figure 4 *Analytical framework for the literature review based on Callon et al (2009)*

3.5 Materials and Methods

Our systematic literature review identifies the relevant literature and includes a directed content analysis of the text. Tranfield et al. (2003) point out that systematic review provides methodological rigour and a base of reliable knowledge derived from a range of studies, allowing researchers "to map and to assess the existing intellectual territory" (Tranfield et al., 2003:208). Directed content analysis is a deductive method for analysing textual data in which "theory or prior research about a phenomenon exists that is incomplete or could benefit from further description" (Hsieh and Shannon, 2005: 1281). We followed the content analysis steps proposed by Kaid (1989).

First, we conducted an iterative discussion of study objectives and theoretical approaches. This was crucial for formulating the conceptual structuring model proposed in Section 4.

In this stage, data selection was based on a review protocol, which included a search strategy and snowballing related to references and citation tracking, in different issues of the Journal of Responsible Innovation, a scientific journal publishing work on RRI. Annex B and Figure 5 provide detailed information on the data search and protocol used to select the data. Our final sample includes 37 articles, book chapters and reports. Some of this material referred to the same mechanisms, so we created clusters of documents representing the 25 research approaches.

In our study's initial phases, we constructed an analytical framework based on theory and prior research. Therefore, we opted for a directed content analysis method whose main strength is that "existing theory can be supported and extended" (Hsieh and Shannon, 2005: 1283). Our coding strategy included the following steps:

- Reading the articles and highlighting all text relevant to the elements in our analytical model.
- Applying deductive coding to the highlighted citations and construction a codebook (Annex C) that included all the elements in our analytical framework, their operational definitions and subcategories, based on the existing theory.
- Inductive coding of additional citation information and its inclusion in the codebook.
- Reviewing the inductive codes and deciding whether a new category or a subcategory of the analytical framework was needed.

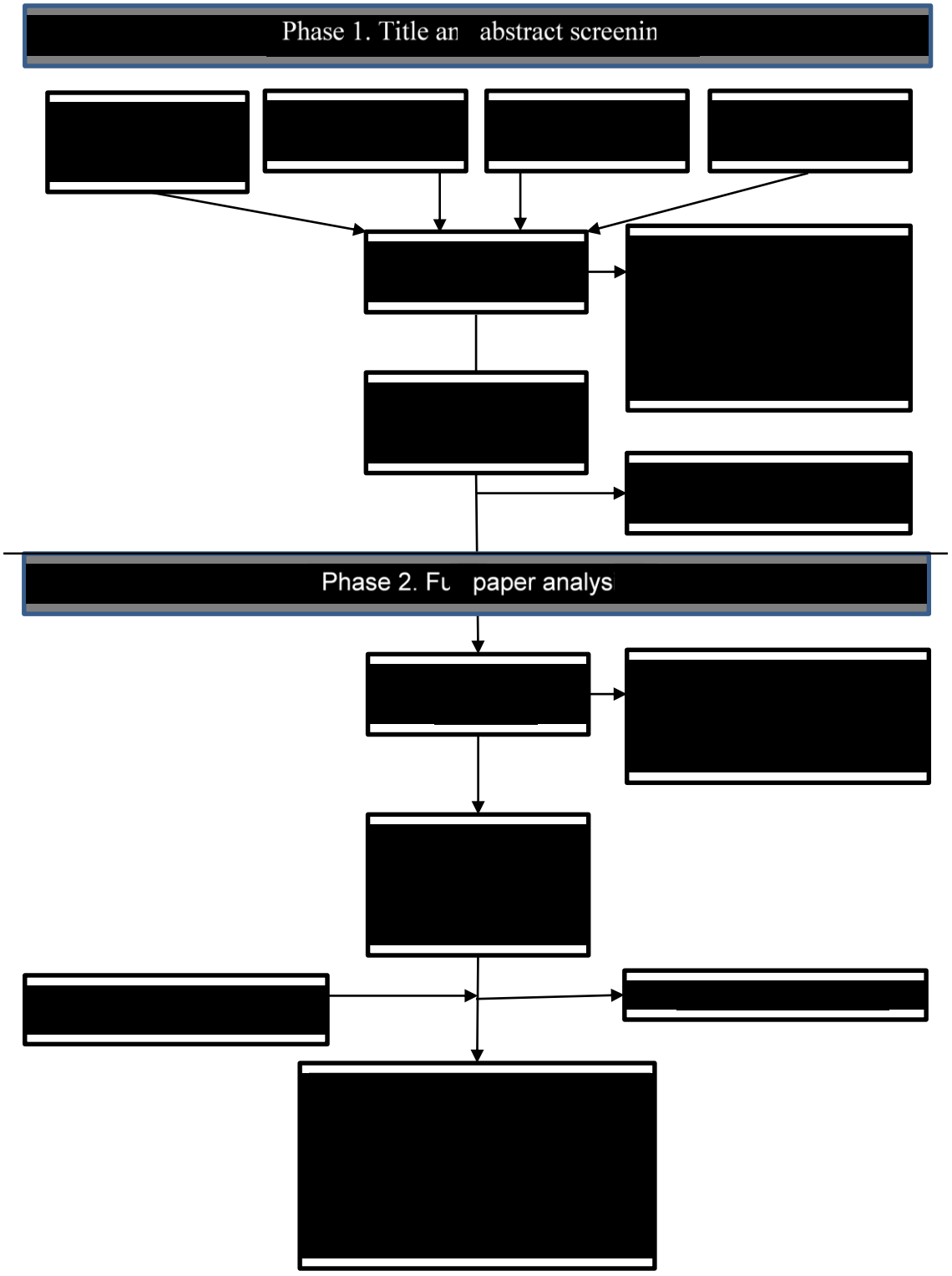

Figure 5 *Flow chart of sources selection*

3.6 Findings

We reviewed 37 documents (19 journal articles, ten book chapters and eight project reports). Some clusters of documents referred to the development of different mechanisms (methods or tools) developed under the umbrella of the same research project and with common members of the research team. When these research processes had high similarities, we clustered them as they referred to the same research approach. So, from the 37 documents reviewed, we identified 25 M&E research approaches developing mechanisms. A complete list of the reviewed documents is provided in Annex A.

The 25 mechanisms identified are diverse regarding different elements. In the first instance, we found mechanisms consisting of developing M&E tools, including quantitative and qualitative instruments such as qualitative questions and indicators. In contrast, others propose methodologies based on a series of procedural steps. Also, the unit of analysis or evaluand differs among the mechanisms. Some are designed to assess units clearly defined as research and innovation projects, megaprojects or institutions, while others are more ambiguous, referring to research and innovation activities, policies or strategies. Limited cases consider people or complete systems of innovation and countries as the unit of analysis. A basic description of the mechanisms and their unit of analysis are summarized in Table 10.

The findings regarding the participation of actors are presented in the succeeding sections. First, we analyse the arguments presented in the documents to justify the need for actors' participation in the research processes. Then we present a general overview of whether participation has been embedded in the described research process (translations 1 and 2), foreseen for future stages of research (translation 3) or not considered or mentioned in the processes reviewed. Afterwards, we analyse the relationship between the M&E purposes of the mechanisms and the existence or not of participation in the research process. Finally, we present in more detail the patterns of participation in translations 2 and 3, which are the phases where higher embedded and foreseen participation. We include quotes relevant to each of the findings and mechanisms analysed, which are also provided in Annex D.

Finding a: The primary motivation to promote contextualisation through participation is to increase the evaluation effectiveness.

The three arguments discussed in favour of participation have been identified in the studies analysed (Table 9). The most common argument for participation is the substantive one, which is mentioned in the documents of nine of the mechanisms (see Annex D for proof quotes). References to the substantive argument relate to increments in the evaluation effectiveness of the mechanisms and identification and reduction of risks, negative impacts and trade-offs of their implementation.

In some cases, the substantive argument refers to participatory strategies, including the innovators or end-users of the mechanisms, as exemplified in this quote from mechanism 8, "KPIs for industry".

> "The KPI we use below are based on earlier studies, in which these KPIs are identified, analysed and validated (Flipse et al., 2013a,b). Their relevance to RRI needed to be discussed in collaboration with the organization in which the KPIs are identified; […]. Namely, the KPIs only become relevant when people talk about these in relation to their work, thereby actively considering also the socio- ethical and socio-

> economic aspects of their work (reflexivity, anticipation) and translating these considerations into concrete actions (inclusion and responsiveness)." (Flipse et al., 2015:138)

In other cases, integrating views from actors beyond the end-users to operationalize the M&E criteria was identified as vital for ensuring effectiveness. This applies to mechanism 1, the "Five-stage societal process model" proposed by Voeten et al. (2014), which considers it necessary to integrate the innovators and the local community in the definition of threshold values to avoid the imposition of Western normative frameworks.

> "In regard to the first issue, from our assessment as researchers, we were inclined to asses that Bat Trang village could be labelled as experiencing responsible innovation. During our discussions in later rounds of validating our tentative field assessments, we were confronted with the views of innovators and villagers in the other villages who had a different judgement than us about the whether the outcomes were negative or positive. […] Any attempt that we - as western researchers, not living in the village - might make to define threshold values for these criteria, would involve imposing our normative framework about what is acceptable and what is not." (Voeten et al., 2014:165)

The instrumental argument was identified in six mechanisms and refers to promoting actor participation to increase the ownership and support the policy objectives underlying the M&E exercise by exploiting the actors' performative function. Among the six mechanisms referring to this argument, we found mechanism 6, "EC Expert Group indicators", a finding that was expected as this strategy was identified prior to the review during the research design of this paper.

> "An additional value of involving stakeholders in indicator development will be the fact that if the stakeholders become the 'owner' of the monitoring they will be more ready to accept this as a valuable instrument to improve their performance." (Strand et al., 2015:5)

The third set of justifications, the normative arguments, refer to the alignment with RRI theory and the demand for inclusiveness and public engagement. Six mechanisms refer to this type of argument. The following quote exemplifies this type of argument:

> "In the development of the tool we wanted to apply the RRI approach itself, thus involving members from different stakeholder groups from the very first draft to the final prototype." (Schrammel et al., 2016:5)

In two cases (Mechanism 1, "Five-stage social process model" and 4, "Self-reflection Tool – RRI Tools"), the researchers' reflections about the relevance of promoting participation in their research have led to changes in their initial research plans and their methodological design.

> "This deliverable is a follow-up of the working definition that can be found in D1.1. Although this deliverable was originally scheduled for month six of the RRI Tools project (close after submission of D1.1), we decided to re-conceptualize its role and meaning to some extent, postponing it to after the Stakeholder Consultation Workshops that were held throughout Europe in months nine to eleven (i.e., September to November 2014). We considered it crucial that the reflections of the participants of the stakeholder consultation workshops informed the criteria displayed here, so as to give the criteria a firmer ground in RRI practices throughout Europe." (Kupper et al., 2015:8)

Finding b: Participation is more common in the latter than early phases of the research process.

Analyzing the identified mechanisms shows limited participation in the early phases of research problematization (translation 1). In contrast, participation tends to be more commonly embedded during the research development stage (translation 2) and expected in the application of the implementation in real settings (translation 3) (Table 5).

We observed only three mechanisms referring to inputs during translation 1 from actors other than the research team. These three cases were the only explicit references identified to the role played by external actors in this research phase. The participation in these three cases consisted of funding organizations acting as commissioners of the research (see Annex C for the definition of actors' roles). We identified explicit references to these funding organizations providing input in translation 1 in mechanisms 6 (EC Expert Group indicators), 7 (MoRRI indicators) and 9 (Res-Agora Tools), both of which were funded by the EC. In all these cases, participation in the problematization phase consisted of commissioning the design of the M&E mechanisms. It was limited to setting research evaluation and monitoring priorities, purposes or criteria.

Although we did not identify any other direct references to the role of funding commissioners, we can assume that all of the research processes that received funding as a result of calls for research that steered the research questions and purposes of the mechanisms included at least limited participation of the funding agency in setting those research priorities. This applies, at least, to the eight other cases that received funding under the EC 7th Framework and the Horizon 2020 programmes (mechanisms 2, 4, 8, 11, 13, 16, 19 and 25). However, the level of participation by the funding agency in the problematization phase would be limited to the terms of the call for proposals in which research priorities and research questions are established. We also found that participation in translation 1 did not include other actors' participation apart from the funding agency in the problematization phase.

In the case of references to embedded or planned participation in translation 2 (development of the research) and translation 3 (implementation in real settings), this involved 19 of the 25 mechanisms analysed (see Table 5). Fifteen mechanisms involved the participation of actors in translation 2, and other ten mechanisms foresee participation in the application of the research outputs in real-world contexts (translation 3). We identified 6 cases of participation in both phases 2 and 3 (mechanisms 2, 8, 9, 11, 14 and 20).

Finally, six of the mechanisms identified were neither embedded for planned participation in any research stages (mechanisms 3, 5, 12, 18, 21 and 22). As we aim to explore the features of participation in the existing M&E methods and tools, we have not included such mechanisms in all the analysis of findings regarding participation (finding d). However, they will be mentioned in the next finding about the relation between the participation and the purposes of the M&E mechanism.

Finding c: Participation is most commonly linked to "Learning and Reflexivity" and "Trust and Cooperation" purposes.

In our analysis of the problematisation phase, we coded the purposes of the M&E mechanisms. Several sample documents referred to more than one purpose for a particular mechanism. We, therefore, included subcategories for a primary and secondary purpose, identified by comprehensive analysis of the original codification. For example, in the case of mechanism 9 (Res-Agora Tools), we found references to all the categories of the purposes and three mechanism components with complementary functions: RRI Trends (monitoring tool), Co-Construction Method (stakeholder workshop method) and Responsibility Navigator (self-assessment tool). To identify the primary purpose, we analysed the general objective of the project and the role and relation between these components. We identified that the RRI Trends and Co-Construction Method supported the design of the Responsibility Navigator, whose primary purpose was included in the "Trust and Cooperation" category.

The most frequent purposes (see Annex C for the definition of the categories) are “Learning and Reflexivity” (ten as primary purpose and five as secondary), “Decision Making and Accountability” (eight as primary purpose and nine as secondary), “, “Knowledge Creation” (six as primary purpose and seven as secondary) and “Trust and Cooperation” (one as primary purpose and three as secondary) (see Table 5).

A special mention should be made regarding mechanisms 6 (EC Expert Group indicators) and 7 (MoRRI indicators) and their primary purposes. These mechanisms are among those that explicitly include the participation of the funding actor in the problematisation phase. In these two cases, the funder’s (EC’s) primary purposes are included in the category “Decision making and accountability”, but the authors of the documents analysed refer to the importance of “Learning and reflexivity” as the primary purpose of the M&E exercise.

Some specific patterns emerge from our analysis of the relation between the primary purposes and the existence of embedded or planned participation. Participation seems to be linked to “Learning and Reflexivity” and “Trust and Cooperation”. The ten mechanisms in the “Learning and Reflexivity” category involved embedded or planned participation in translations 2 or 3, and three mechanisms (9, 11 and 20) included participation in both research phases. Mechanism 9 (Res-Agora Tools), the only mechanism in the “Trust and Cooperation” category, embeds participation in translation 2 and plans participation in translation 3. None of the six mechanisms where participation was not considered in any of the stages (3, 5, 12, 18, 21 and 22) was aimed primarily or secondary at “Learning and Reflexivity” or “Trust and Cooperation”. Instead, they were aimed at “Decision Making and Accountability” (3) and “Knowledge Creation” (3).

Table 5 *Motivation to promote participation, references to participation in the research process and main and secondary purposes*

	Motivation to promote participation			**References to stages for participation**			**Main and secondary purposes**			
	Substantive argument (9)	Instrumental argument (6)	Normative argument (6)	T1 (3)	T2 (15)	T 3 (10)	Knowledge creation (6+7)	Decision making and accountability (8+9)	Learning and reflexivity (10+5)	Trust and cooperation (1+3)
1 Five-stage societal process model	X	X			X		**X**			
2 Quality criteria and indicators for RRI	X				X	X	**X**	X	X	
3 Guide to entrepreneurs […] on RI criteria								**X**		
4 RRI Tools - Self-reflection Tool			X		X		X	X	**X**	
5 Responsible Port Innovation							**X**			
6 EC Expert Group Indicators		X		X		X		X	**X**	X
7 MORRI Indicators				X	X		X	X	**X**	
8 KPIs for Industry	X				X	X	X	**X**		
9 Res-AGORA Tools			X	X	X	X	X	X	X	**X**
10 Responsible Project Management	X					X		**X**	X	
11 PERFORM analytical framework for science education	X	X	X		X	X	X		**X**	
12 Framework aligning activities, aspirations and stakeholders							**X**	X		
13 RRI Maturity Models	X				X		X	**X**	X	
14 INPERRI AHP participatory approach	X	X	X		X	X		**X**	X	
15 Analytical framework of RRI in Smart Farming		X				X	**X**			
16 ENRRICH Peer evaluation approach	X		X		X				**X**	
17 Responsible Innovation in Health Tool					X		X	**X**		
18 RRI index								**X**		
19 COMPASS self-check tool					X			X	**X**	
20 Future-oriented RRI evaluation		X	X		X	X			**X**	X
21 RRI intensity level							**X**	X		
22 Responsible creativity and innovation scale								**X**		
23 Reflexive Monitoring in Action for RRI	X				X			X	**X**	
24 Qualitative Multicriteria Self-Questionnaire						X			**X**	X
25 Societal Readiness Thinking Tool					X				**X**	

Finding d: In translation 2 and 3 participation of actors as criteria providers is aligned with conceptualization through participation.

In the analysis of participation in translation 2, we found three roles of actors participating in translation 2 (see Annex C for further details on roles): criteria providers - those that participate in the process to define the operationalization and evaluative criteria-, design reviewers -those that participate in the research process to provide feedback to the M&E design (i.e. usability tests)-, and respondents or data providers -those that provide evaluation information.

The participation of actors as criteria providers during the research development is aligned with the principles of engagement in RRI. It implies consideration of actors as providers of knowledge and value to the design of M&E mechanisms in different types (different intensity and time commitment) of participation. Participation as design reviewers is focused mainly on providing inputs into the usability of the research outputs and less on involvement in the design and decision processes. In these cases, participation might respond more to the correct research method application than to alignment with RRI principles. Similarly, suppose the actor participating in translation 2 acts as a respondent. In that case, their role is limited to providing the necessary information to perform the assessment or evaluation. Hence, it has methodological importance but does not reflect, per se, an alignment with the principles of RRI. We will therefore analyse in more detail the features of participation in translation 2 of actors as criteria providers. The existence of actors participating in this role responds to what we call contextualization through participation; this is strategies and processes that allow or call for actors' participation in designing these mechanisms to adapt them to a specific context.

In thirteen mechanisms, actors were involved as criteria providers of input and knowledge to develop the evaluative and monitoring criteria (1, 2, 4, 7, 8, 9, 11, 13, 14, 16, 17, 23 and 25). In these cases, actors were involved through a consultive or deliberative approach in the criteria design. Proof quotes can be consulted in Annex D, including:

> "To arrive at a comprehensive model of RRI and its criteria, we engaged in a process of iterative conceptual modelling (Figure 9.1, and see Klaassen et al. 2017 for a more extensive description). Central to this methodology for concept development are different and disparate forms of expertise, confronted in a series of iterative steps which, in this case, sought to answer our question 'What is RRI?'." (Klaassen et al., 2020:225)

In some cases, the participation of actors in translation 2 affects to the dimensions of responsiveness and reflexiveness in the development of the research process. For instance, as an example of responsiveness, including actors as criteria providers in translation 2 implied a change to the initial research plan described in finding a) on mechanisms 1 and 4. In other cases, researchers reflect on the risk of imposing normative frameworks derived from the non-participation of other actors in mechanism 1, "RI Conceptualization" or regarding the degree of participation in mechanism 11, "PERFORM project".

> "At this stage of the project (Month 7), participant students have been already included in the assessment design, through the explorative workshops and the identification and validation of criteria and indicators relevant to them. This is a rather basic level of participation, represented by the implementation of methods to gather participants' opinions and insights about topics of their own interest to be included in the assessment design; such as exploratory workshops or focused discussions." (Heras et al., 2016:59)

The intensity of actor participation as criteria providers in terms of time and number of actors involved varied across mechanisms (see Table 6). Sometimes, it implied multiple meetings over several months,

many participants or using techniques such as Delphi studies. In other cases, they involved explorative sessions with a limited number of participants and a short duration.

In translation 3 there are also different roles foreseen for actors beyond the research teams in the mechanisms analysed. Similarly, to translation 2, there are several cases in which actors are expected to participate in adapting the mechanisms to the context of use by adopting the role of criteria providers through the process that we refer to as contextualization through participation. Additionally, references to the participation of actors acting as evaluator coordinators, final end-users, respondents or data providers are also foreseen in this phase.

Regarding actors participating as criteria providers, we found nine references to planned contextualization through participation in the implementation phase in real settings (2, 6, 8, 9, 10, 11, 14, 15 and 20). It is exemplified in the following quote (see other proof quotes in Annex D):

> "Thus, there are critical questions that need to be kept in mind and solved when the model is applied. […] Fourthly, the evaluation should pay careful attention to the identification and engagement of stakeholders to ensure, not only fair and wide, but also effective participation. And finally, the far from simple challenge of functional indicators and their measurement needs to be addressed to provide appropriate follow-up indicators and incentives for RRI. (Nieminen and Ikonen, 2020: 265)

The commitment to the participation of actors in this phase is especially relevant in mechanism 9, as a specific method (the Res-Agora Co-Construction Method) is provided for facilitating cooperation with actors in the governance of research processes during the implementation of the tool in real settings.

Among the other roles identified in translation 3, reflecting on the strategy proposed to involve experts and independent assessors in the implementation phase is also relevant. We have coded this role as evaluator coordinator, and it is referred to in mechanisms 8 and 17. In the case of "KPIs for Industry", the need to reflect on the role of external assessors to provide an independent assessment that complements self-assessments is pointed out. The "Responsible Innovation in Health Tool" provides recommendations on the skills that the person carrying out the assessment should fulfil to use the mechanism adequately.

We also found contextualization to adapt the M&E mechanism to the context of the unit of analysis but not linked strictly to participation. The expectation to contextualize the research output was limited only to the adaptation of the tool to the characteristics of the unit of analysis in the evaluation and monitoring exercise.

Regarding the patterns of contextualization and participation identified in translation 3, contextualization through actors' participation as criteria providers are well aligned with RRI. This strategy allows different actors to participate actively in adapting the mechanisms to the application context. The second and third patterns identified, the participation of experts in research in implementation and the contextualization to the unit of analysis are relevant from an evaluation perspective. However, these types of contextualization and participation do not imply, per se, integration of the RRI principles regarding actors' involvement.

Table 6 *Basic description of the mechanisms and of the participating features*

Code and name	Evaluand	Description of the mechanism	Participation time qualifiers	Participating actors [2]	Role of participating actors	Method of participation	Duration of participation
1 Five-stage societal process model	Innovation project	5-stage societal process, qualitative threshold	T2	Local communities Innovators	Criteria providers	Observation Interviews	Not specified
2 Quality criteria and indicators for RRI	Project	Rubric of qualitative performance indicators, 7 quality criteria	T2, T3	Business and Industry Scientist and researchers Experts *Various actors foreseen for T3*	Criteria providers	Workshop including World-café, small groups and plenary discussion, outcome space posters	Several months and 2 days' workshop (17 people) in T2
3 Guide to entrepreneurs […] on RI criteria	Project	Grid with 24 criteria for 4 dimensions, to be assessed in 5 levels. Plus qualitative questions and indicators to support the assessment	-	-	-	-	-
4 RRI Tools - Self-reflection Tool	R&I strategies and activities	Self-reflection tool with 6 policy agendas, 4 process requirements and indicators (qualitative questions, including the possibility of create new questions)	T2	Business and Industry CSO Policy Representatives and decision-makers Experts Stakeholders	Criteria providers Design reviewers	Consultation workshops Meetings and one to one online conversation (Focus Group and world-Cafe) Questionnaires and data from users	Several workshops during two months for criteria providers Several events during the project execution for design reviewers. Total 130 people
5 Responsible Port Innovation	(Mega) Project	Methodology (9 steps) and methods (qualitative questions)	-	-	-	-	-
6 EC Expert Group Indicators	RRI initiative (activities, policies)	6 dimensions, with performance (process and product) and perception indicators (plus two dimensions	T1, T3	RFO (T1 and 3) RPO (T3) CSO (T3) Policy representatives and decision-makers (T3)	Commissioning client (T1) Criteria providers (T1, T3)	Framing (T1) Deliberation (T3)	Through the research process (T1) Not specified (T3)

[2] Acronyms: CSO (Civil Society Organizations), RFO (Research Funding Organizations), RPO (Research Performing Organizations)

		with no developed indicators)		Research and project managers and administrators (T3) Scientists and researchers (T3) Publics (T3) Stakeholders (T3)	No commissioning client/end-user (T3)		
7 MORRI Indicators	Research System (strong aggregation of institutions)	Monitoring system of indicators with 6 dimensions and 36 indicators	T1, T2	RFO (T1, T2) Scientists and Researchers (T2) Experts (T2) Publics (T2) Stakeholders (T2) Innovators (T2)	Commissioning client (T1) Criteria providers (T1, T2)	Workshop and meetings (T1) Video conference (T2) Visioning workshop (T2)	Through the research process (T1, T2)
8 KPIs for industry	Innovation projects Group of projects	RP1[3]: Tool based on quality assessment method providing 8 key performance indicators (KPIs), quality scores and scenarios. RP2: Methodological framework with 2 categories, 8 components and 92 key performance indicators	T2, T3	RP1: Innovators RP2: Business and Industry (T2 and 3) and Companies and SMEs (T2 and 3)	RP1: Criteria provider, No commissioning client/end-user RP2: Criteria providers (T2 and T3); Respondents (T3)	Scoring success-related items	RP1: Not specified RP2: Several activities through the project involving more than 100 stakeholders
9 Res-AGORA Tools	R&I strategies and activities	Monitoring tool (RRI Trends) Stakeholder workshop method (Co-Construction Method) Self-assessment tool (Responsibility Navigator)	T1, T2, T3	RFO (T1) RPO (T2) Business and Industry (T2) CSO (T2) Policy representatives and decision-makers (T2) Stakeholders (T2, T3)	Commissioning client (T1) Criteria providers (T2, 3)	Stakeholder workshops	Various workshops during the project
10 Responsible Project Management	Megaproject	Integrative framework including 6 principles of sustainability, 4 dimensions of RI and	T3	Stakeholders	Criteria provider No commissioning client/end-user	Deliberation	Not specified

[3] RP: Research process

		instruments of accountability with customised variables					
11 PERFORM analytical framework for science education	Project (aggregation in some cases of people performance)	Analytical framework composed by 4 key learning dimensions, 32 assessment criteria and learning outputs and 86 indicators	T2, T3	Students (T2) Stakeholder (T3) Scientists and researchers (T3)	Criteria providers (T2, T3)	Participatory action research approach and workshops (T2)	Eleven workshops in three countries (T2)
12 Framework aligning activities, aspirations and stakeholders	Innovation governance	Framework assessing alignment of 2 aspirations with 3 dimensions, 5 types of activities and stakeholders	-	-	-	-	-
13 RRI maturity models	Institution (Industry)	RP1: 3 Key Performance Indicators (KPIs), 12 sub-indicators and 5 levels of for each sub-indicator RP2: RRI Maturity model and self-assessment tool, 3 categories, 14 components, 5 levels	T2	Business and Industry Stakeholders	Criteria provider Design reviewers Respondents	RP1: Interviews and Case study (1) RP2: Interviews, Bottom-up case study, Stakeholder dialogue, Multi-stakeholder workshops, Large-scale Delphi Study, Focus groups and Case studies	RP1: 30 interviews in 11 countries + 5 interviews for a case study RP2: interviews (30 people); Bottom-up case study (5); Large-scale Delphi Study (150 people); Focus groups (15); Case studies (4)
14 INPERRI AHP participatory approach	RRI initiative (activities, policies)	Methodology based on the use of the Analytical Hierarchy Process technique and a participatory approach	T2, T3	RFO (T2) RPO (T2) CSO (T2) Companies and SMEs (T2) Policy representatives and decision-makers (T2) Research and project managers and administrators (T2)	Criteria providers (T2, T3)	RP1: Face-to-face and online interviews RP2: Participatory workshop	RP1: 12 interviews (one per expert) RP2: 1-day participatory workshop

				Scientists and researchers (T2) Experts (T3) Stakeholders (T3)			
15 Analytical framework of RRI in Smart Farming	Project	Analytical framework composed by 4 RI dimensions and 9 indicators	T3	RFO RPO CSO Business and Industry Companies and SMEs Policy representatives and decision-makers	Criteria providers	Deliberation	Not specified
16 ENRRICH Peer evaluation approach	Project	Peer evaluation approach	T2	Students	Criteria providers	Participatory techniques that are built on a bottom-up approach (discussion)	Not specified
17 Responsible Innovation in Health Tool	Health Innovation	Screening (4 criteria), assessment (9 attributes, 5 value domains) and rating (scoring system with 2 components)	T2	Innovators (T2) Experts (T2, T3)	Criteria providers (T2) Evaluator coordinator (T3)	Delphi study Interviews	2-round Delphi study with 19 experts in the second round Interviews (23)
18 RRI index	Company	RRI Index with 6 dimensions and 11 components	-	-	-	-	-
19 COMPASS self-check tool	Company	Self-assessment tool, 4 sections, 43 questions, 249 answer options	T2	RFO RPO CSO Companies and SMEs Experts	Design reviewers	Consultation to experts Interviews Group discussions	1 consultation to experts 84 participants in interviews and group discussions and 30 individuals in a second-round of feedback
20 Future-oriented RRI evaluation	R&I strategies and activities (platforms)	Methodology based on 4 steps	T2, T3	Experts (T2) Stakeholders (T2, T3)	Design reviewers (T2) Criteria providers (T3)	Workshop	1 workshop with 20 people (T2)
21 RRI intensity level	(ICT) Project	Method of 3 steps to ex-ante assessment of technology readiness	-	-	-	-	-

		level and innovation potential					
22 Responsible creativity and innovation scale	People (in business context)	Scale with 7 items	-	-	-	-	-
23 Reflexive Monitoring in Action for RRI	Research Project	Methodology (4 criteria, 17 sub-criteria and inviting questions)	T2	Experts (T2) Stakeholders (T2) Evaluator specialist (T3)	Criteria provider (T2) Evaluator coordinator (T3)	Experts interviews Stakeholder consultation workshop	Through the research process (T2)
24 Qualitative Multi-criteria Self-Questionnaire	Project	Methodology; self-assessment; 6 questions and 31 sub-questions (criteria)	T3	Business and Industry	No commissioning client/end-user Respondents	Questionnaire structure through a MCDA technique	Not specified
25 Societal Readiness Thinking Tool	Research Project	Stage gate model for projects with reflective questions in social dimension	T2	RPO Scientists and Researchers Policy representatives and decision-makers	Criteria providers Designer reviewers	Design Sprint Focus groups Thinking Aloud interviews	2-days design sprint 6 Focus groups with 38 participating actors 6 Thinking Aloud interviews

3.7 Discussion

We have analysed the participation of actors in the design of M&E mechanisms of RRI structured around the three stages of research proposed by Callon and colleagues (2009). To our knowledge, there is just one previous study reviewing M&E methods and tools of RRI by van de Poel (2020), and its focus is on identifying pitfalls in M&E of RRI. Recent literature points out the need for monitoring and evaluating RRI at the territorial level (Völker et al., 2023) and through engaging processes with stakeholders that facilitate contextualized monitoring and evaluation of RRI (Holtrop et al., 2022). In the opposite direction, there are also calls for developing global indicators that overcome the contextualized approaches of M&E (Jensen, 2022). Hence, our work contributes to this research by exploring the role of actors' participation in research processes towards M&E mechanisms of RRI and discussing its implications. The RRI scholarship has been defined as "highly reflexive" (Völker et al., 2023:05). We want to contribute with our analysis to opening a window for further reflexivity in M&E research for RRI.

In this section, we discuss our findings compared with previous literature on features and challenges of participation in RRI. The discussion is structured into three subsections. First, we explore the implications of having found twenty-five research processes towards developing M&E mechanisms of RRI. Then we discuss the specific findings of our paper. Finally, we present a set of recommendations to integrate some learnings from our findings in future research on M&E mechanisms of RRI.

Twenty-five research processes towards M&E mechanisms of RRI

We found research processes developing 25 mechanisms of M&E, which confirms the growing interest in developing these methods and tools in parallel to the growing interest in the RRI notion. This fact aligns Jensen's observation (2022) of the uneven amount of measurement initiatives for data collection and analysis of RRI.

The unit of analysis of the mechanisms is diverse. In some cases, these units are well-defined (such as projects and companies), but in others, they ambiguously refer to strategies or activities. In its analysis of M&E mechanisms of RRI van de Poel (2020) defines the innovator as "the actor that is the object of the RRI assessment" and assumes that it is "a specific organization rather than to the entire knowledge or innovation system" (2020:341). In our analysis, most mechanisms focus on project or company levels. However, we also found some examples of mechanisms addressed to evaluate people or innovation systems, innovation governance or countries. In this regard, Jensen (2022) advocates for "establishing globally relevant and usable indicators is challenging but essential given the global nature of science". So, we identify divergent positions and expectations on who might be the object of assessment in the existing literature. This might be due to the co-existence of diverse approaches to RRI and the difficulty of assigning responsibility roles in the R&I system.

The growing existence of M&E mechanisms can be considered a result of efforts to institutionalise the concept of RRI[4]. A considerable amount of the research processes analysed received funding from calls for proposals steering specific research priorities (such as, at least, the 7th Framework Programme

[4] We would like to thank one of the reviewers for drawing our attention to this point.

and Horizon 2020 of the EC). We coded the role of funding agencies commissioning the development of M&E mechanisms for RRI as commissioning clients, capturing a similar function to the one proposed by van de Poel when defining the regulator or standard setter as the actor setting standards that "can also concern how RRI assessment is to be carried out and by whom" (2020:342). Therefore, we could infer that growing funding has increased the number of research teams interested in the topic. These two elements combined have, in turn, increased the number of developed mechanisms.

Our paper examined the development of M&E of RRI as a research process focusing on actors' participation in such processes. We hypothesise is that the research processes toward M&E mechanisms of RRI can be considered an object of analysis from an RRI perspective, providing new inputs on challenges for the participation of actors. Therefore, we wanted to explore how participation as a proxy of inclusiveness in terms of Stilgoe et al. (2013) or public engagement in terms of the European Commission (2012) was embedded or foreseen in those processes. This strategy aligns with Smith et al.'s (2021) suggestion that RRI should be considered a form of knowledge production and with Rip's (2014) notion of RRI as social innovation. So, we examined the extent of contextualization of M&E mechanisms based on actors' participation in these processes. RRI narratives emphasize public, and stakeholder engagement and inclusion (Burget et al., 2017; Fraaije & Flipse, 2020; Timmermans & Blok, 2021), but our findings show that contextualization through inclusive participation of actors in the design of M&E processes for RRI is not equally distributed in terms of the research phases where it occurs and with relation to the evaluative purposes of the M&E mechanisms.

Findings in our analysis

Our first findings refer to the various **arguments proposed to justify the participation** of different actors in the design of M&E mechanisms for RRI. Our results show that the arguments in the documents analysed include substantive, instrumental and normative arguments. The substantive argument was the most mentioned, with nine research processes referring to it, and the instrumental and normative were mentioned in six cases each. We could have expected higher levels of consideration of the normative argument in the documents reviewed since this argument refers to a core aspect in the different accounts of RRI. Following some of the more common operationalisations of RRI (European Commission, 2012; Stilgoe et al., 2013), both public engagement and inclusion are considered key elements or dimensions of RRI. Even though there are some cases where the normative argument is directly mentioned, it is found in six out of twenty-five cases.

On the other hand, most mechanisms directly referring to arguments (any of them) for the participation of actors also refer to participation at some stage of the research process. Participation was found embedded or planned in 19 of the 25 mechanisms analysed.

Regarding the **moment participation occurs**, we have observed a trend towards a higher presence of participation in the latter than early phases of the research. Translation 1 refers to the early research stage, when the research questions are defined, and important theoretical and methodological decisions are taken, such as the determination of the M&E purposes and the unit of analysis of the M&E exercise.

Our findings suggest that participation in the early research stages is limited to the research commissioners establishing the M&E priorities, purposes or criteria. The lack of (documented experiences on) diversity of actors' participation in this early phase reduces opportunities for discussions (and contestation) in defining the aim and purposes of M&E. This has implications on two

levels. On the one hand, participation of actors in RRI is expected to occur since the early stages of the research (van den Hoven et al., 2013; von Schomberg, 2013) and to be, among others, inclusive, continuous and open to set framing issues (Bauer et al., 2021). This would imply allowing space for contestation and dissent about the monitoring and evaluative purposes of the mechanisms, opening up alternatives of appraisal (Stirling, 2007) and promoting societal alignment to better management of uncertainty at early phases of the research (Ribeiro et al., 2018). Taking this argument to the extreme, contestation in translation 1 might even imply deciding not to develop or implement an M&E mechanism in a particular context if the possible adverse effects did not counterbalance the positive ones. This possibility would fit into the concept of responsible stagnation used by de Saille & Medvecky (2016), which is explained in these terms "It should be noted that a better "output" does not necessarily mean a better "product" – the better outcome may be *no* product" (Ten Holter, 2022:282).

On the other hand, societal engagement is expected to improve R&I decisions, allowing "participants to contribute their knowledge, experiences and perspectives and raise questions and concern about the direction of R&I" (Bauer et al., 2021:352). The decisions taken in the early phases of the research around the definition of purposes of M&E are of key importance for the configuration of roles and context-specificity in the latter phases (van de Poel, 2020). Adapting M&E mechanisms to their objective, based on contextualization and participation strategies, in line with Hicks et al.'s (2015) recommendation to contextualise indicators to their evaluative purposes and to consider the socio-economic and cultural contexts of use and potential variations according to the research field or epistemic context. This type of adaptation is considered vital in contextualizing them to "geographic, social and epistemic conditions" and to the "value preferences of the stakeholders involved" (Ràfols, 2019: 15).

In the latter stages of the research (translations 2 and 3), we found that participation implies actors' participation as criteria providers. This is through strategies involving consultation with actors or actors' deliberation to conceptualize and define the criteria of the M&E mechanisms. The strategies undertaken in translation 2 to embed actors' participation in the research process to operationalize the M&E criteria vary in duration, number of actors participating and techniques used. We found some exemplary cases of high levels of commitment and involvement of stakeholders in terms of the range of actors involved and time dedicated to defining M&E criteria. The major or minor participation of actors in this phase might be due, among other issues, to the resources available by the research teams that could limit or facilitate the strong involvement of actors.

In the case of translation 3, we analysed whether contextualization through participation occurred if the research outputs developed in translation 2 were applied in practice. Our objective was to identify if the actors' involvement before using the outputs of translation 2 was expected to adapt the mechanisms to the context of application. We also identified some exemplary cases of contextualization of the mechanisms through the planned participation of actors. In this case, we analysed how the research teams envisioned actors' participation to contextualise the research outputs (the tools or methodologies developed) to be used in real settings. In translation 3, the scarcity of resources could not justify the lack of consideration of actors' participation in translation 3 as it is a foreseeable exercise.

Another interesting finding is the relation between the evaluative purposes and the presence or foreseen participation in the research process. The most frequent purposes in our analysis are "Learning and Reflexivity" (ten as primary purpose and five as secondary), "Decision Making and Accountability" (eight as primary purpose and nine as secondary), "Knowledge Creation" (six as

primary purpose and seven as secondary) and "Trust and Cooperation" (one as primary purpose and three as secondary) (see Table 9). A common feature regarding the purposes of the analysis of van de Poel (2020) is that some research approaches try to respond to multiple purposes. Van de Poel argues that mechanisms should clearly respond to one rationale and clearly state them to address possible pitfalls.

We could expect that the features of participation were related to the purposes and evaluative aspects of the M&E exercise. Green (2007: 18) refers to "evaluation purposes [that] can be roughly aligned with different philosophical paradigms, but more importantly, are aligned with different audiences for evaluation studies". Therefore, higher levels of participation by a broader range of actors could be expected, as shown in our findings, in mechanisms that respond to "Learning and Reflexivity" and "Trust and Cooperation" purposes (Ligero Lasa, 2015). However, an RRI approach should involve a certain level of participation or, at least, critical reflection about lack of participation, regardless of the research objective, since "engaging a range of stakeholders for the purpose of substantively better decision making and mutual learning" characterizes all of the proposed definitions of RRI Wickson & Carew (2014:255). Future research on the M&E of RRI would benefit from a higher reflection in this regard to work towards a "more ambitious vision for RRI" (Owen et al., 2021:223) and engage, as far as possible, with RRI as the site for ongoing debate, the site of praxis and the site for politics, as proposed by these authors.

From another point of view, when mechanisms have an accountability or decision-making purpose, the need to develop instruments that allow comparison might imply less space for participation. Making global and representative actors participate might be challenging when comparison is necessary. In this line, Jensen (2022) calls for "high quality indicators" that "given the global nature of science, […] need to be relevant to countries across all world regions". So, when the purpose is comparing, and the levels are large units of analysis, such as countries, there might be less scope for participation to happen.

Recommendation for future research in M&E of RRI

From our analysis, we conclude that the level of participation of different actors in developing M&E mechanisms of RRI could be strengthened, especially in the early phases of the research. As one key funding agency for this type of research, the European Commission is the only identified actor behind the research teams participating in decisions about the purposes and units of analysis for the mechanism. The research on M&E mechanisms of RRI would benefit from discussing in detail the role of embedded or foreseen participation through the entire research process, facilitating new opportunities for creating higher reflexivity in the field. We see scope for integrating (and reporting) increased participation in decision-making and co-producing framings with different actors, especially in translation 1. Considering that M&E mechanisms of RRI are tools "entwined with the political and organizations context" in which they operate (Völker et al., 2023:05), we suggest opening up space for contestation and increasing social appraisal (Stirling, 2007). To this concern, implementing evaluative conversations since the early phases of the research process, as proposed by Holtrop et al. (2022) and identifying structured approaches for the management of stakeholders' involvement and decision-making (Ten Holter, 2022) could reinforce the reflexivity and responsiveness of the research in this field.

By using these types of methods and tools, research teams developing M&E mechanisms could better explain the levels of stakeholders' participation and the decision-making process since the early phases of the research, providing valuable thoughts for the RRI community.

3.8 Conclusion

This study aimed to identify the strategies used to contextualize and engage the participation of actors in the design of M&E mechanisms of RRI, considered a key feature of the notion of RRI. Our findings show that the level of participation of actors other than the research team varies widely, and we found only limited participation in the early research. We recommend greater inclusion of actors in the early phases of the research to allow contestation and facilitate social alignment. For this purpose, future research would benefit from using methods and strategies to increase the degree of reflexiveness and responsiveness in the level of participation of different actors and the possibilities of contestation in the decisions made throughout the development of M&E mechanisms of RRI.

Capítulo 4 . Indicators for Responsible Research and Innovation: A Methodological Proposal for Context-Based Weighting

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Indexada en JCR (Q3) en *Green and Sustainable Science and Technology* y JCR (Q2) *en Environmental Sciences* y en Scimago (Q1) en Management, Monitoring, Policy and Law

Abstract

In the last decade, the term Responsible Research and Innovation (RRI) has rapidly attracted the attention of policy-makers and researchers of Europe, mainly due to its promotion by the European Commission (EC). The concretion of this framework of RRI has been articulated by the EC around six key areas: governance, public engagement, gender equality, science education, open access, and open science and ethics. The indicators to measure these dimensions have been proposed recently. In our opinion the set of indicators available so far has two weaknesses: a lack of context-based indicators and a need for hierarchical ordering. Our aim is to provide tools for policy- and decision-makers that might need to identify the more important indicators in a specific context. In this work, we explored how the multicriteria analysis technique Analytical Hierarchical Process (AHP) can be used to prioritize indicators for RRI by involving experts in the specific context. The AHP method allowed weighting indicators according to experts in the different areas and producing four different options to select indicators. The method of AHP can be an appropriated instrument to select the most suitable indicators for RRI policies and initiatives.

Keywords: multiple criteria decision-making (MCDM); Responsible Research and Innovation (RRI); science policy evaluation; sustainable science.

4.1 Introduction

Responsible Research and Innovation (RRI) has attracted notable interest of the scientific community in Europe. The inclusion of this concept in the European scientific policies since 2010 has been an indisputable driving force. In 2014, the European Commission (EC) defined Responsible Research and Innovation (RRI) as a practice in which "societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs, and expectations of European society" (European Commission, 2014). RRI brings together a body of theoretical concerns that arose since the 18th century (von Schomberg, 2013) and crystallized during the 19th century (Stilgoe et al., 2013) around the expected and unexpected impacts of research and innovation, technology assessment, and regulation of science. Increased technological capacity has evolved in parallel with the interest in the consequences and the impact of such research activity. However, using the acronym RRI to channel these concerns is much more recent (Owen et al., 2013). The quick and mainstreamed irruption of the concept RRI in the European scientific agenda caused a reaction from the scientific community, which reflects on how it might be articulated and put in practice, how to measure efforts in this context, and how to integrate the efforts made in other areas of knowledge. The purpose of this article is to present an exploratory study on how the multicriteria analysis technique Analytical Hierarchical Process (AHP) (Saaty, 1980) could be used to weight and select by relevant actors the indicators proposed so far (Strand et al., 2015) to measure the processes, results, and outcomes of the RRI policies and initiatives in specific contexts. AHP is a well-known technique based on assessing criteria by means of pairwise comparisons. This technique enables taking into account several variables in accordance with the multidimensional structure of the object of analysis, making judgments based on paired comparisons and obtaining one-dimensional AHP weights that represent the relative importance of the indicators. A detailed description of this technique is presented in Section 2.3 of this article.

4.1.1 Responsible Research and Innovation in Europe

Proponents of the concept RRI have been mainly organizations funding public research programmes. In this regard, the European Commission (EC) has played a key role due to its influence among the agents of research in Europe.

The current organization of RRI proposed in Horizon 2020 program is the culmination of a process which began in 2001 (European Commission, 2012). The action plan "Science and Society" of the Sixth Framework Program for Research and Innovation of the European Commission (2002–2006) defined a common strategy that would allow a better connection between science and the public. The inclusion of that consideration moved to the next action plan, "Science in Society", in the Seventh Framework Program for Research and Innovation (2007–2013), also of the European Commission. "Science in Society" had as objectives to accelerate participation and promote two-way dialogue between the scientific community and civil society. The interest to improve relations between science and society culminated with the adoption of the concept RRI in Part V, "Science with and for Society", of the Horizon 2020 funding program of the European Commission. This represented a milestone in the consolidation of RRI stands in the jargon of the policies of research and innovation in Europe.

During the last years, the connections between science and society, and efforts to organize innovation ecosystems in which the concerns of the general public were considered also attracted the interest of different groups of academics (Owen et al., 2012). They often used the term Responsible Innovation

(RI), with a special focus on the management and decision-making processes around expected and unexpected impacts of technology and innovation.

The commitment to actively engage stakeholders to improve the processes of decision-making and mutual learning in the field of research and innovation is identified as one of the main features in different definitions of the term RRI (Wickson & Carew, 2014), and it is aligned with the discourse ethics formulated by the German philosophers Karl-Otto Apel (1988) and Jüger Habermas (1992). The participation of stakeholders in these decision-making processes in science through rational dialogue would be necessary to legitimize the demands, interests, and expectations of society. In this regard, the European Commission (2012:2) proposed a definition that adds references about the alignment of values among stakeholders and the research and innovation ecosystem that this process involves: "Responsible Research and Innovation means that societal actors work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs, and expectations of European Society".

Von Schomberg's definition of RRI (von Schomberg, 2013:19) combines the reference to dialogue among stakeholders groups with the shared responsibility of the different actors: "Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovations become mutually responsive to each other with a view to the (ethical) acceptability, sustainability, and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)".

The reference to the sustainability imperative proposed by the Brundtland Commission (World Commission on Environment and Development, 1987) is also mentioned in the definition of Stilgoe et al. (2013:1570): "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present", in line with the concept of responsibility formulated by Hans Jonas (1979).

In a similar way, van den Hoven and Jacob (van den Hoven et al., 2013:3) remarked the importance of active participation of stakeholders in considering future impacts of research and contrasting them with the ethical values as a key feature of RRI: "Responsible Research and Innovation (RRI) refers to the comprehensive approach of proceeding in research and innovation in ways that allow all stakeholders that are involved in the processes of research and innovation at an early stage (A) to obtain relevant knowledge on the consequences of the outcomes of their actions and on the range of options open to them and (B) to effectively evaluate both outcomes and options in terms of societal needs and moral values and (C) to use these considerations (under A and B) as functional requirements for design and development of new research, products, and services".

To the active involvement of stakeholders in all phases of the research and innovation process, a set of dimensions has been added with the purpose of establishing a framework to construct responsible ecosystems of innovation. These dimensions, identified by researchers such as Stilgoe et al. (Owen et al., 2013; Stilgoe et al., 2013) using the term Responsible Innovation rather than RRI, are relevant to the development of the theoretical framework around RRI and RI in the future and include: anticipation, reflexivity, inclusion, and responsiveness.

As far as both concepts, RRI and RI, are developed, different combinations of levels or responsibility can be identified. On the one side, the concept of RRI combines thematic areas of the intrinsic personal responsibility of scientists and collective responsibilities of research and innovation organizations. On

the other hand, the framework for RI emphasizes the features that a responsible ecosystem should have to assure correct technology assessment and decision-making processes.

For the purpose of our study, focused on the indicators proposed to measure RRI initiatives, the approach of the European Commission has been used, which is structured around thematic elements or areas of key importance in the articulation of RRI. The importance of analysing those key areas lies on the fact that they define the components of all the proposals of indicators available so far to measure RRI initiatives and policies. In this sense, the European Commission has a central role in the promotion of Responsible Research and Innovation and is responsible for articulating a framework for its promotion in European scientific policies. This newly created framework was structured by the EC around six key areas (European Commission, 2012):

1. Public engagement, which refers to the "engagement of all the societal actors—researches, industry, policy-makers, and civil society and their joint participation in the research and innovation process" (European Commission, 2012).

2. Gender equality, which means that "all actors—women and men—are on board" in the public engagement activities (European Commission, 2012).

3. Science education, which implies the enhancement "the current education process to better equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation processes" (European Commission, 2012).

4. Open Access, which means "giving free online access to the results of publicly-funded research (publication and data)" (European Commission, 2012).

5. Ethics, which highlights that "in order to adequately respond to societal challenges, research and innovation must respect fundamental rights and the highest ethical standards" (European Commission, 2012).

6. Governance, an umbrella key area that remarks that policy-makers "have a responsibility to prevent harmful or unethical developments in research and innovation" (European Commission, 2012).

The proposal by the European Commission of these six key dimensions has led to the use of this categorization in the research projects and tenders funded by this supra-national administration. Following the argumentation about the current differences between RRI and RI, it can be identified that, apart from the key areas of public engagement and governance, the articulation of the other four areas of the EC is much more aligned with the so-called ethics of causality. In other words, some of the key areas are highly connected with the core role of science, developing knowledge about the world, and not as much with the ethics of dialogue. In fact, the content of those four areas refers to the expectation of responsible procedures and behaviour by scientists such as honest reporting of data, sharing important results, serving as peer reviews, and training the next generation of scientists properly (Douglas, 2003).

The inclusion of these six areas in RRI, and no others, have been timidly discussed. Van den Hoven and Jacob raised attention to the fact that "many societal needs around the globe have not yet received a lot of attention from researchers, companies, and governments, despite the enormous potential for innovative solutions which accommodate widely shared public values" (van den Hoven et al., 2013:15). Some authors (Strand et al., 2015) have proposed to increase the number of key areas of

the EC framework, providing two new ones, social justice and environmental sustainability. These new areas could integrate the unattended fields mentioned by van den Hoven and Jacob. Additionally, the authors of this work consider that the area of gender equality could also include other factors of diversity such as race, age, and disability.

Recently, Stahl et al. (2017) defined a Maturity Model of RRI to integrate the dimensions proposed by Stilgoe et al. (Owen et al., 2013; Stilgoe et al., 2013) with the key areas proposed by the European Commission (2012) around categories and components of the term.

The discussion about what areas, dimensions, and categories should articulate the framework of RRI is certainly incipient, and a passionate intellectual debate on this subject will probably take place in the next years. This debate will be of vital importance, as it will determine the content of the proposals for the monitoring of initiatives, projects, and policies of RRI. The next section will explore the state of the art in that process of monitoring RRI in Europe.

4.1.2 Indicators for Monitoring Responsible Research and Innovation

The commitment of the European Commission to promoting the RRI approach has resulted in the inclusion of specific calls for projects of research and coordination under this topic in Horizon 2020, concretely under the umbrella of Part V, "Science with and for Society Work Programmes". In parallel, the European Commission is making efforts to promote the consideration of RRI as an inter-sectorial issue in the other parts of the Horizon 2020 programme not specifically dedicated to this issue.

The European Commission has also reinforced the commitment to the monitoring of the RRI approach by promoting definitions of indicators to measure initiatives and policies on RRI. For this purpose, it has funded two studies with the objective of evaluating and monitoring the performance of the different scientific actors in each of the six key dimensions previously mentioned.

The first initiative took place in 2015 with the appointment of a group of experts with the objective of establishing indicators for monitoring the impact of RRI. The result of this first action was a report published in June 2015 that provided a list of 82 indicators for the six areas proposed by the European Commission (Strand et al., 2015). Those indicators were organized in three categories: process, outcomes, and perception, in order to include indicators referring to the action taken within the Research and Innovation sector (processes and outcomes) and to the perception of those processes and indicators by other actors and society in general (Strand et al., 2015). The report also proposed the inclusion of two new areas: (environmental) sustainability and social justice. The group of experts decided to include these two new areas to introduce in their work the importance of addressing the question about to what extend does a research field, a research programme, or an RRI initiative contribute to sustainable growth, in the case of (environmental) sustainability and to monitor the impact of research and its effect on social justice and inclusion, in the case of social justice. In reference to these new two areas, the authors did not propose a detailed list of indicators but instead proposed ideas and suggestions about how they could be defined.

This first list of indicators is relevant to the study of monitoring RRI, as it is the first effort made to operatize a system of monitoring and reporting. Even though, it cannot be considered a definitive proposal, as in 2013 the European Commission launched a tender with a double objective: "select a set of quantitative and qualitative indicators and metrics and develop a methodology and the related tools to collect and analyse data in order to monitor evolution of RRI dimensions and benefits over time" (European Commission, 2013:16). The results of this tender will not be available until mid-2017,

which reinforces the idea of Iatridis and Schroeder (Iatridis & Schroeder, 2016) , that metrics and tools for RRI are still preliminary or in the phase of development.

The potential of applying standards, initiatives, and principles already existing for the monitoring of other disciplines as Corporate Social Responsibility has also been explored (Iatridis & Schroeder, 2016). In a similar way, Wickson & Carew (2014) explored the development of indicators and quality criteria through the integration of knowledge of other disciplines such as Corporate Social Responsibility, Public Value Failure Mapping, and Multi-Criteria Decision Analysis.

Under this context, wherein the authors of this study foresee a forthcoming interest to define the areas which compose the RRI approach and the respective indicators of monitoring, this study aims to apply a methodology that will facilitate the adaptation of extended lists of indicators to the reality and requirements of specific contexts.

In this work, an explorative application of the AHP method was designed and applied to assess the importance of the indicators for six areas of RRI based on the available list of indicators. It relies on the opinion of experts in each of the six key areas of RRI proposed by the European Commission who provided different weights for the different indicators under each category (process, outcome, and perception) of the six areas. These weights are later used to propose different options to reduce a large set of indicators to a smaller one according to the experts' opinions. These smaller sets of indicators allow decision-makers to identify where efforts should be made to measure in a specific context the more relevant information of RRI performance. Our work is based on the three hypotheses:

1. Indicators to monitor and evaluate RRI initiatives and policies might not have the same relevance in different contexts.
2. Indicators to monitor and evaluate RRI initiatives and policies can be prioritized.
3. The AHP methodology might be a useful tool to propose reduced and context-based sets of indicators to specific contexts. The availability of a methodology to select reduced and context-based sets of indicators of RRI initiatives and policies can be of great value for policy-makers, funding organizations, and any other decision-makers who have to decide what indicators might be used to evaluate RRI policies and initiatives in a specific context.

The remaining paper is as follows: in Section 2 the methodology for the profiling of stakeholders and the prioritization of indicators is presented, and in Section 3 the application of the proposed methodology and a detailed case study is presented with a broad description of the obtained results. Finally, in Section 4 the authors discuss the results and the main conclusions of the work.

4.2 Materials and Methods

The proposed methodology requires the participation of two types of agents for the adequate implementation of the working sessions, (i) the facilitators of the prioritization process and (ii) a panel of experts in the six key dimensions of RRI (public engagement, gender equality, science education, open access, ethics, and governance). In this work, the facilitators of the process (authors of the article) have reviewed the available list of indicators to measure RRI policies and prepared the

materials to carry out the prioritization. They have chosen the proper list of experts for each RRI key dimension who also had a good level of knowledge of the research and/or innovation ecosystem in Spain. The facilitators have guided the experts all along the process of weighting the evaluation criteria. With these weights, the facilitators have finally ranked the indicators and proposed different options for reducing the initial broad set of indicators into a smaller one. A detailed explanation and the possibilities for its application are presented in Section 3.

The selection of Spain as a case study is based on the reason that the authors of this article have received funds from the Spanish National Ministry of Economy, Industry, and Competitiveness to analyse how the indicators proposed to measure RRI at the European level can be adapted to the reality of the Spanish Research and Innovation system. Spain, as a member of the European Union, is affected by the Research and Innovation European policies, and the methodology applied in this study can be used as an example to develop further adaptations of indicators to other regional research and innovation ecosystems as well as adaptations in other European countries. The discussion of how to identify the most appropriate indicators in different ecosystems might be of high relevance to enrich the debate around RRI indicators with a bottom-up approach.

4.2.1 Regarding the Experts

This work included six groups of experts, one per each dimension of RRI. The creation of a unique pool of experts to measure all the list of indicators was initially considered but discarded. The different areas of RRI have their own problems, as well as different regulatory tracks and grades of implementation in Spain. For instance, there is a large corpus of both legislation and monitoring frameworks in the field of gender equality and ethics in Spain. Working with areas with different grades of implementation and monitoring frameworks led the authors to consider that it was much more important to have reduced groups of experts with a solid knowledge of the area rather than generalists that might not understand the specific technical problems of each of the six areas. Therefore, experts should fulfil two requisites: (i) having a solid academic or professional background in the respective area and, (ii) having knowledge and professional experience in the Spanish research and/or innovation ecosystem.

4.2.2 Regarding the List of Indicators

This study considered the list of indicators provided by the EU report “Indicators for promoting and monitoring Responsible Research” (Strand et al., 2015). The set included 82 indicators for the six key areas of RRI (governance, public engagement, gender equality, science education, open access/open science, and ethics) and several suggestions for defining indicators under the two new proposed areas (sustainability and social justice/inclusion). In our study, it was decided to use for prioritization the indicators directly defined in the report. Therefore, the suggestions given to define indicators for the categories of sustainability and social Justice/inclusion were not used.

As identified by the authors of the aforementioned report, the set of criteria is diverse and heterogeneous, and there is also overlap between them. Moreover, some (in particular ethics, sustainability, and social justice/inclusion) may be thought of as being more overarching and encompassing than certain others (public engagement, science education, and open access).

4.2.3 Regarding Weighting of Criteria

In this study, the AHP method was used for weighting the indicators. The Analytic Hierarchy Process (AHP) proposed by Saaty is a measurement theory of intangible criteria (Saaty 1980). AHP is based on the fact that the inherent complexity of a multiple criteria problem can be solved through the construction of hierarchic structures consisting of a goal, criteria, and alternatives. In each hierarchical level, paired comparisons are made with judgments using numerical values taken from the AHP absolute fundamental scale of 1–9. These comparisons lead to dominance matrices from which ratio scales are derived in the form of principal eigenvectors. These matrices are positive and reciprocal (aij = 1/aji). The synthesis of AHP combines multidimensional scales of measurement into a single one-dimensional scale of priorities.

The method is one of the most extended multicriteria techniques, and it adapts very well to the hierarchy of criteria proposed by the Expert Group on Policy Indicators for Responsible Innovation of the EU. It also has the additional advantage of being easy to explain to the experts that have to assess the different criteria in a simple and systematic way. More details on the AHP can be found in Saaty (1980), Saaty and Peniwati (2008), and García-Melón et al. (2012).

4.3 Results

This section presents the results of the work. In order to facilitate the understanding, a description of the steps undertaken to measure the indicators of each of the six areas is presented and complemented with a detailed description of the tools used and the results obtained of the area that included more complexity in the work, that is, gender.

4.3.1 Step 1: List of Indicators

For the selection of indicators to be weighted, the only available proposal of indicators of RRI at the moment the study was designed was used as a reference. This list was included in the report "Indicators for promoting and monitoring Responsible Research" of the Expert Group on Policy Indicators for Responsible Innovation (Strand et al., 2015).

The 82 indicators proposed were organized in three categories for nearly all of the RRI areas: process, outcomes, and perception. To facilitate the elaboration of the materials used for weighting, the indicators were codified according to the area (and three sub-areas in the case of public engagement) and category they belong to (see Table 7, Annex E for the full list of indicators and their codes, and Table 8). During these preparatory activities, the authors considered that two of the indicators under the category process (codes: GE_PR2.1 and GE_PR2.2) of the dimension of gender should be classified as hierarchically dependent of another indicator (code: GE_PR2).

Table 7 *Summary of the list of indicators*

Area	Category	Number of Indicators
Governance	Process	2
	Outcome	6
	Perception	4
Public engagement/Policies, regulations and frameworks	Process	1
	Outcome	3
	Perception	3
Public engagement/Event and initiative making; attention creation	Process	5
	Outcome	4
	Perception	4
Public engagement/Competence building	Process	4
	Outcome	4
	Perception	3
Gender equality	Process	6
	Outcome	8
	Perception	2
Science education	Process	2
	Outcome	6
Open access/Open science	Process	4
	Outcome	4
	Perception	1
Ethics	Process	4
	Outcome	2
Total		82

Table 8 *List of indicators and codes for the dimension gender*

Area	Category	Code	Indicator
Gender equality	Process	GE1_PR1	% of Member State funding programs explicitly including gender requirements
		GE1_PR2	% of research institutions (including universities) that (a) have gender equality plans and (b) provide documentation of their implementation
		GE1_PR2.1	% of research institutions that document specific actions that minimize/reduce barriers in work environment that disadvantage one sex (e.g., flexibility of working hours)
		GE1_PR2.2	% of research institutions that document specific actions aiming to change aspects of their organizational culture that reinforce gender bias
		GE1_PR3	% of research institutions that provide training/support for researchers in regard to the inclusion of gender dimensions in the content of research
		GE1_PR4	% of schools (primary and secondary) that have programs promoting gender equality issues in regard to career choices
	Outcome	GE2_OU1	% of women in advisory committees
		GE2_OU2	% of women in expert groups
		GE2_OU3	% of women in proposal evaluation panels
		GE2_OU4	% of women in projects throughout the whole lifecycle (in full-time equivalent)
		GE2_OU5	% of women that are principal investigators on a project
		GE2_OU6	% of women that are first authors on research papers
		GE2_OU7	% of research projects including gender analysis/gender dimensions in the content of the research
		GE2_OU8	% of women taking part in research mobility programs
	Perception	GE3_PE1	Perception of gender roles in science amongst young people and their parents, e.g., percentage of young people who believe that science careers are equally suitable for both women and men; percentage of parents who believe their children (daughters) will have equal opportunities to pursue a career in STEM[5]
		GE3_PE2	Perception of people working in the area of R & I[6] in regard to gender equality, e.g., percentage of women in R & I, who believe they have equal opportunities to pursue their careers in R & I in comparison to men

[5] STEM is the acronym of Science, Technology, Engineering and Mathematics.

[6] R&I is the acronym of Research and Innovation.

4.3.2 Step 2: Identify Key Experts

As stated above, six groups of experts were identified, one per RRI area. For our work, two experts per area were selected. In the selection of the experts, it was taken into account their level of expertise in each of the areas, their knowledge of the current research and/or innovation ecosystems in Spain, and their willingness and availability to participate in this study. Moreover, some other personal average data such as gender was also considered.

A description of participant experts is given in Table 9. For some of them it has not been possible to give more details about their names or companies, due to confidential reasons. In brackets, the gender of the expert is shown: male or female.

Table 9 *List of interviewed experts*

Dimension	Experts Interviewed
Public engagement	One project manager responsible for public engagement policies in a public research institution (F[7]) One academic with experience in public engagement in different research and innovation public funded projects (F)
Gender equality	One academic in the field of gender and public policies (F) One representative of a public research and innovation funding body (M[8])
Science education	One academic in the field of science in society, expert knowledge and social engagement, science and values, and science communication and education (F) One academic in the field of Science Education (F)
Open access	One academic in the field of open access and open science (F) One representative of a public research and innovation funding body (M)
Ethics	Two academics in the field of research ethics (M)
Governance	One academic in the field of governance (M) One academic in the field of regulatory science and governance (F)

4.3.3 Step 3: Weigh the Indicators

For the weighting of the indicators, the AHP method was used. AHP requires a hierarchical model of criteria (see Figure 6 for the category "Process" of the area "Gender") to pairwise compare all the criteria (indicators) and to obtain a final weight for them (Saaty & Peniwati, 2008). A questionnaire was designed for each area for this purpose. The questionnaires were conducted through a personal interview with each of the 12 experts. Interviews were carried out either with face-to-face meetings or by videoconference, depending on the interviewee's preferences and availability. First, a set of instructions was presented to explain which comparisons were to be made according to the hierarchical structure proposed and the nine-point Saaty's scale. Last, the surveys were processed using software Superdecisions © v. 2.4.0. (Creative Decision, Pittsburgh, PA, USA). Weights or relative importance for each indicator and for each expert were derived. A sample of the questionnaire for the dimension "Gender" and the category "Process" is shown in Table 10.

[7] F refers to female.
[8] M refers to male.

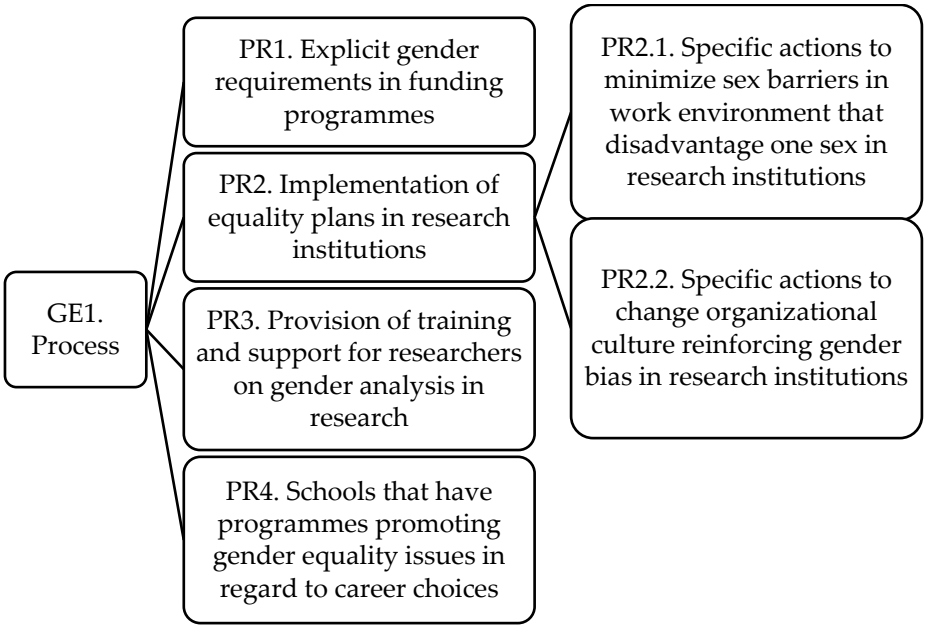


Figure 6 *Hierarchy for criteria (indicators) for the dimension "Gender", category "Process"*

All interviews were carried out personally; on the one hand because experts had to understand the research aims, the AHP method, and the AHP questionnaires, and on the other hand because all comments and other valuable information experts could give were to be gathered for the research. Interviews lasted around 45 min; the first stage was devoted to the research aims, the method, and the questionnaire. The second stage was devoted to answering the questions (comparisons) and the AHP facilitators did not interfere in this stage.

Every expert obtained a different set of weights, according to his/her preferences. In order to obtain the global weighting, the aggregation of the results of the individual priorities by means of geometric mean was used as suggested by Saaty and Peniwati (2008).

The detailed results for the area "Gender" are presented Table 11, and the abbreviations for all the areas are shown in Figure 7 to Figure 14 (for the detailed results of all areas see Annex F).

Table 10 *Sample of the AHP*[9] *questionnaire for gender indicators in the category "Process"*

From Your Point of View, Which Indicator Is More Important and to What Extent can it be used to Evaluate and Monitor RRI Initiatives in Spain Regarding Gender in Research and Innovation Processes?										
GE1_PR1. Explicit gender requirements in funding programmes	9	7	5	3	1	3	5	7	9	GE1_PR2. Implementation of equality plans in research institutions
GE1_PR1. Explicit gender requirements in funding programmes	9	7	5	3	1	3	5	7	9	GE1_PR3. Provision of training and support for researchers on gender analysis in research
GE1_PR1. Explicit gender requirements in funding programmes	9	7	5	3	1	3	5	7	9	GE1_PR4. Schools that have programmes promoting gender equality issues on regard to career choices
GE1_PR2. Implementation of equality plans in research institutions	9	7	5	3	1	3	5	7	9	GE1_PR3. Provision of training and support for researchers on gender analysis in research
GE1_PR2. Implementation of equality plans in research institutions	9	7	5	3	1	3	5	7	9	GE1_PR4. Schools that have programmes promoting gender equality issues on regard to career choices
GE1_PR3. Provision of training and support for researchers on gender analysis in research	9	7	5	3	1	3	5	7	9	GE1_PR4. Schools that have programmes promoting gender equality issues on regard to career choices

[9] AHP refers to Analytical Hierarchical Process.

Table 11 *Normalized geometric mean of the weights obtained in the dimension "Gender"*

Code and Name of the Indicator	Global Weight (% within Category)
Category: Process (first hierarchical level)	
GE1_PR2. Implementation of equality plans in research institutions	39.48
GE1_PR1. Explicit gender requirements in funding programmes	33.56
GE1_PR3. Provision of training and support for researchers on gender analysis in research	22.32
GE1_PR4. Schools that have programmes promoting gender equality issues in regard to career choices	4.64
Category: Process (second hierarchical level)	
GE1_PR2.2. Specific actions to change organizational culture reinforcing gender bias in research institutions	75.00
GE1_PR2.1. Specific actions to minimize sex barriers in work environment that disadvantage one sex in research institutions	25.00
Category: Outcome	
GE2_OU6. Women that are first authors in papers	23.11
GE2_OU5. Women that are principal researchers in projects	21.56
GE2_OU7. Research projects including gender analysis in the content of research	15.04
GE2_OU2. Women in expert groups	11.06
GE2_OU3. Women in evaluation panels	9.06
GE2_OU1. Women in advisory committees	7.81
GE2_OU8. Women taking part in research mobility programmes	6.59
GE2_OU4. Women in projects throughout the whole life cycle	5.77
Category: Perception	
GE3_PE2. Perception of people working in R & I in regard to gender equality	82.09
GE3_PE1. Perception of gender roles in science amongst young people and their parents	17.91

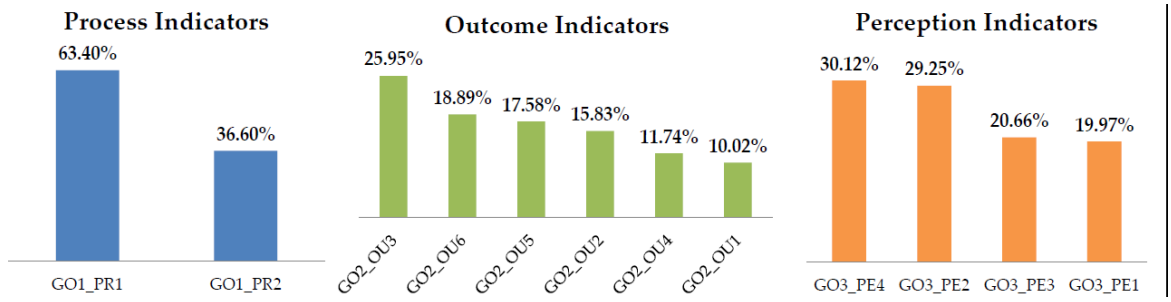


Figure 7 *Prioritization of indicators of Governance*

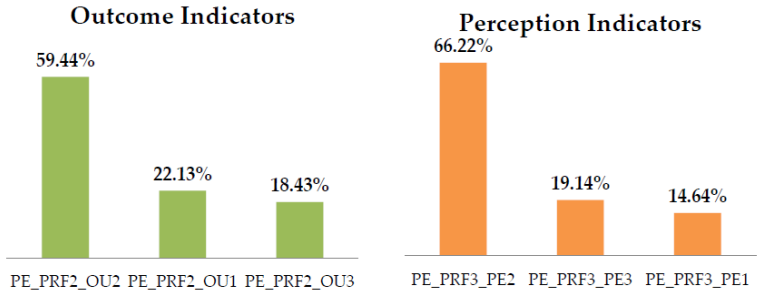


Figure 8 *Prioritization of indicators of Public Engagement in the sub-dimension of Policies, Regulations, and Framework*

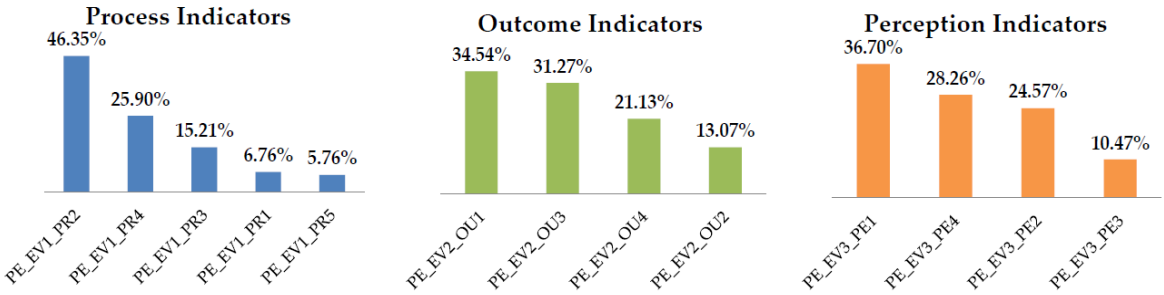


Figure 9 *Prioritization of indicators of Public Engagement in the sub-dimension of Events and Initiative making/Attention*

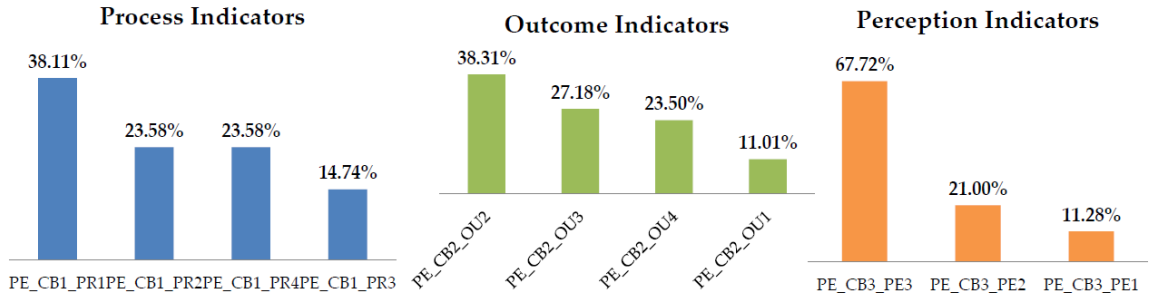


Figure 10 *Prioritization of indicators of Public Engagement in the sub-dimension of Competence Building*

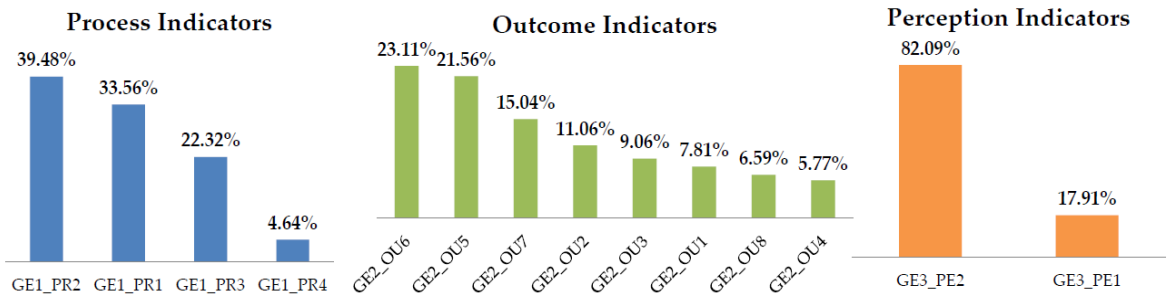


Figure 11 *Prioritization of indicators of Gender equality*

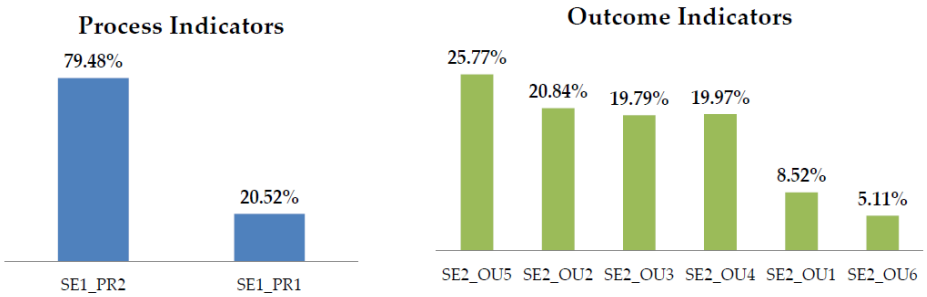


Figure 12 *Prioritization of indicators of Science education*

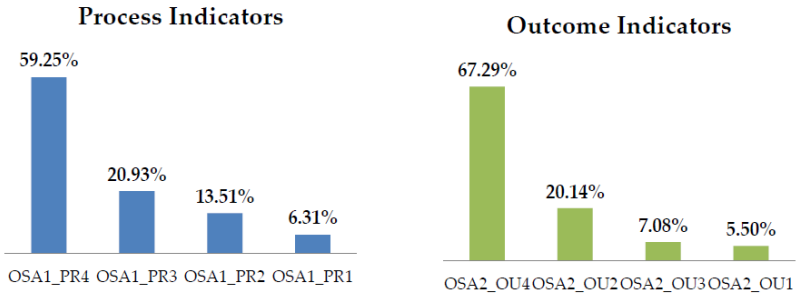


Figure 13 *Prioritization of indicators of Open Science/Open Access*

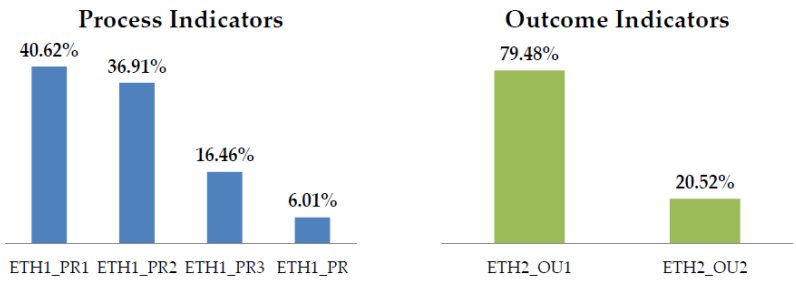


Figure 14 *Prioritization of indicators of Ethics*

4.3.4 Step 4: Reduced Set of Indicators

The prioritization of the indicators presented in the previous section allows ordering a long set of indicators by the importance given by a group of experts under each category and for each area analysed. A list with these characteristics can be a starting point to identify what indicators should be prioritized in a context where, for different reasons, it might not be possible to collect data for all the indicators. With this tool, policy- and decision-makers can identify what sort of information should be collected to monitor RRI initiatives and policies, taking into account the most relevant indicators according to a set of experts or other stakeholders in the area.

Policy- and decision-makers could use different approaches to identify the minimum indicators to be considered when monitoring and evaluating an initiative or policy. One option would be applying the criteria "Best in class"; selecting the more relevant indicator under each area and category. Following with the case of gender, the reduced list of indicators implies considering five indicators from the original list of 16 indicators (see Table 12); one in the categories of outcome and perception and three in the category of process, as the one with higher normalized geometric mean has two hierarchical dependent indicators.

Table 12 *Reduced set of indicators in the area "Gender" applying the criteria "Best in class"*

Code of the Indicator	Normalized Geometric Mean
Category: Process (first hierarchical level)	
GE1_PR2	39.48
Category: Process (second hierarchical level)	
GE1_PR2.2	75.00
GE1_PR2.1	25.00
Category: Outcome	
GE2_OU6	23.11
Category: Perception	
GE3_PE2	82.09
Total indicators in the reduced set	**5**

A second option would be selecting a cut-off percentage and selecting just those indicators starting from the first positions for which normalized geometric means (NGM) sum up the cut-off percentage. This could be applied using the Pareto rule and, supposing that selecting 20% of the indicators could allow monitoring 80% of the phenomena that will imply selecting the first indicators for which the normalized geometric means add up to 20%. In this study, the authors opted to use 50% instead of 20% according to the Pareto rule, as if this rule was applied, the result would be completely the same as the "Best in class" option. As our aim was to show different possibilities to accommodate the concrete needs of policy- and decision-makers, using 50% showed difference in the final sets obtained.

The application of the "50% NGM" resulted in the selection of the indicators listed in Table 13for the area "Gender".

Table 13 *Reduced set of indicators in the area "Gender" applying the criteria "50% NGM".*

Code of the Indicator	Normalized Geometric Mean
Category: Process (first hierarchical level)	
GE1_PR2	39.48
GE1_PR1	33.56
Category: Process (second hierarchical level)	
GE1_PR2.2	75.00
GE1_PR2.1	25.00
Category: Outcome	
GE2_OU6	23.11
GE2_OU5	21.56
GE2_OU7	15.04
Category: Perception	
GE3_PE2	82.09
Total indicators in the reduced set	**8**

A third option would be considering a percentage of the total indicators to be selected. For instance, at least half of the most relevant indicators would be selected in order to reduce the amount of data to be gathered, but still collect 50% of the more relevant indicators. By applying the rule "50% of indicators", the results of the reduced set for the dimension "Gender" implies the reduction of the initial 16 indicators into nine, four of them from the category process, another for the category outcome, and one for the category perception, as presented in Table 14.

Finally, a fourth option would be to select the most relevant indicators not to be discarded in case of a need to reduce a long set of indicators, by selecting those indicators with normalized geometric means higher than the difference between the highest and the lowest normalized geometric mean in the category. The application of this criteria implies the selection of six indicators from the initial list of 16 indicators in the dimension "Gender" (see Table 15. In, both the selected and not selected indicators are included. The aim of this is to facilitate the understanding of the reader, as the difference between the highest and the lowest normalized geometric means is calculated from the NGM of both selected (the highest NGM) and not selected (the lowest NGM) indicators.

Table 14 *Reduced set of indicators in the area "Gender" applying the criteria "50% of indicators"*

Code of the Indicator	Normalized Geometric Mean
Category: Process (first hierarchical level)	
GE1_PR2	39.48
GE1_PR1	33.56
Category: Process (second hierarchical level)	
GE1_PR2.2	75.00
GE1_PR2.1	25.00
Category: Outcome	
GE2_OU6	23.11
GE2_OU5	21.56
GE2_OU7	15.04
GE2_OU2	11.06
Category: Perception	
GE3_PE2	82.09
Total indicators in the reduced set	**9**

Table 15 *Reduced set of indicators in the area "Gender" applying the criteria "NGM higher than the difference between the highest and the lowest NGM"*

Code of the Indicator	Normalized Geometric Mean	Difference between the Highest and Lowest NGM
Category: Process (first hierarchical level)		**34.84**
Included in the reduced set		
GE1_PR2	39.48	
Not included in the reduced set		
GE1_PR1	33.56	
GE1_PR3	22.32	
GE1_PR4	4.64	
Category: Process (second hierarchical level)		
Included in the reduced set		
GE1_PR2.2	75.00	
GE1_PR2.1	25.00	
Category: Outcome		**17.34**
Included in the reduced set		
GE2_OU6	23.11	
GE2_OU5	21.56	
Not included in the reduced set		
GE2_OU7	15.04	
GE2_OU2	11.06	
GE2_OU3	9.06	
GE2_OU1	7.81	
GE2_OU8	6.59	
GE2_OU4	5.77	
Category: Perception		64.17
Included in the reduced set		
GE3_PE2	82.09	
Not included in the reduced set		
GE3_PE1	17.91	
Total indicators in the reduced set	**6**	

The reduced set of indicators for all of the areas, which can be consulted in Annex F, differ in number depending on the criteria of the selection process used. So, for criteria "Best in class" the resulting indicators number 24, for criteria "50% NGM" there are 38, for criteria "50% indicators" there are 45, and finally for criteria "NGM highest than the difference between the highest and lowest NGM" there are 37.

4.4 Discussion

The way in which science and innovation will be aligned with societal concerns and values will be an increasing topic of discussion in the coming years. The proposals to operatize a framework around key areas, as put forth by the European Commission regarding RRI, or around dimensions, as proposed in the framework for RI, still need reflection and broader debate and discussion to be implemented in European and national science and innovation ecosystems. Understanding how to approach science in society and establish a continuum dialogue between scientists and the general public is of key importance both for the implicit responsibility that accompanies the enormous power of science and innovation in transforming the living conditions of society and for a justice imperative.

This exploratory study demonstrated our initial hypothesis, since the proposed methodology is suitable to weight indicators by a group of experts. As a result, we obtained different proposals of reduced sets of weighted indicators. The availability of prioritized sets of indicators can be a useful candidate for a policy-making tool to aid decisions on data gathering for monitoring cross-cutting RRI initiatives in a specific context.

Building a fair society where people can live the life they have reasons to value (Sen, 1999) requires that the scientific praxis and science and innovation incorporate the principles of civic ethics (Cortina, 1997) in its functioning. Our research shows an approach to incorporating the principles of civil ethics in the process of defining how to select specific indicators to assess RRI performance in a specific context to orientate public scientific policies.

Therefore, our aim with this study was not to offer a definitive prioritized list of indicators of RRI for the Spanish research and innovation ecosystem, but to explore the potential of the methodology to advance towards that broader objective by involving relevant actors in the process of selection of indicators.

With this study, we explored how prioritization could be achieved in case that extensive list of indicators could not be used to measure policies due to lack of sources to gather information or due to the will to adapt extensive sets to specific contexts.

In order to produce reduced sets of indicators, four approaches were proposed to numerically reduce the number of indicators for each key area of RRI. The application of each of the four methods used presents different advantages and limitations.

The method “Best in class” allows selecting a short number of indicators and identifying those that are more relevant. However, this advantage is also its main limitation, as it results in a drastic reduction of the number of indicators. Furthermore, there is a relevant dependency of the resulting set of indicators to the inclusion of categories. In the application of all of the criteria, if categories had not been included and all the indicators in each key area had been compared among them, the resulting set of indicators would have been different; this fact makes a very clear impact in the method “Best in class”. Therefore, for the use of this method in future studies, a previous profound analysis of the importance of categorizing indicators or not should be conducted.

The approach based on a cut-off percentage that allows selecting the indicators in the first positions summing up the cut-off percentage, in this study the “50% NGM” method, facilitates the identification of a reduced set of indicators, while at the same time respecting the priorities given in the prioritization process by the experts.

The approach based on reducing the indicators to a concrete number of indicators, in our case to half of them, facilitates establishment of the final number of indicators by selecting the percentage of reduction expected. The main limitation of the "50% of indicators" method is that the number of indicators resulting under each area or category responds only to a numerical value and does not consider the amount of importance given by the experts. The relevance of this method is difficult to justify, as the requirement of reducing indicators in a specific context might be linked to limitation in the resources to collect and analyse data for large lists of indicators. It seems too aleatory if no reason for limiting the number of indicators is provided. To address this limitation, it would be interesting to combine these criteria with the inclusion of the costs of measuring indicators. The maximum budget available for evaluating and monitoring RRI policies could be a criterion used in order to select the cut-off percentage in this approach.

The fourth and last method proposed has a main advantage as it does not limit the number of indicators a priori, but the result depends on the differences between the highest and lowest normalized geometrical means and the position of each indicator in relation to that difference.

The application of these four methods showed that reductions can be made in different ways, and there are some limitations in the methodology used in this study that will have to be overcome to propose a concrete set of indicators by using this or other methods.

Firstly, it should be noted that working with a different expert team could lead to some changes in the ranking, and that the number of experts participating in the study should be increased in future studies. Additionally, the inclusion of other techniques to promote consensus could be used, such as a second round of weighting by using the Delphi method, as has already been conducted in previous studies (García-Melón et al., 2012).

Additionally, a definitive list of context-based set of indicators would require the integration of the forthcoming sets of indicators that are under development. In the coming months, the results from the tender launched in 2013 by the European Commission to identify quantitative and qualitative indicators and metrics to monitor the evolution of RRI dimensions will be available. Therefore, any attempt to provide context-based sets will have to integrate the proposal made in that study.

It would also be necessary to critically review the potential indicators under each dimension considering the current regulation in the specific country or region where the indicators might be applied. In this regard, the Spanish Organic Law 3/2007 of 22 March 2007 for equality among women and men already imposes some reporting requirements to different agents in the research and innovation ecosystem. Not considering those requirements would be a strategical failure to promote gender in science in the Spanish national context.

In a similar way, understanding the current efforts of research and innovation actors reporting their performance on Corporate Social Responsibility and Responsible University policies would be key to assuring the commitment in this process of companies and universities already monitoring and reporting areas of RRI. In this line, it would be also beneficial for future studies to include in the panel of experts, professionals responsible for research and innovation in companies. This will be key to help to introduce into the debate companies developing research and innovation and assuring the success of the proposed indicators both to public and private developers of science and innovation.

Additionally, a profound reflection on how to measure RRI initiatives and policies among experts from the different dimensions would be necessary to be able to include new indicators to measure relevant goals of each of the key areas responding to the specific state of the art in the country. The authors

propose to arrange experts focus groups and the use of participatory methods to define in a specific context the complete list of indicators that should be weighted as a first set in the process to provide context-based indicators for any science and innovation system.

In conclusion, the design of a study to select the more suitable and urgent indicators to measure RRI performance in a territory should include previous work conducted to identify new indicators that complement the proposals made so far. During the development of this study, the authors considered the suitability of the indicators proposed under a European perspective for use in national contexts without any type of adjustment. From our point of view, future study should respond to so far non-explored questions.

Firstly, it would be relevant to explore whether the list of indicators used in this exploratory study includes all the possible and relevant indicators to measure the six dimensions proposed by the European Commission in the Spanish research and innovation ecosystem. It is also necessary to reflect on the inclusion of those widely accepted in our territory and included in the Global Reporting Initiative, the Equality Plans, or the Responsible University Plans. Additionally, future studies should explore whether the set of indicators proposed has the same importance for different research and innovation contexts such as geographic areas (countries and regions) or areas of knowledge (Humanities and Social Sciences, Biology and Biomedicine, Natural Resources and Agricultural Sciences, etc.). Finally, it should be explored whether the all the research and innovation agents should inform the whole set of indicators, or if would it is necessary to establish specific sets of indicators for reporting the performance of different types of agents such as funding agencies, universities, departments and institutes, or private organizations that conduct research and innovation.

Capítulo 5 . Anticipating Environmental Burdens in Research and Innovation Projects. Application to the Case of Active and Healthy Ageing

Irene Monsonís-Payá; Tomás Gómez-Navarro & Mónica García-Melón (2020) Anticipating Environmental Burdens in Research and Innovation Projects—Application to the Case of Active and Healthy Ageing, International Journal of Environmental Research and Public Health, 17:10, 3600. https://doi.org/10.3390/ijerph17103600

Indexada en SCIE y en JCI (Q2) en *Environmental Sciences* y en *Public, Environmental & Occupational Health*

Abstract

In this paper; for research and innovation projects without environmental goals; a procedure is proposed to operationalize the anticipation and reflexivity of environmental concerns in the initial phases. By using the expert knowledge of specialists; we have first conducted a study to identify the general environmental topics relevant in any kind of research and innovation project not addressing the environment. In a second phase; a strategy is proposed to rank order the topics in terms of environmental relevance by means of the Analytic Hierarchy Process. To illustrate it; the case of Information and Communication Technologies for Active and Healthy Ageing is used because of its increasing importance; and because normal environmental targets are not considered. Results show that; in this case; the most relevant topic to be considered is the primary energy consumption by sources; followed by hazardous solid waste and consumption of non-renewable and scarce materials. According to the experts; these should be the main issues to be considered regarding the environmental sustainability of the outputs of such research and innovation projects. In conclusion; this paper contributes to a better understanding of how to promote a wider integration of environmental sustainability in research and innovation when environmental goals are not initially included.

Keywords: responsible innovation; environmental sustainability; ICT and active and healthy aging; AHP

5.1 Introduction

The worldwide scale and permanent impacts on the planet of human activities which have led to the definition of a new geological period, Anthropocene (Crutzen & Stoermer, 2000), are well known. Although the new term has not yet substituted the current term Holocene, the suggestion shows the general concern about human participation in shaping the future of the biosphere. This transformation that has lately reached unprecedented levels is being referred to as the Great Acceleration (Lewis & Maslin, 2015; Steffen et al., 2011).

Research and innovation have such a concern as clearly as any other human activity. This is naturally assumed by research and innovation (R&I) actions that aim to support sustainable transitions (Geels, 2011). However, it could also be assumed by R&I projects focused on other research disciplines and paradigms with potential long-term impacts on the environment.

This is the case of information and communication technologies (ICT) projects for active and healthy aging (AHA). This research has great attention, for instance, in the last European research program Horizon 2020. In the case of the Horizon 2020 program, under the societal challenge “Health, Demographic Change, and Wellbeing”, different calls have been launched to support knowledge production and escalation of ICT-based solutions for active and healthy ageing (European Commission, 2015, 2017, 2020). The concern on environmental sustainability within these work programs is not a key element and the term sustainability is usually referred to as economic sustainability in regard to the health care system. It is a matter of time before exercises of reflexivity on long-term environmental impacts of the research and innovation outputs will be required by agents submitting proposals to this research field. In the meanwhile, agents within such R&I fields also need to anticipate and manage their present and potential future significant undesirable environmental impacts. However, anticipating the long term environmental impacts involves dealing with a high uncertainty; only increased if applied to research fields not as yet investigated, or driven by research teams not so specifically trained (Iatridis & Schroeder, 2016).

Therefore, this paper aims to put forward a methodology for actors working at the early stages of R&I projects without environmental goals. The research gap to cover is how to identify the most relevant environmental challenges in order to anticipate the unexpected potential environmental impacts in the medium and long term. To validate it, the ICT projects for AHA are used as a case study.

Next, the literature review about the approaches to the problem is presented; following the methodology that is proposed, the results of its application to the case study, the discussion of results, and the conclusions of the research.

5.1.1 Literature Review

The anticipation of the unexpected environmental impacts of starting R&I is a situation of uncertain and incomplete information (Wender et al., 2014). Uncertain and incomplete information refers to the well-known variables of environmental assessment: system life cycle, user habits, the environmental profile of energy in the future, the evolution of materials scarcity, impacts to ecosystems yet to be discovered, etc. The way to react in situations of uncertainty in research and innovation has a long tradition. Different theoretical and conceptual frameworks

have been developed in that regard, some of them highlighting the importance of combining expert and non-expert knowledge to deal with uncertainties and advance toward more legitimate responses to global challenges. Concepts such as post-normal science (Funtowicz & Ravetz, 1993), hybrid forums (Callon et al., 2009), or responsible innovation (Stilgoe et al., 2013) call for the participation of concerned or interested agents at the early stages of research. Previous research points out that articulating responsible research and innovation systems requires the combination of different strategies and methods, the involvement of different actors (Stilgoe et al., 2013), and the consideration of context realities (Mejlgaard, 2018). In conclusion, responsible innovation poses a great amount of complexity for R&I practitioners (or policy-makers) and hence, the need for the operationalization of R&I practices, which is the goal of this paper.

5.1.2 Environmental Responsibility of Research and Innovation

The early reflection on environmental sustainability in research and innovation projects could be considered a normative anchor (von Schomberg, 2013), inviting the incorporation of these concerns transversally when designing and thinking about R&I activities and outputs. The various EU directives, policies, commitments, and declarations on the matter justify the need to incorporate environmental concerns about R&I activities. Examples of these normative anchors could be from the Treaty of the European Union until the environmental directives of the DG-EC for Environment, including the Paris Agreement on climate change of 2015, among others. So the considerations on environmental sustainability in R&I projects would respond to the need to take care of the future (Stilgoe et al., 2013), the expectations of European society (European Commission, 2014), and to the proper embedding of scientific and technological advances in society (von Schomberg, 2013).

Based on the framework of responsible research and innovation (RRI) developed by Stilgoe et al. (Stilgoe et al., 2013), there are two dimensions that could support a better understanding of environmental concerns in early stages of research: anticipation and reflexivity. Anticipation "concerns understanding how the present dynamics of research and innovation practices shape the future and, also, imagining a socially desired future and how to contribute to it" (RRI Tools, 2014); while reflexivity "ask scientists, in public, to blur the boundary between their role responsibilities and wider, moral responsibilities" (Stilgoe et al., 2013). Environmental anticipatory activities in the context of a project would imply to analyze the plausibility of the environmental impacts of the project outputs, or the environmental limitations to scaling up those outputs. The analysis of plausibility done by exploring its possibility, feasibility, and probability (Nordmann, 2013) would help to foresee environmental conditionings and impacts of the R&I output. Such an understanding of possible environmental implications of a project's output by the R&I team will activate the reflexivity dimension. The introduction of a new variable in the project design, the environmental responsibility of the project output, is faced with a new moral responsibility. The team needs to position itself (or not) towards a friendlier environmental product. Hence, developing such anticipatory and reflexive exercises during early phases of R&I would support a more conscious approach towards the future. A future steered to some extent by the project's outputs (ITU-T, 2012).

With the aim of promoting and monitoring RRI, a group of experts proposed a first attempt at indicators for the policy areas proposed by the European Commission (Strand et al., 2015). This framework can inform and support the dimensions suggested by Stilgoe et al. (Stilgoe et al.,

2013). Nevertheless, neither is the framework applied nor are indicators suggested for the added areas of social justice and sustainability. Some recommendations have been provided in the work of Kettner et al. (Kettner et al., 2014). However, in their current status, they are more recommendations than practical solutions, and they are more intended for public policies than for environmental assessment. Hence, they would hardly be useful for driving responsible research in practice (Ligardo-Herrera et al., 2018).

Technology assessment (TA) is closely related to RRI in aims and approaches. Indeed, Delvenne (Delvenne, 2017) affirms that the latter appeared in the realm of the former. Since its first appearance around fifty years ago, TA "became a process of ongoing dialogue that supports actors' decision-making processes and the formation of opinions on science–society issues" (Delvenne, 2017). Therefore, this paper research could be said to belong to the overlap between RRI and the branch anticipatory technology assessment (Stemerding et al., 2019), with the aim of anticipating and reflecting on the environmental consequences of the R&I process and its outcome, especially if it might turn into a commodity. Currently, anticipatory TA is varied in attitudes and methods, selecting what seems best suitable given the available information and other resources. However, based on the research's literature review, no proposal including all environmental topics has been found in the realm of anticipatory TA, which could be applied to any type of R&I. Hence, the literature from other disciplines has been reviewed.

The fields of corporate social responsibility (CSR) and sustainable innovation (SI) have devoted more attention to the development of tools covering the anticipation of environmental sustainability (Bossink, 2018; Ligardo-Herrera et al., 2018). Unfortunately, SI is not yet applicable to R&I whose goal is not sustainability (De Medeiros et al., 2014).

Conversely, in the CSR realm, a variety of guidelines, handbooks, standards, and other tools have been proposed to help integrate the environmental concern in organizations' operations, even if the environment is not strategic. For a good compendium, see Iatridis and Schroeder (Iatridis & Schroeder, 2016). Nevertheless, most of these tools are concerned with the environmental accountability of business rather than with innovation (Halme & Korpela, 2014; Hemphill, 2016; ISO, 2010). Anyhow, the review of CSR literature resulted in a set of potentially useful topics for investigation, as explained in the following section.

Finally, the methodologies of environmental impact assessment (EIA), life cycle assessment (LCA) and strategic environmental assessment (SEA) were also reviewed as potential tools for the goals of the paper. With their differences, all those methodologies were found alien to R&I because of three main reasons (Motta et al., 2018; A. W. L. da Silva et al., 2014; Wender et al., 2014):

They are developed for concrete projects (EIA), policies/plans/programs (SEA) or product/services (LCA), and are not directly suitable for the ill-definition of the first stages of research and innovation.

They need to be performed by specialists in environmental assessment, normally not the background of the R&I practitioners this paper addresses.

They involve a great amount of time, data, and other resources unavailable at the anticipation and reflexivity stages of R&I.

Besides, Wender et al. (2014) argued that LCA is not yet effective because its approach is mostly retrospective, when a forward-looking method is necessary. To address this challenge, ex-ante LCA approaches are being proposed (Villares et al., 2017; Wender et al., 2014) but they do not yet offer a systematic operationalization for the purpose of our study. Furthermore, although EIA and SEA are different in concept and method, the evidence available suggests that SEA is still largely practiced according to a project's EIA (Lobos & Partidario, 2014). This must be the reason why proposals or examples of SEA that could be followed in this paper could not be found.

5.1.3 Environmental Responsibility of ICT for AHA

ICT projects for AHA need digital and electronic devices, i.e., mobile phones, cameras, sensors, senders and receivers, data centres, and servers to process information, etc. The production, use, and disposal of ICT solutions and services may have environmental impacts both at a local and a global level, even if they are deemed less important than other impacts related to security, the privacy of data, or other specific risks. However, ICT for AHA projects are not normally considered to have relevant environmental responsibilities and, thus, they do not normally address environmental impacts among their targets (Rivard et al., 2020; Yaghmaei, 2018). Thus, the case of ICT for AHA involves the use of emerging technologies whose future impacts are too often overlooked (Chatfield et al., 2017; Liotta et al., 2018; Rivard et al., 2020). This is normally due to the lack of awareness, and (or) resources and (or) skills.

This case illustrates the need for the development of context-based approaches that allow the identification of the specific relevance of environmental issues in a specific area of research and innovation. Therefore, the research questions are:

- How to identify the main environmental issues to incorporate them into R&I projects or programs without environmental goals, through anticipation and reflexivity dimensions.
- What those environmental topics might be.
- How to assess the importance of those environmental issues of an R&I project or program in a particular context, e.g., research field.

This paper affirms that anticipation and reflexivity of the environmental impacts is a requirement in R&I projects of ICT for AHA. Europe is aging and a number of ICT projects are being developed in order to improve the elderly's quality of life (Liotta et al., 2018; Smith et al., 2021). However, there is still a research niche in operationalizing this requirement (Rivard et al., 2020). As an example of the need, some recent studies (Añón Higón et al., 2017; Belkhir & Elmeligi, 2018; Porcelli & Martínez, 2015) conclude that ICT is among the sources relevantly contributing to the increasing levels of CO2 emissions. The idea of predicting possible environmental consequences, especially in the early stages of the project, should, therefore, be a driver for responsible firms or public researchers, interested in the economic benefits and low risks of environmentally sound technologies (Belkhir & Elmeligi, 2018; Lubberink et al., 2017; Rivard et al., 2020).

Hence, in this paper we aim to put forward a methodology for identifying, prioritizing, and proposing environmental sustainability elements for anticipation and reflexivity by research groups, not environmental specialists, working in projects not directly related to environmental research (Hambling et al., 2011). Furthermore, we use the case of ICT for AHA to illustrate its

applicability and recommend prioritization of such environmental topics for this specific research field.

5.2 Material and Methods

5.2.1 Methodology

To respond to the objectives of this research we propose a methodology organized in two phases (see Figure 15). The first phase deals with the first research question about which elements related to the environment are to be included in research and innovation projects without initial environmental goals. The set of topics resulting from this first phase is a starting point to design anticipation and reflexivity activities for projects under any line of research and innovation.

The second phase assumes that some of those elements are more relevant for specific lines of research. Therefore, environmental issues are prioritized, illustrating the procedure with the case study of the ICT for AHA.

Therefore, the results obtained in the second phase are valid for articulating anticipation and reflexivity activities for projects of ICT for AHA. The method to obtain the prioritized environmental elements is replicable for other lines of research and innovation.

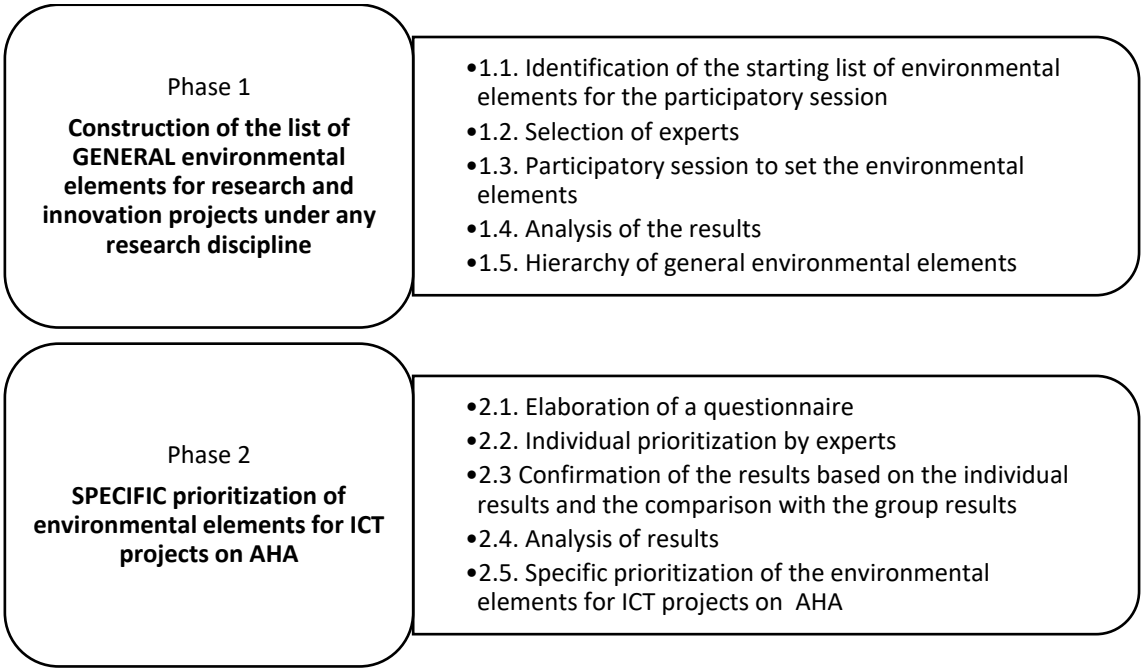


Figure 15 *Methodology of the study*

5.2.2 Methods

The identification of the environmental elements to start with was based on the literature review advanced in Section 1.3. In short, the aim was to identify a guideline or approach that both encompassed all the environmental issues and also had the right level of generality. Moreover, a management approach was desired, as the intention is to help to manage a R&I process in a responsible way.

Participation in the selection of the environmental issues is achieved by means of experts. Those experts will also participate in the rank order of the elements for the case study as AHP is based on expert knowledge and qualitative judgments. Therefore, a group of experts has to be selected with care, and the quality of experts is more important than the number of them, as discussed in García-Melón et al. (2016).

In Phase 2, the environmental elements are prioritized by means of the well-known multi-criteria decision-making technique: the analytic hierarchy process (AHP henceforth) (Saaty, 1980). AHP is a measurement theory of intangible criteria based on the fact that the inherent complexity of a multiple criteria evaluation problem can be solved through the construction of hierarchic structures consisting of a goal and several levels of criteria. In each hierarchical level, paired comparisons are made with judgments using numerical values taken from the AHP ratio scale of 1-9. These comparisons lead to dominance matrices from which ratio scales are derived in the form of principal eigenvectors. These matrices are positive and reciprocal (aij = 1/aji). The synthesis of AHP combines multidimensional scales of measurement into a single one-dimensional scale of priorities. These priorities will be calculated for environmental elements.

The AHP method is one of the most extended multi-criteria decision-making techniques (MCDM). In particular, it has been applied in the CSR field (García-Melón et al., 2016; Lubberink et al., 2017; Saaty, 1980) and also to the RRI field (Gómez-Navarro et al., 2018; Lee & Li, 2019). Moreover, it has the advantage of being easy to explain to the experts assessing the environmental elements (Zhang et al., 2015). More details on the AHP can be found in (Kazuva et al., 2018; Saaty, 1980).

Of all the MCDM techniques, AHP has been chosen because it is the most suitable to work with both quantitative and qualitative criteria. Besides, it is very appropriate when dealing with complex situations with scarce information, such as anticipation of environmental consequences. AHP also helps to manage the consistency of the data, that is, to identify if the experts are inconsistent in eliciting their judgments.

Indeed, many studies have used the AHP to support decision making for environmental assessment, both isolated or connected to other techniques, such as fuzzy theory, the technique for order preference by similarity to ideal solution (TOPSIS), the decision making trial and evaluation laboratory, principal component analysis (PCA), and others (Dos Santos et al., 2019; Mardani et al., 2015)

Thus, the large number of manuscripts and their wide range of application fields together with the long previous experience of the authors in applying AHP in participatory environments paves the way for its use in this research.

Finally, and no less relevant for this work, the design of an evaluation methodology based on the AHP multi-expert technique allows its replicability. Once the aspects have been defined, their hierarchical structure has been collaboratively constructed and the questionnaires have been created, the technique could be applied in research project scenarios other than the paper's, by recruiting appropriate experts in the new field of research.

5.2.3 Application of the Method. Phase 1. Construction of the List of General Environmental Elements for Research and Innovation Projects

As stated, the objective of Phase 1 is to propose a list of environmental elements relevant for anticipation in R&I. The list should be holistic, including all the relevant concerns that a research or innovation project might need to anticipate and reflect. For that reason, four activities explained in Figure 18 were carried out, the results of which will be presented in the following section.

5.2.3.1 Identification of the Starting List of Environmental Elements for the Participatory Session

After the literature review, and aligned with other authors' proposals (Chatfield et al., 2017; Halme & Korpela, 2014; Iatridis & Schroeder, 2016), the CSR guidelines and tools were selected for three reasons: (i) they include guidelines and tools with all relevant environmental impacts, (ii) they have a life cycle perspective and (iii) CSR has a management approach, designed to be valid for all sorts of activities, as well as corporate or public research and innovation. Within CSR, the global reporting initiative (GRI) (Global Reporting Initiative, 2016) was selected as the source of environmental elements to start the debate among the experts. Various other initiatives and tools were studied and finally discarded for that purpose. To mention the most important ones: ISO 26000 (ISO, 2010), the AA1000 series of standards (AccountAbility, 2015), and the United Nations' Global Compact (United Nations Global Compact, 2015). GRI was deemed the most suitable to help to incorporate the full spectrum of environmental questions to all organizations' activities, regardless of their type, region, or size, based on the dialogue with stakeholders about the materiality of those aspects (Global Reporting Initiative, 2016; Iatridis & Schroeder, 2016). Besides, GRI presents insights about its monitoring, discussion with stakeholders, and communication, all of which are necessary inputs for later experts' work in the methodology (see Annexes G and H). Hence, GRI general environmental indicators act in Phase 1 as the starting information for the discussion about how to anticipate and reflect upon possible future environmental impacts, and to structure the debates among the experts.

5.2.3.2 Selection of Experts

For the methodology, a participatory approach is proposed as the relevance of the environmental elements is sure to be subject to uncertainty and diversity of preferences. Multi expert participation in such activities is not only crucial for selecting relevant sustainability indicators but also for improving the recognition and use of the indicators (Rametsteiner et al., 2011). However, it is usually unclear how many participants should be considered in the selection process. Greenbaum (1998) proposes that to be considered an appropriate expert for the research, requisites should be: broad experience on the issue, to belong to a specific category of specialists on the problem, and willingness to apply the procedure.

In participatory decision-making procedures based on AHP, the quality of experts is more important than the quantity (Saaty, 2004; Saaty & Peniwati, 2008). Ferwati et al. (Ferwati et al., 2019) affirm that AHP does not need a big sample size while, after a careful review of the literature, this number was found to greatly vary depending on the type of problem, and the way the model was approached. It is most common to work with a range of 2 to 20 experts. As explained, they are selected because they belong to a certain group or institution (Alizadeh et al., 2018; Huang & Wey, 2019), on the basis of their specific competences in certain fields (Giordano et al., 2010; Grošelj et al., 2016), due to their years of experience (Xia & Cheng, 2019), or for their interest in the problem (Grošelj & Zadnik Stirn, 2015).

In the end, following those rules, we recruited five experts in the field of sustainability, environmental assessment, and environmental education; all of them with professional experience in participating and managing R&I projects, and with different professional roles. The experts were selected because they were capable of applying their knowledge in the first phase to provide a general list of environmental topics for projects under any research line. And in the second phase, because they could contribute to identifying those criteria which were more relevant and urgent in the field of ICT for AHA. Table 16 presents the different experts' profiles.

Table 16 *Experts' profile*

Expert	Profile
Expert 1	Senior researcher expert in life cycle assessment, with responsibility in the environmental part of national and European research and innovation projects.
Expert 2	Coordinator of environmental educational activities and project manager of European projects.
Expert 3	Professor, specialist in life cycle assessment, main researcher of various national and European projects.
Expert 4	Professor with experience as an evaluator of research and innovation projects. Expert in environmental assessment.
Expert 5	Professor and expert on pollution prevention and control.

5.2.3.3 Participatory Session to Set the Environmental Elements

A meeting with the experts was arranged. They met in June 2018. First, they reviewed and accepted the proposal of the list based on the GRI universal environmental indicators. During the meeting, they analyzed the environmental topics proposed in the GRI indicators. Then, the description of the GRI environmental indicators was used to structure the debate among the experts. A deductive analysis allowed discussion of the validity of the GRI indicators and the identification of new environmental general elements. This resulted in a new set of elements aligned with the specificities of research and innovation projects.

5.2.3.4 Analysis of the Results

After the participatory session and considering the discussions among the experts, a definition of each element on the list was proposed. In addition, the elements were hierarchized to group them in categories and allow prioritization in the second phase. The experts received the definitions and the hierarchy to confirm that they respected the agreements of the participatory session (see the section of Results and Annex H for the hierarchy and description of each

element). Thus, the hierarchy can be used as a complete list of environmental issues to discuss during the anticipation and reflexivity activities of any R&I project. These results are presented and commented upon in the sections of Results and Discussion.

5.2.4 Phase 2: Prioritization of the Agreed Environmental Issues for ICT Projects on AHA

The objective of phase 2 is to propose a methodology for identifying the most relevant topics for a specific research line in a way that a tailored, reduced set of elements can be provided. Built upon the hypothesis that there are environmental elements that are more important to consider in certain projects, the aim is to avoid overburdening researchers by discarding those with lesser impact in their projects.

In this phase, the experts were asked to prioritize the environmental elements for projects of ICT for AHA. As described in the introduction, ICT for AHA projects do not usually focus on reducing the environmental impact of the outputs of the research. Hence, experts explored the connections of ICT for AHA and environmental sustainability. The prioritization phase required the completion of the following tasks.

5.2.4.1 Elaboration of a Questionnaire

A questionnaire was developed, with the list of environmental elements resulting from the first phase. The questionnaire allowed the experts to compare two elements of the same level of the hierarchy following the AHP method. The questionnaire included two examples of these types of projects to ensure that the experts were acting bearing in mind the same type of research disciplines. Those two examples were based on real projects funded under the Horizon 2020 research program of the European Commission (FrailSafe and Activage project). An example of a section of the questionnaire is included in Table 17.

Table 17 *Example of questionnaire*

From Your Point of View, Which Element is More Important, and to What Degree Does It Anticipate/Reflect on the Environmental Impacts of ICT Projects Applied to AHA?										
E1. Flows from biosphere	9	7	5	3	1	3	5	7	9	E2. Flows to biosphere

The used questionnaire is the standard questionnaire for paired comparisons required by the AHP matrices. Comparisons between criteria are made pairwise. The questionnaire uses the Saaty fundamental scale (Saaty, 1980), which is a 9-point ratio type scale, where 1 means equally important and 9 extremely more important. In this example, as number five was highlighted, the asked expert judges the cluster *Flows from biosphere* much more relevant than the cluster *Flows to biosphere*, in order to anticipate and reflect on the environmental impacts of ICT projects applied to AHA.

As the experts need not be familiar with the questionnaires, each time an expert was asked, the AHP facilitators accompanied them during the task, helping to sort out the difficulties. Besides, AHP allows the identifying of inconsistencies in the experts' judgments that, when they appeared, were also discussed and solved with the aforesaid experts.

5.2.4.2 Prioritization of ICT for AHA by the Experts

The questionnaires were issued out to each expert and they answered according to their level of preference following the Saaty 1–9 fundamental ratio scale. After processing the individual responses using Superdecisions® software, the individual and the whole group results were compiled.

This approach ensured that the prioritization of the environmental elements was ICT-specific and based on the environmental experts' perception of the current relevant topics on this line of research. Therefore, the participatory procedure resulted in a set of prioritized environmental elements that are research-area specific.

5.2.4.3 Confirmation of the Results based on the Individual Results and Comparison with the Group Results

After obtaining the results derived from the analysis of the questionnaires, both the individual results of each participant and the group results were sent to each expert so that they could confirm them or, otherwise, modify any of their individual judgments. Two experts expressed their aim to adjust their judgments and did so.

5.2.4.4 Analysis of the Results

After the revisions, the questionnaires with the final judgments of the experts were analyzed with Superdecisions. As proposed by Saaty and Peniwati (Saaty & Peniwati, 2008), the aggregation of all the individual judgments was calculated by means of the geometric mean to obtain the prioritization by the group of experts. The results of the phase two are presented and commented upon in the next section.

5.3 Results

The results of the study can be grouped into two categories. On the one hand, the first phase resulted in a panel of environmental elements organized in a hierarchy. The hierarchy included all the topics that the experts considered should be used in any research and innovation project without initial environmental goals, as a starting point to design the content of anticipation and reflexivity activities. On the other hand, as a result of the second phase, a prioritization is obtained of the environmental elements for a specific line of research, ICT for AHA.

5.3.1 Results from the First Phase: Hierarchy of Environmental Elements for Anticipation and Reflexivity Activities for any Research Line

The hierarchy obtained included twenty-five environmental elements and is presented in Figure 16. As can be seen, the environmental elements have been arranged in clusters by the experts. To achieve that, the general guidelines of GRI were debated and, applying a simple tree-building technique, the elements were classified in levels of specificity, and grouped by similar environmental features: Flows to Biosphere, Flows from Biospheres, etc. For definitions of each element, see Annex H. This hierarchy contained the environmental issues that research and innovation projects of any topic should use to design anticipation and reflexivity activities on the

potential intended and unintended consequences of the outputs of their projects and the scaling up of those products.

The hierarchy is based on the GRI proposal, and the adaptation to the R&I activity carried out by the experts. Thus, it is a list of elements closely related to the environmental consequences of R&I, the kind of information its stakeholders may demand, and the elements can readily be turned into indicators for monitoring, management, and disclosure if need be. Hence, these elements help to operationalize the dimensions of reflexivity and anticipation in line with other proposals such as (Iatridis & Schroeder, 2016; Monsonís-Payá et al., 2017; Res-AGorA Project, 2017; RRI Tools, 2014) .

This hierarchy aims to be complete more than to be usable, i.e., the model will normally be too complex for the anticipation and reflexivity of an R&I project. Therefore, for its application, specific to a research area, the hierarchy has to be prioritized and the relevant environmental elements be distinguished from the rest. Hence, the need for the second phase in the procedure, the one illustrated with a case study in the next section.

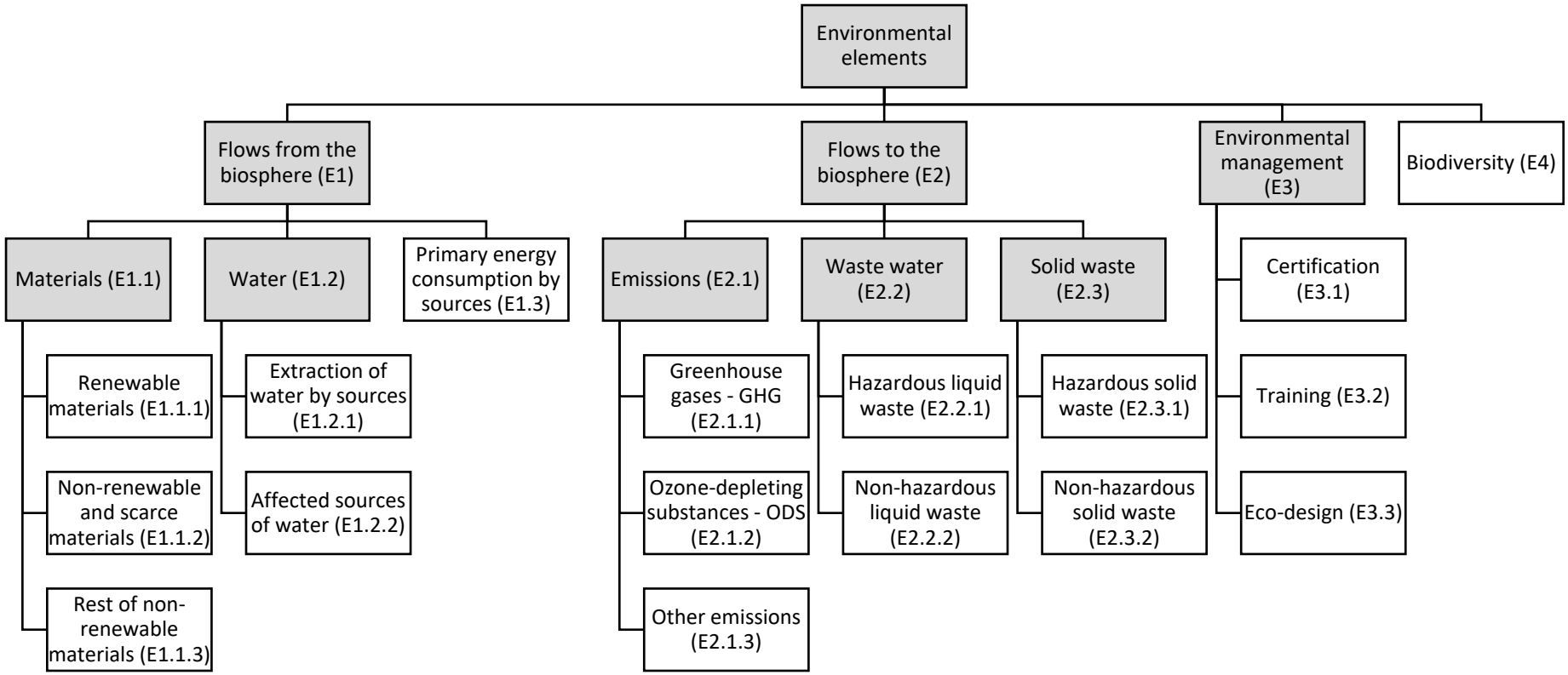


Figure 16 *Hierarchy of the environmental elements for anticipation and reflexivity activities for any research line without initial environmental goals*

5.3.2 Results from the Second Phase: Prioritization of Environmental Elements for ICT for AHA

The second phase of the study resulted in a prioritization of the environmental elements of the hierarchy obtained from phase 1. This prioritization was tailored for projects dealing with ICT for AHA solutions. The prioritization presents the order and percentage of importance that the experts assigned to the seventeen environmental elements at the end level of the hierarchy (with no sub-elements) for the specific case of ICT for AHA research and innovation projects.

The ranked environmental elements are presented in Table 18. This table shows in rows the elements ordered by importance (last column for the group), and in columns, the percentage assigned to each of them by the individual experts, together with the group aggregation.

These data show that in a given group of experts such as the ones participating in this study, there are different perceptions about the importance of the compared elements in order to reach a specific objective (e.g., anticipate and reflect on relevant environmental impacts of ICT on AHA projects).

Table 18 *Prioritized list of environmental elements for anticipation and reflexivity activities for ICT for AHA projects. Individual weights assigned by each expert (E) in percentage, and aggregated weight for the group*

Environmental Element	E1	E2	E3	E4	E5	Aggregated (Group)
Primary energy consumption by sources (E1.3)	3.0%	17.1%	21.5%	36.3%	27.9%	21.54%
Hazardous solid waste (E2.3.1)	2.5%	9.7%	9.6%	16.9%	8.4%	12.06%
Non-renewable and scarce materials (E1.1.2)	6.5%	4.5%	1.6%	11.7%	9.7%	11.61%
Eco-design (E3.3)	22.7%	4.5%	7.8%	9.2%	2.9%	10.86%
Greenhouse gases GHG (E2.1.1)	3.8%	0.8%	15.0%	3.8%	5.4%	7.0%
Biodiversity (E4)	9.6%	3.9%	7.0%	3.9%	8.0%	6.7%
Training (E3.2.)	22.7%	38.5%	1.2%	0.8%	0.8%	5.38%
Hazardous liquid waste (E2.2.1)	7.4%	3.0%	2.8%	1.5%	2.6%	4.52%
Affected sources of water (E1.2.2)	7.8%	1.1%	1.7%	2.9%	2.3%	3.49%
Certification (E3.1)	3.2%	1.2%	2.4%	1.7%	0.3%	3.32%
Rest of non-renewable materials (E1.1.3)	2.0%	0.4%	4.6%	3.3%	3.0%	2.90%
Ozone-depleting substances ODS (E2.1.2)	1.3%	0.1%	6.5%	0.6%	23.2%	2.90%
Other emissions (E2.1.3)	3.8%	0.2%	1.7%	1.5%	2.9%	2.58%
Non-hazardous solid waste (E2.3.2)	0.5%	1.4%	1.6%	4.2%	1.2%	2.13%
Renewable materials (E1.1.1)	0.5%	0.9%	1.0%	0.9%	0.7%	1.04%
Extraction of water by sources (E1.2.1)	1.1%	0.4%	1.7%	0.6%	0.5%	1.01%
Non-hazardous liquid waste (E2.2.2)	1.5%	0.4%	0.4%	0.2%	0.4%	0.69%
Total	100%	100%	100%	100%	100%	100%

This ranking is useful to identify the most relevant elements, by agreement or average, to be considered in the design of anticipation and reflexivity activities related to environmental sustainability. In order to use this result in the design of such activities, it might be useful to choose the most representative elements. In previous studies by the authors, this has been done by identifying the elements of the list that represent 50% of the total weight (Monsonís-Payá et al., 2017). The application of this criterion will produce a tailored-reduced panel of elements for ICT for AHA projects, resulting in a more manageable list of topics in cases of the scarcity of resources such as specific knowledge and time. Figure 17 shows this procedure. As can be seen, the weight of each criterion is displayed as a bar, and the curve line shows the accumulated weight after adding each element's weight. The first four elements altogether represent 56.07% of the total weight.

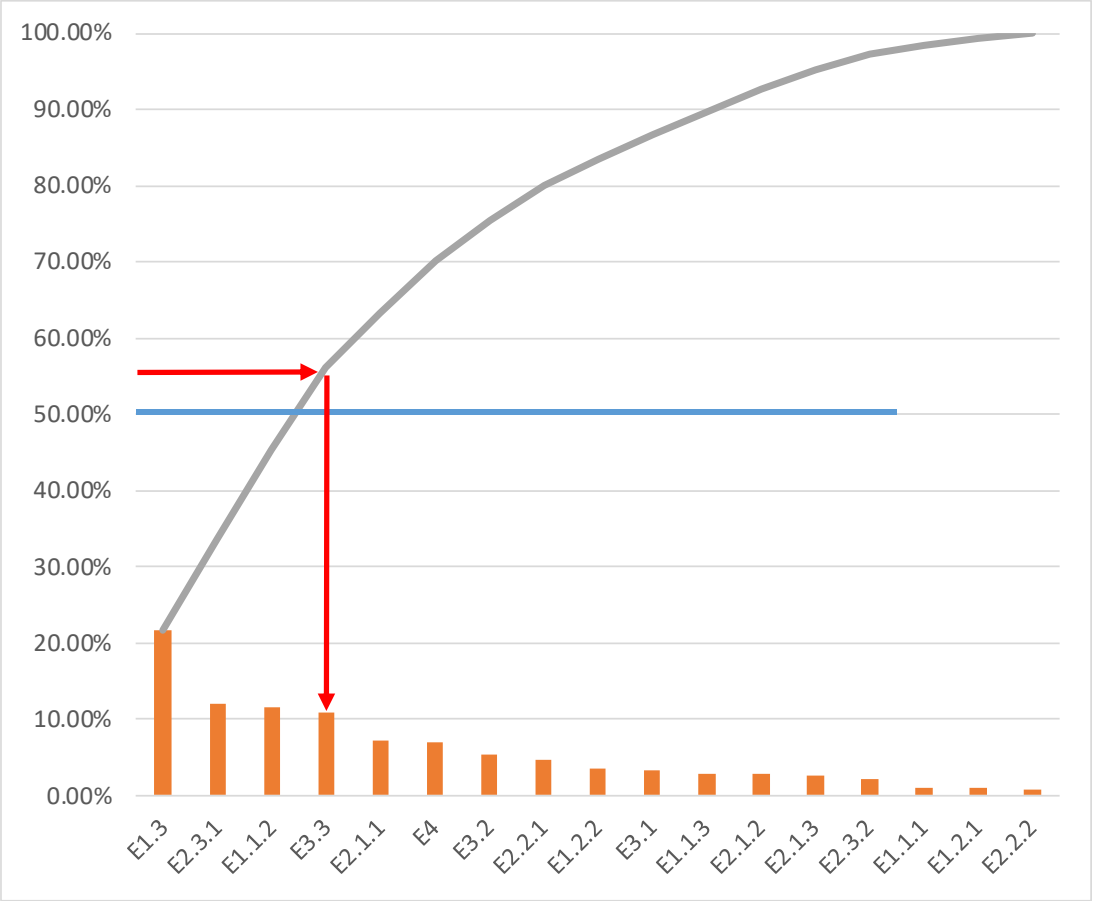


Figure 17 *Application of the criterion "up to 50%" to select the most relevant environmental elements according to the group of experts*

5.4 Discussion

Normally, ICT research is much more concerned with goals such as the process speed, reliable communication, wide-coverage, data privacy, duration of service, etc. In fact, ICT for AHA, in the same way as many other western paradigms, is rooted in a socio-political framework of growth based-economies (Pansera & Owen, 2018). Reducing the environmental burden on this line of research might imply swift forward strategies aligned with the principles of de-growth, which might not be naturally considered without an explicit exercise to anticipate and reflect on the long-term impacts of this research line outputs. The use of the proposed relevant environmental elements for a specific R&I domain could be used to inform through the design of the several activities and strategies identified to be contributing to these dimensions (Lubberink et al., 2017).

Comparing the results with the literature on ICT and sustainability, for example (Añón Higón et al., 2017; Belkhir & Elmeligi, 2018; ITU-T, 2012), there are clear coincidences with the outcomes of those research teams. Elements such as primary energy consumption, hazardous waste, greenhouse gas emissions, and consumption of scarce materials are the top concerns for the life cycle of ICT technologies. Or to give another example, eco-design and eco-innovation are consistently mentioned as in need of more attention in ICT development (European Commission, 2018; Porcelli & Martínez,

2015). Thus, these results and methodology contribute to raising awareness on the most relevant environmental issues of any research without environmental goals. Furthermore, in order to feasibly integrate the environmental concerns during the R&I practice, a methodology has been applied to focus on the most relevant elements. In the case of ICT for AHA, as demanded by (Añón Higón et al., 2017; Yaghmaei, 2018), it operationalizes and informs the critical first steps of the anticipation and reflexivity on the future environmental impacts of these R&I projects.

Regarding the methodology, AHP has proven to be a convenient tool to model a decision-making problem in which data are not complete, i.e., the expected environmental impacts and the available data are often qualitative and/or uncertain. AHP is based on experts that have a clear enough idea of how to compare environmental elements for anticipation and reflexivity during research and innovation. The results of the method were deemed by the experts to represent what they know, to convey their experience on the environmental assessment of R&I, and particularly, on the case study of ICT for AHA.

As introduced, the results in Table 22 show that there are significant discrepancies among the experts, although there is an overall agreement about the relevance of most elements. For example, '(E1.3) Primary Energy Consumption' of the product-to-be has been ranked as the most important element for anticipation and reflexivity by the group, also by experts 3, 4, and 5, and the second most relevant by expert 2. However, for expert 1 it is not even relevant, and she maintained her opinion after knowing the other experts' preferences.

Another example of discrepancies is the element '(E3.2) Training'. It is the most relevant element for expert 1 (together with 'Eco-design') and expert 2 (clearly differentiated from the rest). However, it has so little importance to experts 3, 4, and 5 that, for the group, it is only the 7^{th} in weight of the selected elements. This situation is normal when discussing the importance of environmental concerns from different approaches. Decision-makers, in this case, R&I practitioners, have to finally align with some experts or others, or with an average preference, aggregating all judgments.

AHP can also help the discussion as it shows the individual and the aggregated preferences, and it is fully disclosed and traceable. Specific judgments (pairwise comparisons) leading to the elements' preferences can both be acknowledged and discussed. Afterwards, a cut off rule can be applied to trim the list of elements to be assessed.

In this case study, the weights of the aggregated model do not differ much and the cut off was set at 50%. A trade-off is necessary between including as much importance (weight) as possible and keeping the list of elements simple. However, it is debatable where this threshold should be fixed.

Considering the experts' profiles, experts 3, 4, and 5 who work at universities coincide clearly. On the other hand, expert 1 (at a business association) and expert 2 (at a research center) show different preferences from the academics, and also between them.

Finally, whenever an interview with experts takes place, there will always be comments apart from the questionnaire that enrich the results. In this case, some of the insights provided by the experts were:

The selection of elements for reflexivity/anticipation could vary somehow from one region to another, for example, as the primary energy mix may be more or less polluting in different countries. This also applies to the evolution with time. It is expected that electricity will become ever less polluting in the

industrialized countries, while breakthrough innovations may solve the problem of e-waste, scarce materials, etc.

Given the topics, throughout an R&I project, it is not clear if it would be more convenient for the R&I team to get training in those environmental matters, to incorporate environmental experts to the project, or to add them to the stakeholders to achieve dialogue.

Hence, this work must be reviewed periodically, updating the list of environmental elements, and their preferences for particular research fields, like ICT for AHA. Additionally, the results of this research are somehow biased by the region where experts live, mainly Spain. Thus, the prioritization of environmental elements for particular case studies will not only consider the features of these cases but, also, will be influenced by the region where those projects will be carried out. For example, it is not the same to design devices that will consume currently polluting Spanish electricity than the much cleaner current Finnish electricity. Furthermore, research work such as Añón Higón et al. (2017), Belkhir & Elmeligi (2018) and Rivard et al. (2020) add insights on the advantages and disadvantages of either incorporating environmental experts to the project or to outsource that part.

The study focused on anticipation and reflexivity regarding the outputs of research and innovation activities. Other studies on R&I have pointed out the importance of intervening at the dimensions of "Process" and "Perception" in the stakeholders' network to reach the objectives of this policy (Strand et al., 2015), which have not been an object of this study.

5.5 Conclusions

In a situation of an ever-increasing application of ICT tools for active and healthy aging, their environmental impacts, however small, will be relevant by accumulation. Hence, the ever-increasing demand for environmental responsibility will reach R&I projects without initial environmental goals. Hence, this research is framed in the approach around the concept of responsible innovation and, specifically, in the need for anticipation and reflexivity of potential impacts of research and innovation to respond to the demands of society. The research contributes to operationalize this response in R&I without environmental goals. This model of the environmental concerns of R&I practice helps to raise awareness and to identify the problems to anticipate and reflect about. While the method for ranking ordering the environmental concerns of specific research fields enables the feasibility of the task.

As the environmental consequences of R&I outcomes are a wide and complex problem, GRI has been applied to divide them into clusters, elements, and their connections and hierarchy. Then, each element can be dealt with separately, though considering its role in the whole model.

To achieve it, the knowledge of five experts is processed. Experts on research and innovation, environmental assessment, and, to a lesser extent, ICT for AHA. Their job was to identify the environmental elements and to rank order them to enable an effective and efficient carrying out of the anticipation and reflexivity tasks.

However, this proposal has its limitations. On the one hand, the outcomes are temporary and must be updated as the understanding of the environmental causes and consequences, and the main challenges of each period evolve. On the other hand, while the hierarchy of environmental elements is quite consistent with the literature, and thus a good manageable summary, the rank order of the

elements is case-specific, and very debatable. Indeed, the consensus among experts was impossible in this case. This situation is frequent and does not invalidate the procedure. It reflects the aforementioned uncertainty about future environmental impacts. Hence, it has the positive effect of informing R&I practitioners on the intrinsic difficulties of anticipation and reflexivity and the possible debates. Furthermore, it also gives key concepts and arguments for a realistic balance among environmental goals and other R&I project goals. Finally, it is still the R&I team's task to engage stakeholders in a debate on the elements, contributing to what has been defined as forward-looking moral responsibility. The approach has to be pragmatic because better monitoring is achieved (i.e., better data, a better understanding of the data, more appropriate recommendations, and better uptake of findings); but also, ethical, because it is the right thing to do (i.e., people have a right to be involved in informing the decision-making process, whose outcomes will directly or indirectly affect them). Stakeholder participation is crucial also for improving the recognition and use of the reflexivity results, and to contribute to the consideration of a shared-responsibility.

Finally, the prioritized elements could form part of training contents to increase research and innovation teams' capabilities to enhance sustainable innovations. They could also serve to focus the elements to be reviewed in interdisciplinary collaborations. It can be argued that the integration of such exercises in the ICT for the AHA domain could lead to a better understanding of how to reduce potential unintended environmental impacts of massive promotion of technologies for supporting active and healthy aging. Anticipation and reflexivity might commit researchers and innovators in imagining more environmentally respectful technologies and to reflect on the norms and assumptions behind the development of their research outputs. Creative solutions and new imaginaries might appear to tackle the challenge of an aging population by focusing on research and innovation efforts based on ICT in reducing the environmental burden of their massive application in Europe.

Abbreviations

AHA—Active and Healthy Ageing
AHP—Analytic Hierarchy Process
ICT—Information and Communication Technologies
RI—Responsible innovation
R&I—Research and Innovation
RRI—Responsible Research and Innovation
TA—Technology Assessment

Capítulo 6 . Deliberative participation and the AHP technique: a process to identify and prioritise Responsible Research and Innovation's challenges on ethical issues in Spain

Autores: Irene Monsonís Payá, Félix Lozano

Pendiente de envío

Abstract

Responsible Research and Innovation (RRI) approaches call for engaging various actors in the different phases of the research and innovation processes. This paper explores a methodology to include deliberative exercises using the Analytical Hierarchy Process (AHP) with various actors participating in designing instruments to monitor and evaluate RRI. This paper critically analyses the contribution of such methodology in the area of Ethics and presents the benefits and challenges that its use might arise. Our results show that the positive effects of the method include opening up the discussion on relevant ethical aspects about RRI and the high level of commitment that the participants experiment in the process. The results also reflect limitations of the methodology for its implementation, such as being a demanding process in terms of time and costs and the need for a solid follow-up to ensure the correct application of the AHP technique. We conclude that this methodology should be carefully used after a reflective exercise on the purposes of the monitoring and evaluation instrument to be designed and the level of commitment and resources dedicated by the evaluator client.

Keywords: Responsible Research and Innovation; participatory deliberation, AHP, civic ethics, evaluation

6.1 Introduction

Responsible Research and Innovation (RRI) refers to a governance approach to deal with several challenges related to the responsible development of research and innovation. The features of the RRI approach have been extensively analysed since it appeared one decade ago (Owen et al., 2021). Since earlier phases of the research and innovation processes, facilitating the engagement of different actors has been identified as a common element in the different RRI accounts (Burget et al., 2017; Fraaije & Flipse, 2020; Timmermans & Blok, 2021).

In parallel with the evolution of the term RRI, different efforts crystallised to develop theoretical and practical instruments for monitoring and evaluating RRI (van de Poel, 2020). In 2017, the INPERRI project was designed to explore how a participatory methodology could support the identification of the more relevant indicators for a research system in a specific national context by promoting dialogue and deliberative discussions among experts and stakeholders in Spain. The project plan proposed to work with the six policy key areas suggested by the European Commission to articulate RRI (European Commission, 2012).

Thus, the work presented in this study focus on exploring a participatory technique in the discussion of indicators for evaluating and monitoring ethics (one of the key policy areas of the EC). The approach followed in the INPERRI project is inspired by a dialogical conception of responsibility, justifying the participation of interested groups in the process of discussion and decision-making. Also, the authors of this study justified the implications of considering dialogical ethics, and specifically, civic ethics of Adela Cortina as a normative framework for RRI (Lozano & Monsonís-Payá, 2020). In this work and inspired by Habermas (1983), some principles were proposed for practical dialogues about RRI in real settings: inclusion, symmetry, no coercion and publicity and accountability.

So, this study has a twofold objective: on the one hand, it presents the results of applying the INPERRI methodology to the key area of ethics. On the other hand, the article reflects on the lessons learned, benefits and difficulties, of using the methods and its contribution to the alignment of dialogues about RRI with civic ethics.

Therefore, this work contributes to the existing research in two critical ways. First, it provides interesting information about how the ethical aspects of science and technology are considered to be linked with the concept of RRI within the group of participants involved in the project. This output can be interesting to advance the operationalisation of the ethical management of science and technology. Second, the results of the critical assessment are relevant to future studies considering the use of the AHP technique for actors' engagement with decision-making purposes.

6.2 Materials and methods

In this work, we applied participatory techniques and the Analytical Hierarchy Process to foster discussion and deliberation by different actors. Our objective was to obtain a set of the most relevant aspects and a potential prioritised list of criteria and indicators that the participants considered essential regarding Ethics from an RRI perspective in Spain. Our methodological approach had a common standard with some of the participatory sessions organised within the INPERRI Project (Monsonís-Payá et al., 2017, 2020; Otero-Hermida & García-Melón, 2018).

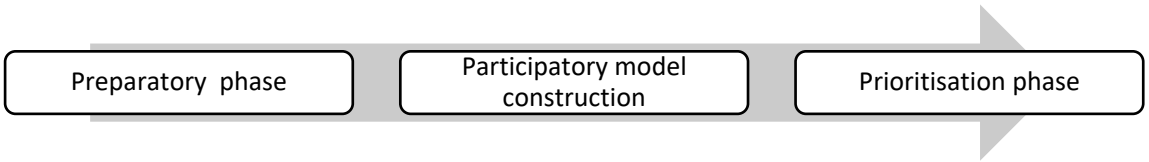


Figure 18 *Methodological and communication structure*

The methodological approach included three phases (seeFigure 18). The preparatory phase consisted of all the activities to prepare the participatory session, including the design of the participant's engagement process (see Figure 22 for dates and content). Then, in the second phase, experts and stakeholders worked together to analyse the key aspects regarding ethics from an RRI perspective in Spain and construct a set of potential criteria and indicators to monitor them. The third phase entailed prioritising the experts' and stakeholders' criteria and indicators. A continuous loop of communication with the participants in the research allowed for providing feedback on the development of the project in terms of both administrative and scientific content (seeFigure 19).

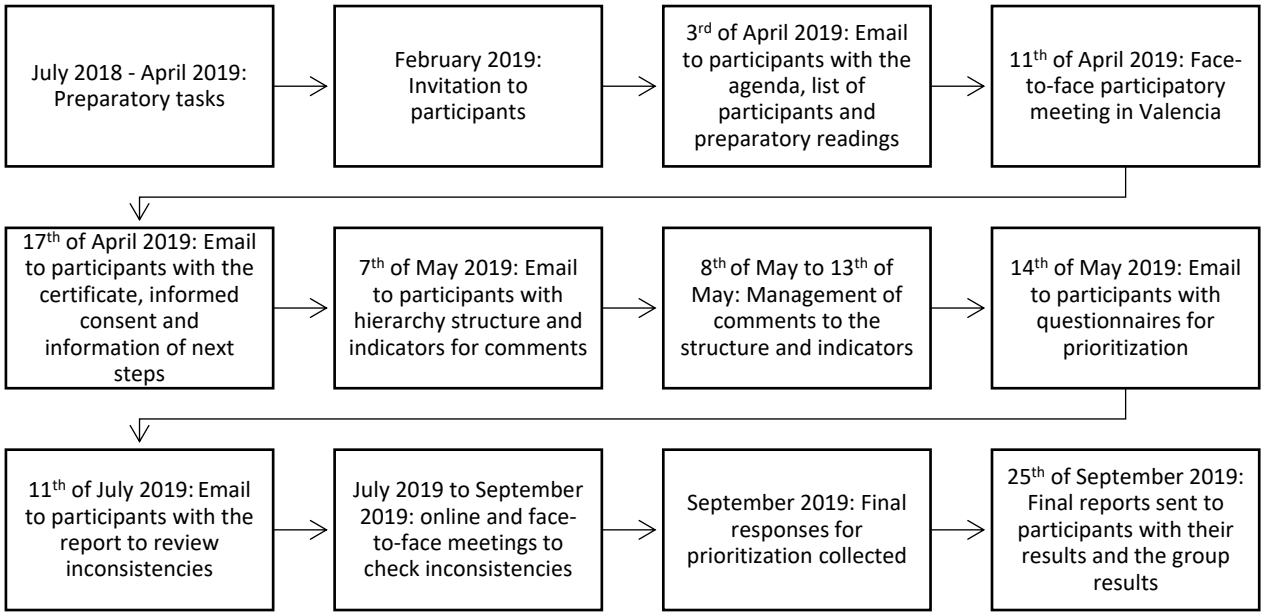


Figure 19 *Chronogram of the communication process and feed-back with the participants*

Preparatory phase

The preparatory phase consisted of all the activities undertaken to design and prepare the construction of a model of relevant aspects and a potential prioritised list of criteria and indicators regarding Ethics in the Spanish Research and Innovation system. Firstly, the authors of this study reviewed the relevant literature on RRI indicators in the key area of ethics. The objective of this review was twofold. On the one hand, the authors analysed the content of relevant reports to design a preliminary hierarchical criteria proposal for the participatory meeting. On the other hand, the authors identified pertinent literature to be shared among the experts and stakeholders to ensure a common understanding of the issues to be discussed during the participatory model construction. The documents reviewed included, among others, the Report from the Expert Group launched by the European Commission on Policy Indicators for Responsible Research and Innovation (Strand et al., 2015) and reports from the MORRI Project: the "Analytical Report on the dimension of research and innovation" (Griessler et al., 2016) and the report "Summarising insights from the MoRRI project" (Mejlgaard, 2018). It was decided to selected as recommended readings the summary and the extract on ethics of the Report from the Expert Group launched by the European Commission on Policy Indicators for Responsible Research and Innovation (Strand et al., 2015).

Secondly, the selection and invitation of experts and stakeholders took place. Eleven participants were confirmed, but one of them cancelled his participation the day before the participatory meeting. The participants were selected due to their expertise and background in five categories:

- Background in applied ethics.
- Background in RRI.
- Background in research and innovation in other areas of knowledge.
- Expertise in committees of ethics in academic institutions.
- Expertise in research and innovation policy in public administration.

Some experts were included in multiple categories, summarising their profiles in Table 19.

Table 19 *Experts and stakeholders' profile*

Expert code	Applied Ethics	RRI	Research in other areas	Committees of Ethics	R&I policy in public administrations	Area of academic or research expertise
Expert 1	X					Philosophy
Expert 2			X			Engineering (Design)
Expert 3	X	X				Philosophy
Expert 4		X	X			Law and Business
Expert 5			X			Engineering (Industrial)
Expert 6			X		X	Engineering (Energy)
Expert 7	X					Philosophy
Expert 8		X			X	Political science
Expert 9	X			X		Philosophy
Expert 10			X	X		Biology

The experts and stakeholders were invited and provided the preparatory readings to allow a common level of understanding of the discussion that would take place in the second phase, the participatory model construction.

Participatory model construction

The participatory meeting took place on the 11th of April 2019. Firstly, the researchers managed the informed consent regarding using the information obtained during the meeting for research purposes and using the names of the participants and audio-visual material for communication and diffusion purposes.

The participants had previously read the preparatory readings to ensure a minimum shared knowledge of the participants to carry out the discussion. During the meeting, some key definitions of RRI and their features (European Commission, 2012; Stilgoe et al., 2013; van den Hoven et al., 2013; von Schomberg, 2013) were presented and discussed, as well as the three subfields proposed by Strand et al. (Strand et al., 2015) for the ethics key area and the related indicators. These three subfields include a) research integrity and good research practice, b) research ethics of protecting the objects of research and c) societal relevance and ethical acceptability of the R&I outcomes. Then, a reflexive exercise about using indicators was presented, introducing critics and precautions about using such indicators. Aspects related to strategies to contextualise monitoring and evaluation exercises in the use of indicators of science (Mejlgaard, 2018; Ràfols, 2019; Strand et al., 2015), the need for participation (Ràfols, 2019) and prioritisation (Strand et al., 2015) were presented and discussed.

Having finished with the leveraging exercise, the session continued in two phases. The first one was called open discussion and focused on identifying relevant ethical issues and challenges in science and innovation in Spain. The discussion consisted of an analysis done by groups of 2 or 3 people to identify the aspects (issues and challenges). They were asked to categorise these relevant aspects or elements in the proposed categories of Strand et al. (2015) or include new categories. The experts worked in small groups and were asked to present their proposal to all the participants and try to get a consensus on the structure of categories, issues and challenges accepted by the group. This process resulted in an agreed frame of relevant ethical aspects (issues and challenges) in research and innovation in Spain.

The second part of the session consisted of identifying indicators suitable to monitor the issues and challenges identified in the first session. The experts were divided into two groups and given the following instructions to identify relevant indicators to the issues and challenges identified:

1. They should try to find indicators to monitor challenges and problems regarding the ethics of science and innovation in Spain;
2. They could select indicators from the sets of indicators included in the preliminary readings;
3. They could propose modifications to the sets of indicators included in the preliminary readings;
4. They could propose new indicators.

Then, the groups shared their conclusions, and all the experts worked together to build an agreed set of indicators to monitor the advances of ethics in science and innovation in Spain. The AHP technique requires that elements to be compared should be lower than seven (Saaty & Ozdemir, 2003), so experts and stakeholders were asked to decompound the elements of the structure in hierarchy levels with less than seven items per level.

In the last part of the participatory meeting, the researchers explained to the participants the methodology used to weigh the importance of indicators based on the AHP method and the instruments and processes that will be carried out to prioritise the indicators. A summary of this

information, a chronogram, the certificate of participation and a copy of the informed consent gathered during the session was also emailed. During this process, the authors analysed and synthesised the results of the participatory session and created a hierarchical model including a complete, exhaustive and coherent set of indicators according to the discussion undertaken in the participatory session. The report was shared to the experts via email to confirm the results, including the list of the indicators grouped by categories and the hierarchical structure adjusted to the agreements made in the participatory session. One expert provided suggestions to improve the description of two indicators that were considered appropriate and included in the final set of indicators and shared with the complete pool of experts that presented no objection. Three other experts confirmed that the report included very well the work done during the session and that the hierarchy synthesised precisely their discussions and agreements.

Prioritisation

With the model constructed, the paper's authors (Lozano and Monsonís) proceed to the design of the prioritisation phase. Firstly, they created templates to prioritise the indicators through a questionnaire. The questionnaire allowed the comparison of the elements at the same hierarchy level. This questionnaire is the standardised version used in the AHP technique and uses the Saaty fundamental scale, a 9-point ratio scale, where 1 means equally important, and 9 is extremely important. So, experts and stakeholders were asked to compare, using numerical and verbal expressions, the level of importance of one element against the other. To clarify the exercise, the colours blue and red were used to differentiate the elements under comparison. An example of the questionnaire is included in Table 20.

Table 20 *Example of the questionnaire*

	EX	MF	F	MO	=	MO	F	MF	EX	
Degree of participation of interest groups in the design of policies	9	7	5	3	1	3	5	7	9	Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects
Degree of participation of interest groups in the design of policies	9	7	5	3	1	3	5	7	9	Degree of the impact of participatory processes in projects and lines of research
Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	9	7	5	3	1	3	5	7	9	Degree of the impact of participatory processes in projects and lines of research

The questionnaires were sent on the 14th of May 2019 to the participants (see Annex I "Questionnaire") who fulfilled them, and the researchers introduced the data into the Superdecision software. Then, we analysed the inconsistency levels of the questionnaires. The use of the AHP technique requires that comparisons "fall in an admissible range of consistency" (Saaty, 1994:19). Following Saaty, "inconsistency is inherent in the judgement process" (Saaty, 1994:27). Levels of inconsistency lower or 1% or 0.1 are considered tolerable in the application of AHP. The results of the inconsistency analysis showed that just one participant presented levels of inconsistency lower than 0.1. The case with higher inconsistencies implied inconsistencies ranging from 2.71 to 4.24 in most of the levels of analysis, so the results of this participant were dismissed. The other eight participants

presented inconsistencies ranging from 0.11 to 0.58. The AHP technique allows one to identify "one by one in sequential order which judgements are the most inconsistent, and also suggest the value that best improves consistency" (Saaty, 1994:28). So, a strategy was designed to carefully review the inconsistencies of these eight participants by implementing the following steps. First, the data was exported to create an individual analysis of the results for each expert and stakeholder. Then, an individual report was prepared for the eight experts. The reports included a description of the following:

1. What inconsistency is in the application of the AHP technique?
2. Examples of acceptable responses with low levels of inconsistency and unacceptable responses with high levels of inconsistency.
3. A proposal to review the inconsistent responses by providing both the initial question, the answer provided by the participant and the resulting percentage of importance of each item, an explanation of why the answer was inconsistent and two or three possible alternatives to reduce the inconsistency to tolerable levels (lower than 0.1).

The report asked participants to:

1. Select between different options provided to reduce the inconsistency.
2. Ask for new options to reduce inconsistency.
3. Maintain their initial response by justifying it.

The objective of the report was to review in a systematic way the levels of inconsistency by supporting the participants in the understanding of the concept of inconsistency and engaging them in the revision. An anonymised version of one of the reports is included in Annex J.

The individual reports created to review the inconsistencies were emailed to the eight participants on the 11th of July. It was explained that the report was designed to allow them to make decisions autonomously. Still, we provided the possibility to organise a Skype call or a face-to-face interview to explain its content and logic if they deem it appropriate. Four of these participants autonomously reviewed their responses and emailed them back. The other four expressed the need for further assistance to check their answers. Face-to-face meetings were organised, and one interview was set via telephone. So, in September 2019, we had the final responses of nine participants with acceptance inconsistencies.

With the final set of responses without intolerable inconsistencies, we processed the data to obtain the individual and group results of the prioritisation exercise. On the 25th of September, the participants received an individualised report with their responses and the result of the aggregation of all the participants' responses. All the participants confirmed their agreement with the results.

In March 2023, with the preparation of this document, participants were informed of the presentation of the PhD by Irene Monsonís Payá and the confirmation of the information on the consent and the use of an individual anonymised report.

6.3 Results

Our study brought three results that will be presented in this section. The participatory model construction phase resulted in the two first groups of results. Firstly, we present the relevant aspects regarding monitoring ethics from an RRI perspective in Spain identified during the participatory meeting. Then, we present the proposed structure of categories and indicators of ethics considered relevant in this context. This structure included four dimensions discussed, and indicators were identified for all. Still, the participants agreed that just the dimension of the social relevance of the research was purely aligned with RRI. The other dimensions were considered relevant in terms of ethics and integrity of research. So, the prioritisation exercise would be performed only regarding the dimension of the social relevance of the research. The results of the third phase are the individual and group prioritisation, presented in the third sub-section.

Relevant aspects of ethics in Research and Innovation in Spain.

The first result is the list of relevant aspects of ethics in Research and Innovation in Spain. The discussion was articulated as explained in the previous section, according to the three categories proposed by (Strand et al., 2015), this is: a) research integrity and good research practice, b) research ethics of the protection of the objects of research and c) societal relevance and ethical acceptability of the R&I outcomes. During the discussion, the participants commented and agreed that only the group of questions related to "Social relevance and ethical acceptability of the R&I results" had to do with RRI. However, the other two topics are also very relevant. This goes in line with the statement of Strand et al. (2015:7), considering societal relevance and ethical acceptability of research and innovation outcomes as "the one that is closest to the general policy of RRI as a cross-cutting principle and the one for which the European Union has the most distinct role to play". For this reason, we will present the results regarding the societal relevance and ethical acceptability of the research and innovation results in more detail, as this was the area selected for prioritisation in the last phase. In Annex K, the aspects identified for the categories "research integrity and good research practice" and "research ethics of the protection of the research objects" are presented.

The relevant aspects allow understanding or contextualising the selection of indicators and the subsequent model and hierarchy developed in the following phases. The participants identified twelve ethical issues and challenges regarding the societal relevance and ethical acceptability of Spain's research and innovation results (Table 21). These challenges and issues were grouped into aspects related to 1) citizen participation and scientific dissemination, 2) management and research teams, and 3) the social relevance of the research.

Regarding the first sub-area (citizen participation and scientific dissemination), the participants considered it relevant to address three main issues. On the one hand, encouraging citizen participation in the Spanish research and innovation system was considered a key element. Citizen participation was supposed to face some challenges regarding using participatory processes in the initial phases of the research agendas, creating real multi-stakeholder dialogues that assure responsiveness, and promoting public consultations with high standards of appropriate information provided to citizens in terms of quality and relevance. The second issue regarding citizen participation and scientific dissemination referred to promoting citizen training to facilitate participation. In contrast, the third issue referred to the media dissemination of the ethical implications of the research.

The second sub-area structuring problems and challenges to improve the social relevance and ethical acceptability of the research and innovation results referred to managerial aspects of research teams. The participants agreed that challenges and problems in this regard referred to the system's complexity and individual decision-making can lead to "collective irresponsibility" and the need to align better incentives to promote societal relevance and acceptability. They also reflected and agreed on the difficulties linked to using indicators for creating incentives, as its use assumes that anticipation is possible and encounters lock-in difficulties. The need for a better alignment between "what is measured" (the current indicators to evaluate science) and the expected values were also an essential concern to the group. Also, the need to reflect on current lifestyle models was considered a challenge. The group felt that current lifestyles generate demand for technologies to cover needs that could be covered in other ways (alternatives better aligned with societal values and expectations). In this regard, it was considered that there is no explicit reflection on the root causes that generate the mainstream use of certain technologies that negatively affect societies. Finally, the sixth challenge in this sub-area referred to the risks associated with the lack of early awareness of undetected unconscious biases. Participants pointed out the need to reflect on the learning curve in research and innovation and how many errors and of which nature we can allow happening before discriminating a technique for lack of alignment with societal values.

Table 21 *Relevant aspects identified for the dimension "Societal relevance and ethical acceptability of the R&I results"*

Sub-area	**Relevant aspects**
Aspects related to citizen participation and scientific dissemination	1. Encourage citizen participation a. Inclusion of participatory processes in the initial phases of defining research agendas. b. Real multi-stakeholder dialogue that includes responsiveness. c. Popular consultations and quality and relevance of the information given to citizens 2. Citizen training (public opinion and emotionality) 3. Dissemination through the media of the ethical implications of research
Aspects related to the management of research teams	4. The complexity of the system and individual decision-making can lead to "collective irresponsibility." 5. Need for better-aligned incentives 6. Difficulty establishing indicators (assumes anticipation and encounters lock-in difficulties) 7. Need for better alignment of indicators (what is measured) with what values are expected 8. Lifestyle models that generate demand for technologies to cover needs that could be covered in another way (alternatives) - There is no explicit reflection on the root causes that create certain technologies 9. Learning curve - how many errors and of what type can we allow before discriminating the technique? Risks associated with the lack of early awareness of undetected unconscious biases.
Aspects related to the social relevance of the research	10. What is socially relevant? Is there a reduction of real unresolved problems? Are there abandoned areas? How are agendas prioritised? 11. Sustainability of the results, not only the ecological aspect but also the non-increase of gaps and the generation of social cohesion. 12. Use of normative anchors (such as SDG)

Hierarchy of dimensions and indicators of ethics

The second result of our study is the hierarchy of indicators to monitor challenges and problems related to ethics in the Spanish research and innovation system. As the methodology explains, the hierarchy is the result agreed upon by the participants. To achieve this agreement, they were first split into two groups where they proposed categories and indicators for monitoring the relevant aspects identified during the first session. Then all the participants discussed the conclusions of the two groups and agreed on the structure. This exercise was done for the three categories proposed by Strand et al. (2015), and participants considered it necessary to create a new one: "Ethics' training". In this section, we will present the results for the category "societal relevance and ethical acceptability of the R&I outcomes". These results were later on used for the prioritisation exercise. The structure of indicators proposed for "research integrity and good research practice", "research ethics of the protection of the objects of research", and "Ethics' training" can be consulted in Annex L.

The resulting hierarchy of categories and indicators for social relevance and ethical acceptability of the R&I results is presented in Figure 20. We included a pattern of colours to distinguish between the three sub-categories proposed by the participants: collaboration between areas of knowledge (yellow), participation of interested groups (blue) and support and monitoring of reflexiveness to promote social relevance and ethical acceptability (green). The hierarchy is organised into three levels, the first level responds to categories of dimensions to be monitored, and the second level includes the indicators proposed by the participants to monitor those dimensions. It was considered necessary to split two indicators into more specific ones, the ones in the third level of the hierarchy. During the discussion between the participants to agree on the hierarchy and define the indicators, some issues and comments on interpreting the indicators were expressed. The authors considered it relevant to include them in the results, and the documentation shared to the participants throughout the process. Table 22 details the sub-categories, indicators, codes and comments on the indicators.

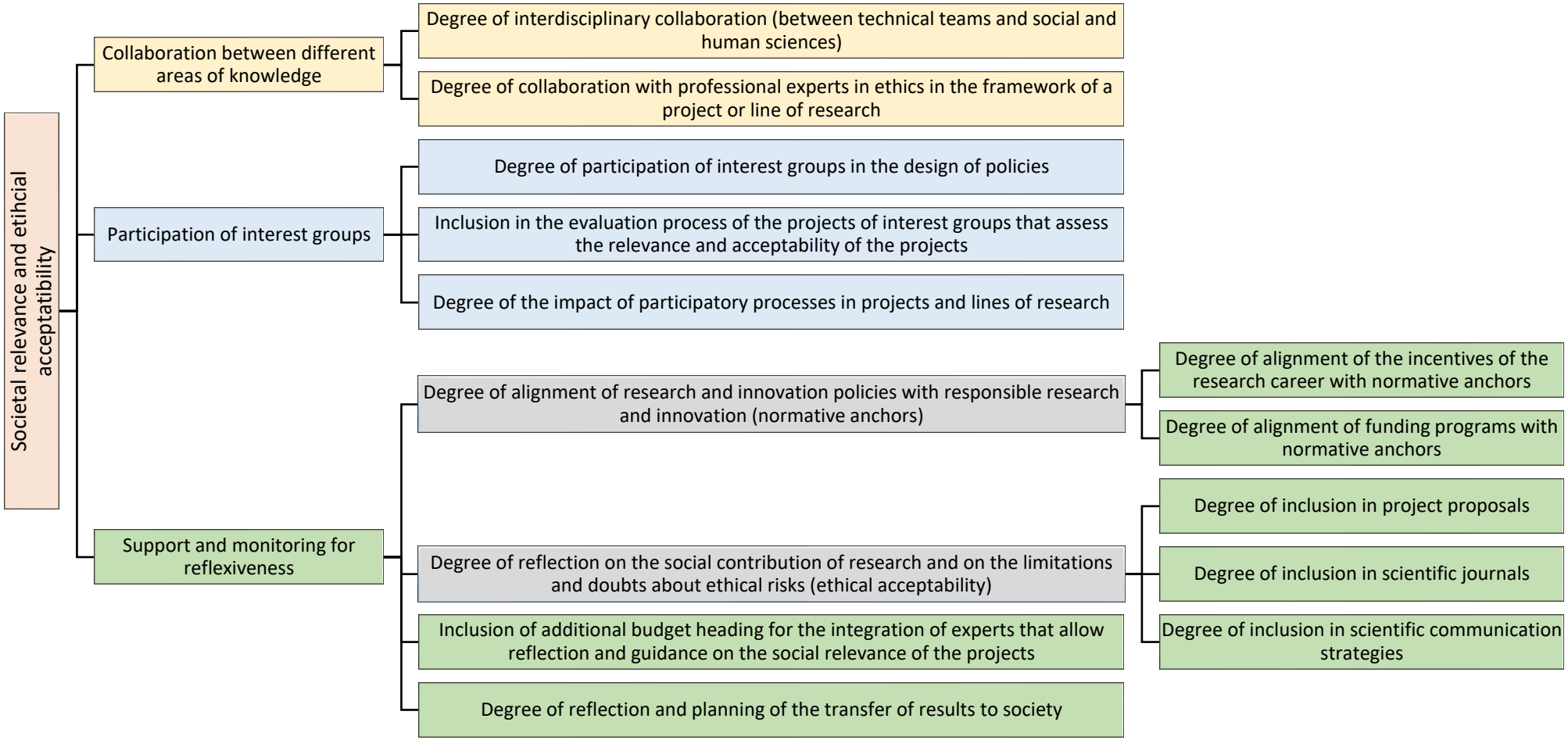


Figure 20 *Hierarchy of categories and indicators for societal relevance and acceptability of the research and innovation results*

Table 22 Categories, indicators, codes and notes for the dimension "Societal relevance and ethical acceptability of the R&I results"

Sub-Category	Code	Indicator	Notes about the indicators
Collaboration between different areas of knowledge	COL 1	Degree of interdisciplinary collaboration (between technical teams and social and human sciences)	
	COL 2	Degree of collaboration with professional experts in ethics in the framework of a project or line of research	
Participation of interest groups	PART 1	Degree of participation of interest groups in the design of policies	This indicator refers to the design of research agendas.
	PART 2	Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	This indicator refers to the project evaluation phase. These interest groups, which could be non-academic, would evaluate the relevance and acceptability of the project.
	PART 3	Degree of the impact of participatory processes in projects and lines of research	This indicator refers to the execution phases of the development of projects and lines of research and analyses the adjustments and modifications carried out due to the participatory processes.
Support and monitoring for reflexiveness about the social relevance and acceptability of the research and innovation results	SEG 1	Degree of alignment of research and innovation policies with responsible research and innovation (normative anchors)	Normative anchors are political objectives and international agreements such as the SDGs, human rights declarations, supranational strategies on social justice and environmental sustainability, etc.
	SEG 1.1	Degree of alignment of the incentives of the research career with normative anchors	
	SEG 1.2	Degree of alignment of funding programs with normative anchors	
	SEG 2	Degree of reflection on the social contribution of research and the limitations and doubts about ethical risks (ethical acceptability)	
	SEG 2.1	Degree of inclusion in project proposals	
	SEG 2.2	Degree of inclusion in scientific journals	
	SEG 2.3	Degree of inclusion in scientific communication strategies	This indicator would indicate the breadth, quality and diversity of communication strategies used by the unit of measurement to disseminate the research results responsibly.
	SEG 3	Inclusion of additional budget heading for the integration of experts that allow reflection and guidance on the social relevance of the projects	
	SEG 4	Degree of reflection and planning of the transfer of results to society	This indicator would include elements on the reflection on the social relevance and ethical acceptability in the transfer procedures and processes and the strategies for reducing the time of application of the research results.

Prioritisation of indicators of societal relevance and ethical acceptability

The third phase of this study consisted of prioritising the relevance of the indicators included in the hierarchy proposed during the participatory model construction. Each participant obtained their own set of weights for the twelve indicators. As referred to in the methodology, the results of one participant were excluded from the analysis for needing to be more consistent. In this sub-section, we will present three different analyses - first, the prioritised set of indicators for each participant. Then we will show the results of the group. Finally, we will analyse the results of the group differentiating the results of the participants with a background in social sciences and humanities and those with a background in engineering.

Individual results

The results of the individual prioritisation by the participants are presented in Table 23. The table is complemented with a legend to explain the colours used to highlight the three most and less relevant indicators for each participant. In the table, each individual most relevant indicators appeared in orange, from dark orange for the higher percentage to light orange for the third more relevant indicator. Similarly, grey highlights the less weighted indicators, from dark grey for the less weighted one to light grey for the third less weighted indicator. Using these colours allows for identifying the patterns of importance given by the participants to the sub-categories and the indicators.

It can be observed that the sub-category of participation is considered relevant for most participants compared to collaboration between areas of knowledge and support of reflexiveness. Inside the sub-category, two indicators are between the three with the highest weights for most participants: "Degree of participation of interest groups in the design of policies" and "Degree of the impact of participatory processes in projects and lines of research". Also, the indicator "Inclusion of additional budget heading for the integration of experts that allow reflection and guidance on the social relevance of the projects" in the sub-category of support to reflexiveness is considered highly relevant for most participants.

On the opposite extreme, the indicators related to the "Degree of alignment of research and innovation policies with responsible research and innovation (normative anchors)" and the "Degree of reflection on the social contribution of research and on the limitations and doubts about ethical risks (ethical acceptability)" received the lowest weight by most of the participants.

Group results

To obtain the composite of individual judgements using the AHP, it is necessary to calculate the geometric average (geometric mean). Table 24 and Figure 21 show the prioritised list of indicators by aggregation of theirs. Similarly to the analysis of colours of the individual results, it can be observed both in Table 28 and Table 32, the category "Participation of interest groups" was considered of higher relevance than the others, and their related indicators were at the top of the list of prioritised indicators by the group.

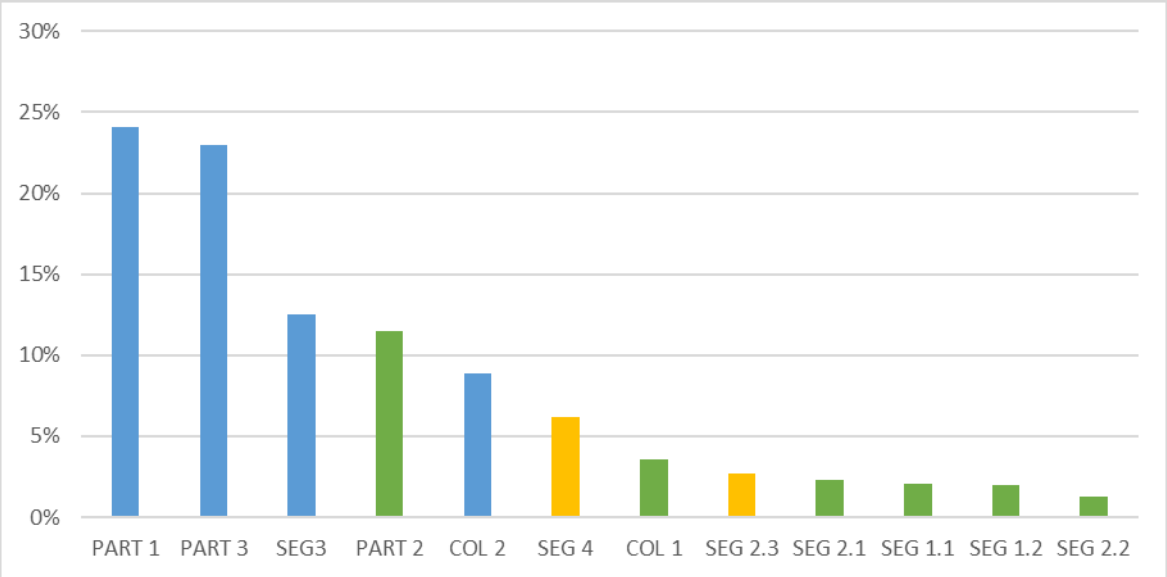
Table 23 *Individual results of prioritisation*

Indicators	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	EXP 7	EXP 8	EXP 9	EXP 10
COL 1 Degree of interdisciplinary collaboration (between technical teams and social and human sciences)	1,97%	0,88%	7,58%	6,46%	2,62%	1,05%	31,50%	0,70%	0,94%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	5,90%	6,16%	1,52%	19,37%	7,85%	5,25%	10,50%	6,34%	6,57%
PART 1 Degree of participation of interest groups in the design of policies	17,31%	16,32%	11,74%	30,62%	40,58%	3,79%	21,90%	56,46%	5,38%
PART 2 Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	4,87%	4,94%	28,95%	7,26%	6,67%	3,79%	7,30%	5,29%	26,90%
PART 3 Degree of the impact of participatory processes in projects and lines of research	4,10%	53,88%	4,76%	25,82%	16,45%	18,96%	21,90%	13,39%	26,90%
SEG 1.1 Degree of alignment of the incentives of the research career with normative anchors	11,85%	0,66%	7,90%	0,84%	2,09%	8,08%	0,14%	0,22%	0,21%
SEG 1.2 Degree of alignment of funding programs with normative anchors	11,85%	1,97%	1,58%	0,12%	0,42%	8,08%	0,14%	1,52%	1,04%
SEG 2.1 Degree of inclusion in project proposals	3,41%	1,54%	0,55%	1,38%	4,32%	5,04%	0,40%	0,53%	0,95%
SEG 2.2 Degree of inclusion in scientific journals	0,56%	0,25%	1,97%	0,33%	0,71%	5,04%	0,40%	0,53%	0,95%
SEG 2.3 Degree of inclusion in scientific communication strategies	1,38%	1,37%	2,33%	1,17%	1,75%	1,68%	0,40%	2,66%	4,77%
SEG 3 Inclusion of additional budget heading for the integration of EXPs that allow reflection and guidance on the social relevance of the projects	26,31%	10,24%	27,66%	4,98%	14,93%	27,48%	1,08%	0,91%	19,34%
SEG 4 Degree of reflection and planning of the transfer of results to society	10,50%	1,80%	3,46%	1,66%	1,59%	11,76%	4,35%	11,45%	6,06%

Table 24 *Group results of the prioritisation*

Indicators	%
PART 1 Degree of participation of interest groups in the design of policies	24,10%
PART 3 Degree of the impact of participatory processes in projects and lines of research	22,95%
SEG 3 Inclusion of additional budget heading for the integration of EXPs that allow reflection and guidance on the social relevance of the projects	12,50%
PART 2 Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	11,50%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	8,88%
SEG 4 Degree of reflection and planning of the transfer of results to society	6,22%
COL 1 Degree of interdisciplinary collaboration (between technical teams and social and human sciences)	3,54%
SEG 2.3 Degree of inclusion in scientific communication strategies	2,71%
SEG 2.1 Degree of inclusion in project proposals	2,30%
SEG 1.1 Degree of alignment of the incentives of the research career with normative anchors	2,09%
SEG 1.2 Degree of alignment of funding programs with normative anchors	1,98%
SEG 2.2 Degree of inclusion in scientific journals	1,23%

Figure 21 *Prioritised list of indicators according to the group of participants*



With these results, we would like to apply three of the criteria proposed in our previous study to reduce the list of indicators: "best in class", "cut-off percentage", and "percentage of indicators" (Monsonís-Payá et al., 2017). The first criterion proposed is "Best in class", referring to creating a short set of indicators by including the most weighted one for each category. Following these criteria, the reduced set for this study will consist of the three indicators inTable 25.

Table 25 *The reduced set of indicators applying the criteria "Best in class"*

Indicators	%
PART 1 Degree of participation of interest groups in the design of policies	24,10%
SEG 3 Inclusion of additional budget heading for the integration of EXPs that allow reflection and guidance on the social relevance of the projects	12,50%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	8,88%

The second criterion for selecting a short list of indicators would be using a cut-off percentage of the geometric means. If we set the rate at 50% as we did in previous studies (Monsonís-Payá et al., 2017, 2020), the resulting list will be the one included inTable 26, representing 59,99% of the total weight. The graphical representation of the 50% cut-off can be seen inFigure 22.

Table 26 *Reduced set of indicators applying the criteria "up to 50%"*

Indicators	%
PART 1 Degree of participation of interest groups in the design of policies	24,10%
PART 3 Degree of impact of participatory processes in projects and lines of research	22,95%
SEG 3 Inclusion of additional budget heading for the integration of EXPs that allow reflection and guidance on the social relevance of the projects	12,50%
Total weight	59,55%

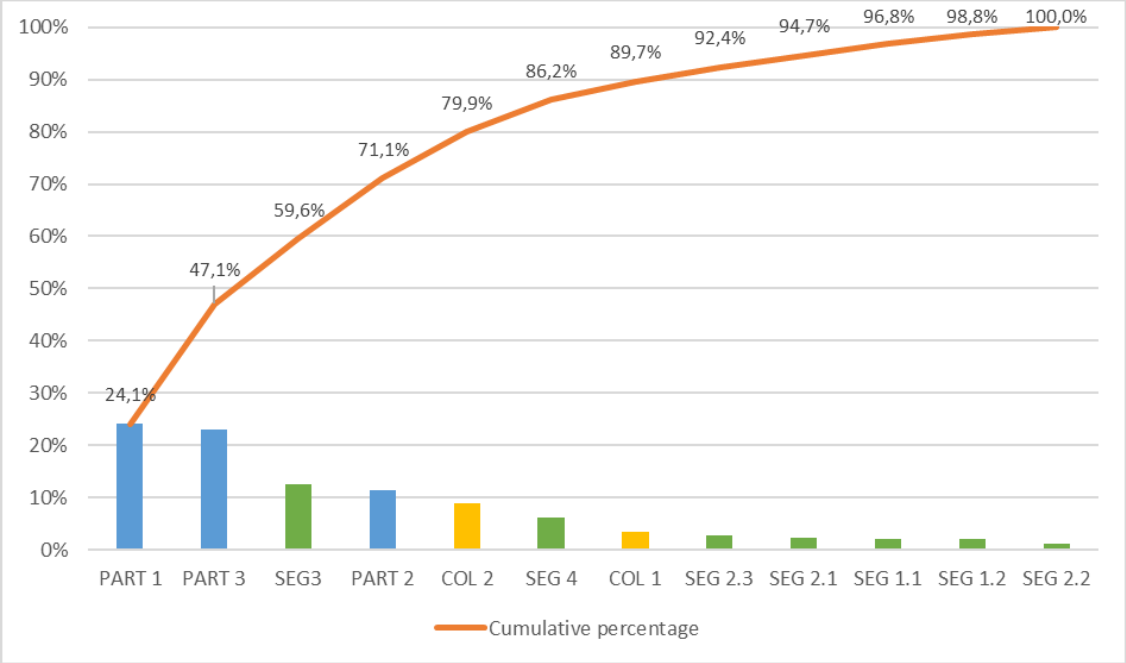


Figure 22 *Application of the criterion "up to 50% of Geometric Mean" to the prioritised list of indicators by the group*

The third criterion implies selecting a percentage of indicators, for instance, 50% of the proposed indicators by the group. Applying this criterion, we would reduce the list to the six first indicators out of the twelve that compound the prioritised list (Table 27).

Table 27 *Reduced set of indicators applying the criteria "50% of the indicators"*

Indicators	%
PART 1 Degree of participation of interest groups in the design of policies	24,10%
PART 3 Degree of impact of participatory processes in projects and lines of research	22,95%
SEG 3 Inclusion of additional budget heading for the integration of EXPs that allow reflection and guidance on the social relevance of the projects	12,50%
PART 2 Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	11,50%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	8,88%
SEG 4 Degree of reflection and planning of the transfer of results to society	6,22%
Total weight	86,15%

Table 28 *Group results of relevant aspects' weigh*

Relevant aspects	Group
COL	12,42%
PART	58,55%
SEG	29,03%

Group results by the background of the participants

The results of the group by using the geometric mean have been presented. We considered it relevant to explore the results by splitting the participants according to their academic and research backgrounds. Based on the area of knowledge of academic or research background presented in Table 23, we grouped the participants into two categories: a background in Science and Engineering and a background in Social Sciences and Humanities (see Table 29).

Table 29 *Participant's category according to their background*

Expert code	Science and Engineering (SCI & ENG)	Social science and Humanities (SS & HUM)	Area of knowledge of academic or research background
Expert 2	X		Engineering (Design)
Expert 3		X	Philosophy
Expert 4		X	Law and Business
Expert 5	X		Engineering (Industrial)
Expert 6	X		Engineering (Energy)
Expert 7		X	Philosophy
Expert 8		X	Political science
Expert 9		X	Philosophy
Expert 10	X		Biology

The first comparison we explored was the differences between the groups to the weight given to the first hierarchical level; this is, the importance given to the relevant aspects. The results were very similar for both groups (see Figure 23).

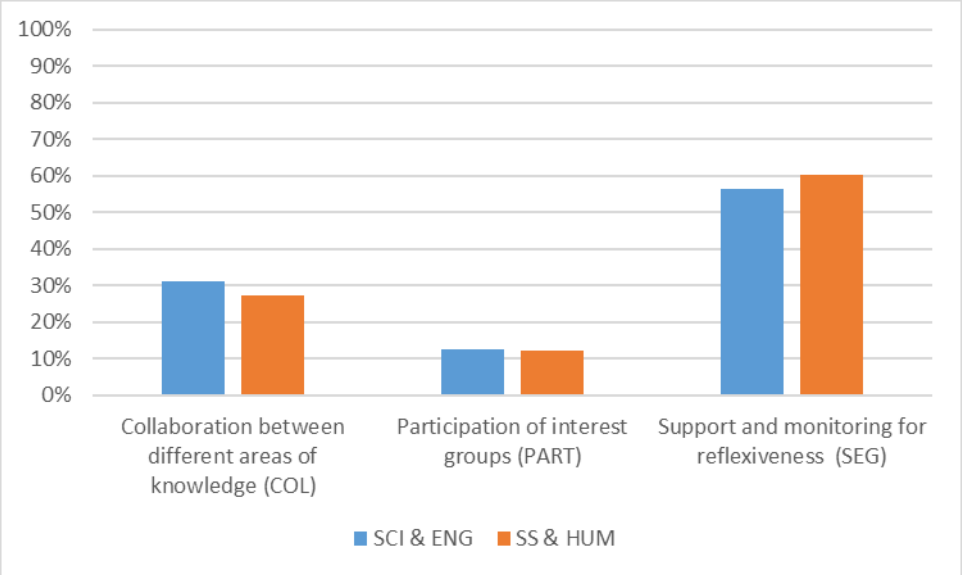
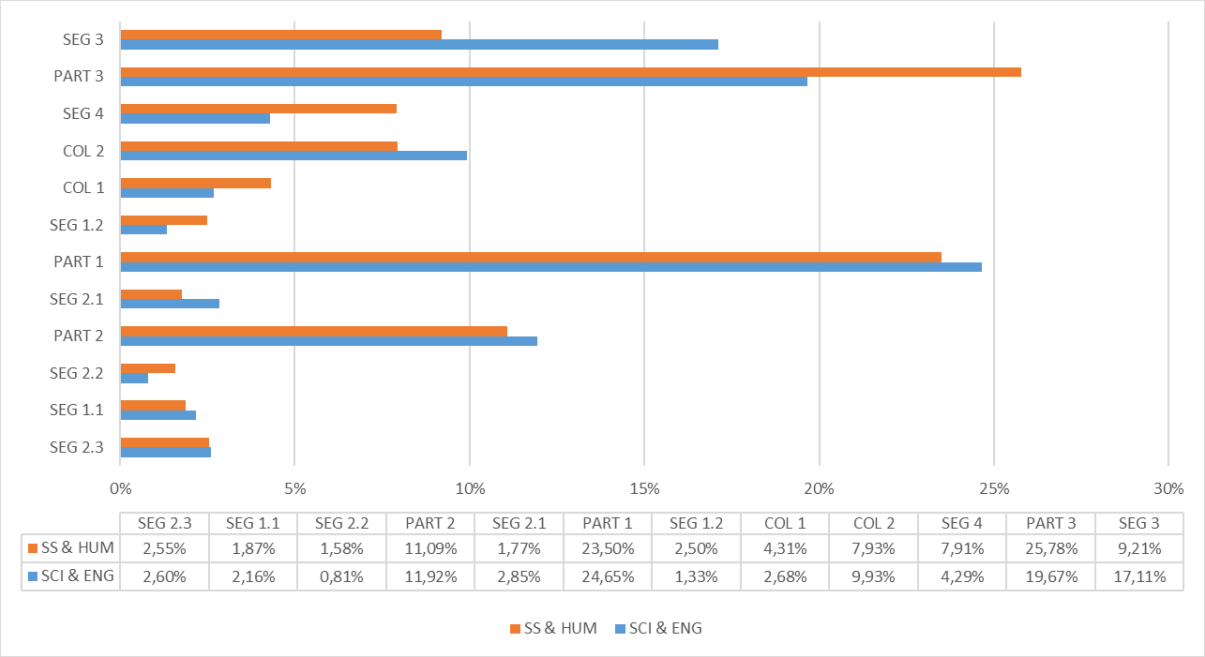


Figure 23 *Group results of relevant aspects' weigh for the different backgrounds of participants*

Then, we explored the different weights given to the indicators by each group of participants. Figure 24 presents the different weights for the indicators resulting from the analysis of the two groups. The results in this figure are presented in order according to the difference observed between both groups. Therefore, the indicator "Inclusion of additional budget heading for the integration of experts that allow reflection and guidance on the social relevance of the projects" was considered much more important for the participants with a background in science and engineering than for the ones belonging to the category social sciences and humanities. The second indicator that presented higher differences in weight among both groups was the "Degree of the impact of participatory processes in projects and lines of research". This indicator received more weight from the group of social sciences and humanities.



	SEG 2.3	SEG 1.1	SEG 2.2	PART 2	SEG 2.1	PART 1	SEG 1.2	COL 1	COL 2	SEG 4	PART 3	SEG 3
SS & HUM	2,55%	1,87%	1,58%	11,09%	1,77%	23,50%	2,50%	4,31%	7,93%	7,91%	25,78%	9,21%
SCI & ENG	2,60%	2,16%	0,81%	11,92%	2,85%	24,65%	1,33%	2,68%	9,93%	4,29%	19,67%	17,11%

Figure 24 *Group results of indicators for the different backgrounds of participants*

Finally, we would like to compare the resulting prioritisation lists for each group (see Table 31 and Table 32) with the participants' results. First, in Table 30, both lists are presented together.

Table 30 *Prioritisation list for the compete group and the two groups according to background*

Total group	Science and engineering	Social Sciences and Humanities
PART 1	PART 1	PART 3
PART 3	PART 3	PART 1
SEG 3	SEG 3	PART 2
PART 2	PART 2	SEG 3
COL 2	COL 2	COL 2
SEG 4	SEG 4	SEG 4
COL 1	SEG 2.1	COL 1
SEG 2.3	COL 1	SEG 2.3
SEG 2.1	SEG 2.3	SEG 1.2
SEG 1.1	SEG 1.1	SEG 1.1
SEG 1.2	SEG 1.2	SEG 2.1
SEG 2.2	SEG 2.2	SEG 2.2

Table 31 *Group results of prioritisation for the group with background in Science and Engineering*

Indicators	%
PART 1 Degree of participation of interest groups in the design of policies	24,65%
PART 3 Degree of the impact of participatory processes in projects and lines of research	19,67%
SEG 3 Inclusion of additional budget heading for the integration of experts that allow reflection and guidance on the social relevance of the projects	17,11%
PART 2 Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	11,92%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	9,93%
SEG 4 Degree of reflection and planning of the transfer of results to society	4,29%
SEG 2.1 Degree of inclusion in project proposals	2,85%
COL 1 Degree of interdisciplinary collaboration (between technical teams and social and human sciences)	2,68%
SEG 2.3 Degree of inclusion in scientific communication strategies	2,60%
SEG 1.1 Degree of alignment of the incentives of the research career with normative anchors	2,16%
SEG 1.2 Degree of alignment of funding programs with normative anchors	1,33%
SEG 2.2 Degree of inclusion in scientific journals	1,23%

Table 32 *Group results of prioritisation for the group with background in Social Sciences and Humanities*

Indicators	%
PART 3 Degree of the impact of participatory processes in projects and lines of research	25,78%
PART 1 Degree of participation of interest groups in the design of policies	23,50%
PART 2 Inclusion in the evaluation process of the projects of interest groups that assess the relevance and acceptability of the projects	11,09%
SEG 3 Inclusion of additional budget heading for the integration of experts that allow reflection and guidance on the social relevance of the projects	9,21%
COL 2 Degree of collaboration with professional experts in ethics in the framework of a project or line of research	7,93%
SEG 4 Degree of reflection and planning of the transfer of results to society	7,91%
COL 1 Degree of interdisciplinary collaboration (between technical teams and social and human sciences)	4,31%
SEG 2.3 Degree of inclusion in scientific communication strategies	2,55%
SEG 1.2 Degree of alignment of funding programs with normative anchors	2,50%
SEG 1.1 Degree of alignment of the incentives of the research career with normative anchors	1,87%
SEG 2.1 Degree of inclusion in project proposals	1,77%
SEG 2.2 Degree of inclusion in scientific journals	1,58%

In the following spider chart we include the result of both groups for all the indicators (Figure 25), and the four represented the three with higher weight (Figure 26).

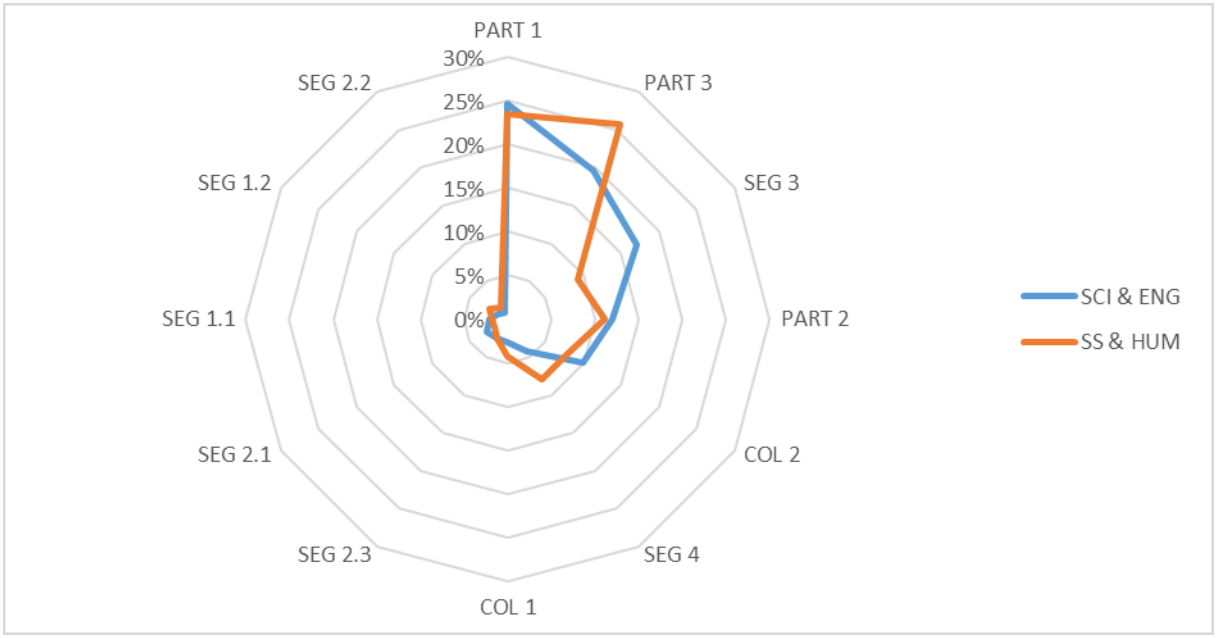


Figure 25 *Weight given to all the indicators for each group according to the background of participants*

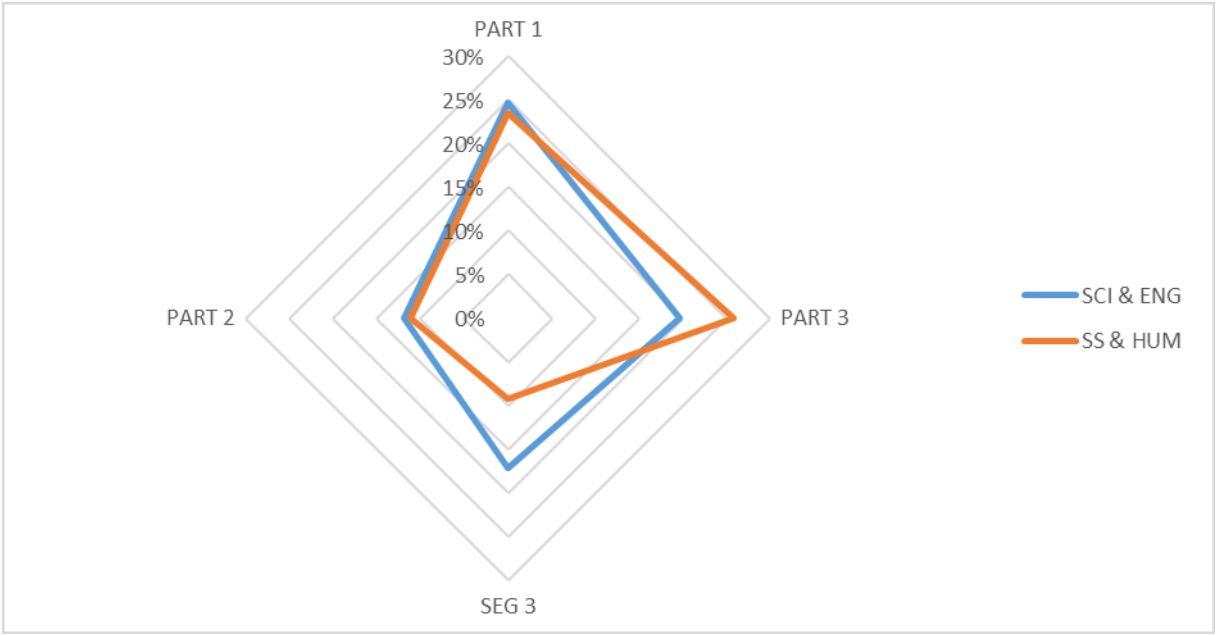


Figure 26 *Weight given to the four more weighted indicators for each group according to the background of participants*

6.4 Discussion

This article had a twofold objective. On the one hand, presenting the results of applying the methodology to the key area of ethics, similarly to the work done by the authors in other areas (Monsonís-Payá et al., 2017, 2020).

In the first place, the application of the AHP technique made it possible to open a discussion on the essence of the object to be evaluated in the Spanish context and to make decisions about it. The participants reflected on which aspects were most relevant for the three categories proposed by Strand et al. (2015), and identified a hierarchical structure and indicators for the evaluation and monitoring of ethics in Spanish science and innovation. A new category was created to bring together specific training needs and the participants pointed out that only social relevance was in line with what they considered RRI should look at. Subsequently, possible indicators were identified, some of which were completely new with respect to those shared in the preparatory readings. Thus, the process designed made it possible to reach a consensus on the hierarchical structure, to individually prioritize the importance of the indicators and to obtain confirmation of the results by each individual. This process is in itself valuable as it allows opening up the discussion on the object of evaluation or monitorization.

In the research process, we observed some difficulties in the application of the technique among the participants. On the one hand, the logic of the application of pairwise prioritization was not clear or easily executable for one participant (Participant 1). On the other hand, we observed that the application of the methodology required an extensive review of inconsistencies for most experts, with the associated economic and time cost.

The participants also showed alternative trends on the weights given to the indicators depending on their background. So, participants of the Science and Engineering group are closer to an Elsi/Elsa conception involving experts while those of the Social Sciences and Humanities group give more importance to stakeholder participation.

Regarding the experts' satisfaction with the process, we received expressions of satisfaction both with the level of feedback offered to the participants and with the final result of the participatory process.

As a result of the experience developed in this research process, we conclude that the methodology is interesting for opening discussion, involving affected agents and obtaining prioritized lists. However, the use of the technique requires a careful measurement of resources, both temporal and economic. As a future line of research, it is proposed to explore the development of an experimental research that allows the testing of the resulting indicators in a similar process for a real environment. Thus, it would be interesting to carry out this process for a specific context such as a research performing organizations or companies. Likewise, it would be interesting to use the technique to evaluate existing alternatives for evaluating and monitoring RRI.

On the other hand, we wanted to discuss how the process developed contributed to the application of the principles the authors proposed (Lozano & Monsonís-Payá, 2020) for a practical dialogue about RRI: inclusion, symmetry, no coercion, and publicity and accountability.

The realization of the principle of inclusion implies that the interests and opinions of the affected should be considered in the decision-making processes. In the research process presented here, this principle materialized as follows.

The selection of participants sought the participation of experts in ethics as well as other stakeholders. By stakeholders, we refer to professional profiles that could hypothetically be affected by RRI evaluation and monitoring processes. Thus, we mainly selected researchers from different fields of knowledge and technical personnel in public administrations with competences in science and innovation. The focus of this explorative study was more on the side of public funded research that private-oriented innovation. The application of the concept of RRI to private companies has specific tensions (Lubberink et al., 2017) and was not the purpose of this work to address them. So, the main limitation in the selection of participants from a business perspective would be the lack of professionals from the private sector. But this does not mean the process was not inclusive. The methodology was inclusive in the sense that it allowed discussing and integrating pluralistic visions through the face-to-face activities organized and the combination of different profiles within the pool of participants.

The principle of symmetry is a regulatory idea about the minimum necessary for the possibilities of dialogue to be real (de facto). Thus, this principle requires that participants have the knowledge to participate in the dialogue and the resources (material and temporal) to do so. The research design responded to the principle of symmetry by ensuring, in the first place, that all participants in the process had a sufficient and comparable level of knowledge of the Spanish scientific context. However, the participants had different academic and professional backgrounds. Some of them were familiar with the RRI literature or aspects of applied ethics while for others this was a completely new topic. For this reason, background reading was selected to contextualize both the concept of RRI and its evaluation and monitoring in the field of ethics. In addition, during the face-to-face session, time was devoted to the introduction of the concept and the presentation of the risks and concerns about the use of RRI indicators. These two strategies were developed to promote greater symmetry in the dialogues in pairs, small groups, and large groups of participants. Additionally, the existence of budget within the project to cover the travel expenses of some participants facilitated the material and temporal symmetry.

The third principle we tried to apply to the process was that of non-coercion. Basically, our objective here was to ensure respect for the force of the best argument, without interference from coercion of any other kind during the decision-making process. Formal coercion, i.e., prohibiting someone from speaking was not envisaged in any way. But in addition, an attempt was made to facilitate an environment around the research process that avoided other types of subjective coercion. First, the participants received the invitations by e-mail and had the possibility to accept or decline the invitation. During the face-to-face meeting, a relaxed and collaborative environment was created among the participants. Although we had internally classified the participants as experts and stakeholders, this classification was not made public. The group represented a diverse group of technicians and researchers in different fields of science in Spain. The session was not recorded to allow participants to feel more freedom to express their ideas spontaneously. The notes taken by the facilitators during the session were included in the summary documents that were shared with the participants after the session. During the face-to-face meetings there was a combination of work in pairs, small and complete group to allow participation of all the participants in the provision of arguments and ideas. Regarding the final results of prioritization of indicators, it implied first a process of consensus on the elements in the hierarchy structure and an individual process within which each individual could attribute the importance that he or she considered.

Subsequent to the face-to-face meeting, a fluid communication and feedback channel was established with the participants to ensure no coercion and symmetry in the third phase of the research. Was also in this part of the research were the principle of publicity and accountability of the decisions taken had also the strongest impact. For instance, participants received the summary of the face-to-face results and were offered a sufficiently large time frame to make any comments they considered necessary anonymously (with respect to the rest of the participants). Also, the process of reviewing inconsistencies was carried out with great care to ensure understanding by all participants. We proactively sought to facilitate the time and resources necessary to meet the needs of each participant. This process was carried out by drafting personalised inconsistency reports and offering personal interviews to review the reports when deemed necessary.

In conclusion, the application of the principles proposed for dialogue in the RRI framework were put into practice in this exercise. The AHP technique has great potential for applying these principles in decision-making processes. However, as noted above, it is important to plan existing resources to apply this technique in accordance with the requirements of inclusiveness, symmetry, non-coercion and openness presented in this paper.

Capítulo 7 . Discusión general y conclusiones (Spanish version)

Esta tesis está motivada por una pregunta central que articula los resultados obtenidos en cada uno de los tres procesos de investigación presentados: ¿Cómo una metodología para la toma de decisiones a través de la técnica AHP puede apoyar la participación de las partes interesadas en los procesos de investigación e innovación hacia la monitorización y la evaluación de la RRI? En este último capítulo recapitularemos las conclusiones extraídas de cada capítulo respecto a los objetivos y preguntas de investigación planteados y se discutirán las principales contribuciones de la tesis doctoral.

7.1 Discusión general de los resultados

Objetivo 1: Definir las implicaciones de la ética cívica como marco normativo de la RRI.

Pregunta de investigación 1: ¿Cuáles son las implicaciones para la Investigación e Innovación Responsable (RRI) de una concepción dialógica de la responsabilidad?

Pregunta de investigación 2: ¿Cuáles son las implicaciones para la RRI de utilizar la ética cívica como marco normativo?

El primer objetivo del trabajo consistió en definir las implicaciones de considerar la ética cívica propuesta por Adela Cortina como marco normativo de la RRI. Para ello, en el Capítulo 2 presentamos la evolución del término RRI, la concepción dialógica del concepto de responsabilidad, así como las implicaciones de considerar la ética cívica como marco normativo para la RRI.

En este capítulo introducimos por qué es necesario reflexionar sobre la fundamentación normativa de la RRI. En primer lugar, nos referimos al potencial constructivo y destructivo de la ciencia e innovación y al surgimiento de propuestas de gobernanza que permitan abordar las tensiones creadas por estas dos potencialidades. La RRI es una de estas propuestas que ha ganado protagonismo durante la última década en el ámbito europeo. Bajo este término se han articulado preocupaciones sobre por qué y cómo integrar a diferentes actores en los procesos para determinar la direccionalidad de los desarrollos científicos y tecnológicos desde fases tempranas. En este capítulo, presentamos la necesidad de reflexionar sobre la fundamentación ética que sostiene la necesidad de promover la direccionalidad de la ciencia e innovación a través de conceptos como la inclusividad o *public engagement*, es decir, integrando conocimiento, valores y expectativas de diferentes actores.

Tras revisar la evolución del concepto de RRI, justificamos por qué el concepto de responsabilidad en RRI debe tener una concepción dialógica desde un marco post convencional frente a concepciones utilitaristas. Una aproximación meramente utilitarista del concepto de responsabilidad en ciencia e

innovación presenta limitaciones en cuanto a la posibilidad de prever las consecuencias de toda acción, la dependencia a evaluaciones expost de acciones concretas y el establecimiento de criterios y normas basados en la individualidad y subjetividad. Sin embargo, desde una aproximación dialógica, al concepto de responsabilidad podemos integrar tanto la consideración de aspectos puramente deontológicos con la evaluación de consecuencias posibles de las acciones o normas. Para ello, se propone un concepto de responsabilidad en RRI que incorpore los principios básicos de las éticas del discurso basado en la inclusividad y diálogo racional y en el que se considere la responsabilidad sobre las condiciones de los participantes en el discurso, la responsabilidad por los argumentos esgrimidos en el diálogo y la responsabilidad por las consecuencias de las decisiones tomadas.

En el Capítulo 2, justificamos la idoneidad de incorporar a los conceptos de simetría y diálogo racional de las éticas del discurso, la consideración de la complejidad y singularidad del contexto en el que se toman las decisiones. Así, se introduce la propuesta de Adela Cortina de incorporar la inclusión de los valores de libertad, igualdad, solidaridad, respecto y diálogo a la idea regulativa del proceso de toma de decisiones en los que los argumentos de los afectados por las mismas sean tenidos en cuenta. En el trabajo articulamos la propuesta de integración de los principios de la ética cívica en la toma de decisiones en RRI en base a los principios de inclusión, simetría, no coerción y publicidad y rendición de cuentas. Esta propuesta teórica es discutida respecto al uso de la técnica AHP en los procesos de diseño de mecanismos de monitorización y evaluación del área de ética en RRI en el Capítulo 6.

Objetivo 2: Describir en qué medida y cómo se integra o se prevé la participación de los actores en las actividades de investigación para el desarrollo de mecanismos para la monitorización y la evaluación de la RRI.

Pregunta de investigación 3: ¿En qué medida RRI informa el diseño de mecanismos de monitorización y evaluación respecto a la participación de actores?

Pregunta de investigación 4: ¿Cómo están previstas e integradas las estrategias de contextualización y participación en el diseño de los mecanismos de monitorización y evaluación de la RRI?

El segundo objetivo buscaba identificar el grado de inclusión de actores en los diferentes procesos de investigación llevados a cabo para desarrollar mecanismos de evaluación y monitorización de la RRI. Para ello, se diseñó una metodología que, valiéndose de una revisión sistemática de la literatura, permitiese identificar cómo se había incluido hasta el momento a los actores en estos procesos de diseño de metodologías e instrumentos de evaluación y monitorización.

En el Capítulo 3 presentamos los resultados de este estudio. Por un lado, la identificación de 25 procesos para el desarrollo de mecanismos de evaluación y monitorización de la RRI confirman el interés creciente por el desarrollo de este tipo de instrumentos. Este interés puede ser fruto de los esfuerzos por institucionalizar el concepto por parte de entidades financiadoras como la Comisión Europea. La existencia de financiación para el estudio de la RRI y el subsiguiente aumento del número de equipos de investigación interesados en el tema, pueden explicar el interés específico por el desarrollo de mecanismos de evaluación y monitorización de la RRI.

Las unidades de análisis de los mecanismos identificados son diversas. En algunos casos, estas unidades están bien definidas (como proyectos y organizaciones) pero en otros, se refieren de forma ambigua a estrategias o actividades de RRI. La mayoría de los mecanismos identificados tienen como unidad de evaluación proyectos u organizaciones. Sin embargo, también encontramos algunos ejemplos de mecanismos dirigidos a evaluar personas o sistemas de innovación (países). Así

identificamos posiciones y expectativas divergentes sobre el objeto de evaluación y monitorización de la RRI en la literatura existente, pudiéndose deber a la coexistencia de diversos enfoques de la RRI y a la dificultad de asignar roles de responsabilidad en el sistema de I+D+i.

En el estudio se propusieron tres tipos de argumentos para justificar la participación de actores en el desarrollo de estos mecanismos: sustantivos, instrumentales y normativos (Fiorino, 1990; Stirling, 2007). Los argumentos sustantivos hacen referencia al incremento de la calidad de los resultados del proceso; los argumentos instrumentales argumentan una mayor legitimidad y confiabilidad de los resultados fruto de la participación de dichos agentes; por último, los argumentos normativos se refieren a aquello que debe realizarse.

El análisis de los mecanismos identificados en este estudio incluyó los argumentos esgrimidos por los equipos de investigación para justificar la participación (pasada o futura) en el diseño e implementación de los mecanismos de M&E de RRI. Nuestros resultados muestran que los tres tipos de argumentos son utilizados en la literatura analizada. El argumento sustantivo fue el más mencionado en los documentos analizados. Cabría esperar mayores niveles de consideración del argumento normativo en los documentos revisados ya que este argumento se refiere a un aspecto central en las diferentes operativizaciones del concepto de RRI. A este respecto también observamos que en aquellos documentos en los que se reflexionaba sobre por qué debían participar los actores a lo largo del proceso, existía o se preveía participación de algún tipo en alguna fase del proceso.

Respecto a la existencia o previsión de participación en las diferentes fases de los procesos de diseño de los mecanismos, observamos que cabrían mayores niveles de participación, especialmente en las fases iniciales. Las escasas y limitadas evidencias encontradas sobre la participación de actores en esta fase nos llevan a concluir que, por un lado, existe un amplio margen para alinear el diseño de la evaluación y monitorización de la RRI con los principios de inclusividad y participación (*public engagement*). Además, la falta de participación de diversos actores en esta etapa clave, limita la posibilidad de debate sobre los objetivos y propósitos de la evaluación y monitorización e, incluso, la impugnación de la necesidad de desarrollar este tipo de mecanismos en un contexto específico o sus características.

La participación y previsión de participación de actores en las fases de investigación e implementación en entornos reales se identificó principalmente a través de estrategias de consulta o deliberación sobre la operativización de la RRI y los criterios de evaluación de los mecanismos de M&E. Sin embargo, los procesos analizados resultaron heterogéneos de nuevo respecto a la duración de la participación, cantidad de actores participantes y las técnicas utilizadas. Se podría hipotetizar sobre que la participación real de los actores en la investigación podría vincularse a la existencia de mayores o menores recursos para ejecutar una investigación. Sin embargo, nuestro análisis también exploró la previsión futura de participación para la contextualización de los resultados de la investigación en la aplicación en entornos reales. Aun existiendo limitaciones materiales para la participación de actores en determinados procesos de investigación, la falta de consideración de esta participación en el futuro no puede ser explicada por límites presupuestarios o temporales, llevándonos a afirmar que existe espacio para introducir mayor reflexividad y alineación con el concepto de RRI en los procesos de desarrollo de herramientas de monitorización y evaluación.

Objetivo 3: Explorar el potencial de la técnica AHP para contextualizar y promover la participación de los actores en el diseño del mecanismo de monitorización y evaluación de la RRI.

Pregunta de investigación 5: ¿Cómo puede la técnica AHP contribuir a priorizar un conjunto específico de indicadores de RRI en un contexto específico?

Pregunta de investigación 6: ¿Cómo puede AHP contribuir a identificar y priorizar temas (ambientales) relevantes a nivel de proyecto y programa para promover la anticipación y la reflexividad?

Pregunta de investigación 7: ¿Cómo puede AHP contribuir a identificar nuevos criterios para la monitorización y evaluación de la RRI?

El tercer objetivo de la tesis doctoral consistía en explorar cómo la técnica AHP podía ser utilizada para contextualizar y promover la participación de actores en el diseño de mecanismos de evaluación y monitorización de la RRI. Para ello se llevaron a cabo tres investigaciones exploratorias en el marco del proyecto INPERRI presentados en los capítulos 4, 5 y 6.

En el Capítulo 4, exploramos el uso de la técnica AHP con un grupo de expertos en cada una de las seis áreas consideradas. Como resultado, obtuvimos una primera aproximación a cómo se podían contextualizar sets de indicadores propuestos a nivel europeo mediante la priorización ajustada a las necesidades de un contexto específico como el caso español. Nuestra finalidad consistía en explorar cómo se podría utilizar la técnica AHP para priorizar en base al conocimiento de expertos una lista extensa de indicadores con el fin de adaptar conjuntos extensos de indicadores a contextos específicos. Fruto de este estudio, definimos un proceso que permitiese involucrar a actores en la priorización de indicadores y aplicar diferentes estrategias para la selección de sets reducidos de indicadores.

La primera estrategia propuesta se denominó "*Best in class*" y consistía en seleccionar un número reducido de indicadores e identificar aquellos que son más relevantes en un área concreta. La principal ventaja de esta estrategia es también su principal limitación, ya que se traduce en una drástica reducción del número de indicadores. Además, el resultado de la aplicación de este método está muy condicionado por la estructura y categorías incluidas en el modelo jerárquico. La segunda estrategia se basó en la consideración de un porcentaje de corte que permitiese seleccionar los indicadores en las primeras posiciones hasta alcanzar dicho porcentaje ("% de corte"). Esta estrategia facilita la identificación de un conjunto reducido de indicadores, a la par que considera la priorización por parte de los expertos. La tercera estrategia se basó en la reducción de los indicadores en base a un número de indicadores predeterminado. La principal limitación de la estrategia "% de indicadores" es que la cantidad de indicadores en cada categoría responde únicamente a un valor numérico y no considera la cantidad de importancia otorgada por los expertos. El valor a asignar al porcentaje de indicadores a seleccionar debería justificarse por los motivos que condujesen a la necesidad de reducir listas extensas de indicadores. Así, por ejemplo, si se tratase de una motivación presupuestaria, se podría combinar este criterio con la inclusión de los costes de medición de indicadores. El presupuesto máximo disponible para evaluar y monitorear las políticas de RRI podría ser un criterio para seleccionar el porcentaje de corte en este enfoque. Por último, la cuarta estrategia propuesta consistía en seleccionar aquellos indicadores con medias geométricas normalizadas superiores a la diferencia entre la media geométrica normalizada más alta y la más baja en la respectiva categoría. La aplicación de este criterio tendría una ventaja principal ya que no limitaría a priori el número de indicadores, sino que el resultado dependería de las diferencias entre la mayor y menor media geométrica normalizadas y la posición de cada indicador en relación a esta diferencia.

La aplicación de estos cuatro métodos mostró que la técnica AHP puede ser utilizada para integrar priorizaciones por parte de diferentes expertos ante la necesidad de adaptar y reducir listados extensos de indicadores a un contexto específico.

Sin embargo, este estudio exploratorio era limitado en cuanto a algunos aspectos que consideramos necesarios para poder alinear el mayor grado la contribución de la técnica AHP al concepto de RRI, aspectos que fueron incorporados en las investigaciones de los capítulos 5 y 6.

En el Capítulo 5, incorporamos al diseño metodológico aspectos relevantes para explorar las posibilidades de AHP en el diseño de mecanismos de evaluación y monitorización.

En este caso, queríamos explorar la contribución de la técnica para identificar temas medioambientales relevantes a proyectos y programas que pudiesen ser priorizados para fomentar las dimensiones de anticipación y reflexividad de los grupos de trabajo de dichos proyectos y programas. Propusimos la creación de una estructura jerárquica por parte de expertos en temas medioambientales sobre la cual pudiese posteriormente priorizarse aquellos más relevantes para ciertas áreas de conocimiento o aplicación en proyectos y programas. Dada la complejidad y amplitud de las posibles consecuencias ambientales de los resultados de investigación e innovación, se utilizaron las categorías del *Global Reporting Initiative* para estructurar e identificar los posibles elementos medioambientales a tener en cuenta. Posteriormente, los expertos participantes priorizaron los elementos a tener en cuenta para un tipo concreto de proyectos, aquellos que desarrollan tecnologías de la información y comunicación para el envejecimiento activo y saludable (*ICT for AHA*). El estudio partía de la premisa de que en un contexto de creciente investigación y desarrollo sobre herramientas TIC para el fomento de un envejecimiento activo y saludable, los impactos ambientales de los resultados de proyectos en este ámbito serían relevantes en caso de su uso masivo.

Esta aplicación de la metodología participada por expertos y uso de la técnica AHP permitió explorar la posibilidad de introducir un listado corto de elementos medioambientales a considerar en proyectos de investigación cuyo foco no estaba centrado en aspectos medioambientales (como el caso de las *ICT for AHA*) pero cuyos resultados de investigación podían tener un alto impacto si se masificaba su uso. Sin embargo, esta propuesta plantea limitaciones. Por un lado, los resultados son temporales y deben actualizarse a medida que evoluciona la comprensión de las causas y consecuencias ambientales y los principales desafíos en cada contexto. Por otro lado, mientras que la jerarquía de los elementos ambientales es bastante consistente con la literatura, el resultado de la priorización de los elementos es específico del caso y con gran divergencia entre expertos. Esta situación es frecuente y no invalida el procedimiento, sino que refleja la incertidumbre sobre los impactos ambientales futuros. Tiene así el efecto positivo de evidenciar las dificultades intrínsecas en cuanto a la anticipación de ciertas consideraciones medioambientales y fomentar la reflexividad al respecto. De hecho, los ejercicios de priorización de elementos para una línea de investigación específica como la llevada a cabo en este estudio, podrían formar parte de contenidos formativos para aumentar las capacidades de los equipos de investigación e innovación para potenciar innovaciones con menores impactos medioambientales o como punto de partida para enfocar los elementos a revisar en colaboraciones interdisciplinarias.

Por último, en el Capítulo 6, integramos la experiencia de los diferentes experimentos llevados a cabo en el proyecto INPERRI e introdujimos mejoras metodológicas que permitiesen explorar el potencial de la técnica AHP. Se utilizó como elemento de análisis la aplicación de la RRI al área de ética. Se introdujo una nueva categoría de actores, que denominamos grupos de interés que colaboraron junto con perfiles que respondían a la categoría de expertos. Durante este proceso, nos centramos en identificar la contribución de la técnica a las implicaciones de considerar la ética cívica como marco

normativo e identificar barreras y limitaciones a tener en cuenta. El proceso de definición de la jerarquía de elementos a considerar para el diseño de mecanismos de evaluación y monitorización de la RRI incorporó nuevas actividades y se enriquecieron los procesos de desarrollo de la jerarquía y de priorización. Así, comprobamos que la metodología propuesta permitía abrir un debate sobre las necesidades específicas de la ética en el marco de la RRI en el contexto español, enriqueciéndose la estructura de indicadores utilizada como referencia. Además, observamos dificultades en la aplicación de la técnica AHP e identificamos la necesidad de incrementar la comunicación y retroalimentación prestada a los participantes para alinear el proceso a los requerimientos de la ética cívica propuestos en el Capítulo 1. Así concluimos que la técnica AHP junto con la aplicación de la metodología propuesta ofrece la posibilidad de abrir un enriquecedor debate a la hora de diseñar mecanismos para la evaluación de la RRI, pero para desarrollarla de acuerdo con los principios de inclusión, simetría, no coerción, publicidad y rendición de cuentas, se requiere un cálculo cuidadoso de recursos temporales y económicos para su ejecución.

7.2 Conclusiones

Esta tesis doctoral tiene por objetivo responder a la ¿cómo puede una metodología para la toma de decisiones a través de la técnica AHP apoyar la participación de las partes interesadas en los procesos de investigación e innovación hacia la monitorización y la evaluación de la RRI? Para responderla se han diseñado tres procesos de investigación de carácter normativo, descriptivo y exploratorio. Así, hemos abordado la pregunta mediante la consideración de los aspectos normativos que justifican la participación de actores en los procesos de evaluación y monitorización de la RRI, de la revisión de las características de la participación de actores en los procesos de investigación en esta área y de la aplicación de tres casos exploratorios con participación de actores y grupos de interés mediante el uso de la técnica de toma de decisiones multicriterio AHP. Exponemos en esta sección reflexiones sobre las principales contribuciones y limitaciones de este estudio.

En primer lugar, podemos concluir que la participación en los procesos de toma de decisiones sobre el diseño de la evaluación y monitorización de RRI es un área de estudio de creciente interés. La capacidad tecnológica e innovadora de nuestra sociedad plantea retos a la par que oportunidades para la construcción de un futuro habitable y alineado con los valores de nuestra sociedad. El creciente interés por articular propuestas teóricas que aborden la inclusión de diversos actores en la toma de decisiones, así como la incorporación de conocimientos diversos ha cristalizado en diferentes propuestas que exploran la relación ciencia y sociedad en las últimas décadas. En este marco, la RRI ha sido una propuesta vinculada a entidades supranacionales que, con sus esfuerzos por institucionalizar el concepto, ha fomentado la aparición de mecanismos de evaluación y monitorización de la RRI. Independientemente de que el uso del término RRI se mantenga en el tiempo o sea sustituido por otros, la preocupación inherente al mismo sobre cómo incorporar las necesidades, valores, exigencias éticas y preocupaciones de la sociedad en la gobernanza de la ciencia e innovación, sobrevivirá, especialmente debido a la magnitud de los retos que enfrenta la humanidad a principios del siglo XXI.

En segundo lugar, se puede decir que la fundamentación de la participación de los actores en la toma de decisiones requiere de unas sólidas bases filosóficas que superen el puro utilitarismo y se asienten

sobre la idea de justicia vinculada a la participación de los actores en aquellas decisiones que les afectan. En este sentido, las éticas del discurso y la incorporación de los valores de la ética cívica sirven como idea regulativa que permitan justificar el desarrollo de procesos participados como una característica irrenunciable de las sociedades posconvencionales.

En tercer lugar, concluimos que las dificultades de incorporar la inclusividad y participación (*public engagement*) de los actores en los procesos de investigación hacia mecanismos de evaluación y monitorización de la RRI son todavía evidentes. La comunidad científica que viene desarrollando estos procesos es conocedora del marco teórico y conceptual que justifica dicha incorporación. Sin embargo, en la revisión realizada en esta investigación concluimos que queda espacio para una mayor reflexividad y búsqueda de estrategias para incorporar diversos actores. Especialmente, se requiere reflexionar sobre la falta de inclusión de actores en las fases tempranas de las investigaciones y el desarrollo de espacios en los que se permita el debate y la contestación sobre el uso, adecuación, propósitos y alternativas a los mecanismos de monitorización y evaluación de la RRI.

En cuarto lugar, concluimos que el diseño de metodologías en las que participen actores, tanto expertos como grupos de interés mediante el uso de la técnica AHP, permite la apertura de debates e identificación de problemáticas y retos respecto a la evaluación y monitorización de la RRI. Sin embargo, el uso de la técnica exige un cálculo cauteloso de los recursos materiales y temporales necesarios en su aplicación para alinearse con los principios de la ética cívica propuestos en este trabajo. Un correcto acompañamiento y comunicación del proceso desarrollado con los participantes es necesario para asegurar que se cumplen con los principios de inclusión, simetría, no coerción y publicidad y rendición de cuentas. Con el fin de poder integrar a colectivos diversos en estos procesos, se tiene que considerar la posible existencia de dificultades en la comprensión de los procesos y dedicar el tiempo necesario para que la aplicación metodológica y técnica sea posible.

Capítulo 7 . General discussion and conclusions (English version)

This thesis is motivated by a central question that articulates the results obtained in each of the three research processes presented: ¿How can a methodology for decision making through the AHP technique support stakeholder participation in research and innovation processes towards RRI monitoring and evaluation? In this last chapter we will recapitulate the conclusions drawn from each chapter with respect to the objectives and research questions and discuss the main contributions of the doctoral thesis.

7.1 General discussion of the results

Objective 1: Define the implications of civic ethics as normative framework for RRI.
Research question 1: What are the implications of the dialogic conception of responsibility for Responsible Research and Innovation (RRI)?
Research question 2: What are the implications of using civic ethics as a normative framework for RRI?

The first objective of the paper was to define the implications of considering the civic ethics proposed by Adela Cortina as a normative framework for RRI. To this end, in Chapter 2 we present the evolution of the term RRI, the dialogical conception of the concept of responsibility, as well as the implications of considering civic ethics as a normative framework for RRI.

In this chapter we introduce why it is necessary to reflect on the normative rationale for RRI. First, we refer to the constructive and destructive potential of science and innovation and the emergence of governance proposals to address the tensions created by these two potentialities. RRI is one such proposal that has gained prominence over the last decade at the European level. Under this term, concerns have been articulated about why and how to integrate different actors in processes to determine the directionality of scientific and technological developments from early stages. In this chapter, we present the need to reflect on the ethical rationale behind the need to promote the directionality of science and innovation through concepts such as inclusivity or public engagement, i.e. integrating knowledge, values and expectations of different stakeholders.

After reviewing the evolution of the concept of RRI, we justify why the concept of responsibility in RRI should have a post-conventional dialogical conception as opposed to utilitarian conceptions. A purely utilitarian approach to the concept of responsibility in science and innovation has limitations in terms of the possibility of foreseeing the consequences of any action, the dependence on ex-post

evaluations of concrete actions and the establishment of criteria and norms based on individuality and subjectivity. However, from a dialogical approach, the concept of responsibility can integrate both the consideration of purely deontological aspects and the evaluation of possible consequences of actions or rules. To this end, we propose a concept of responsibility in RRI that incorporates the basic principles of discourse ethics based on inclusivity and rational dialogue and which considers responsibility for the conditions of the participants in the discourse, responsibility for the arguments put forward in the dialogue and responsibility for the consequences of the decisions taken.

In Chapter 2, we justify the idea of incorporating into the concepts of symmetry and rational dialogue of the ethics of discourse the consideration of the complexity and singularity of the context in which decisions are made. Thus, we introduce Adela Cortina's proposal to incorporate the inclusion of the values of freedom, equality, solidarity, respect and dialogue into the idea of regulating the decision-making process in which the arguments of those affected by decisions are considered. In the paper we articulate the proposed integration of the principles of civic ethics in RRI decision-making based on the principles of inclusion, symmetry, non-coercion, publicity and accountability. This theoretical proposal is discussed with respect to the use of the AHP technique in the process of designing monitoring and evaluation mechanisms in the area of ethics in RRI in Chapter 6.

Objective 2: Describe to what extend and how actor's engagement is embedded or foreseen in research activities towards the development of mechanisms for monitoring and evaluation of RRI.

Research question 3: To what extent RRI is informing the nature of monitoring and evaluation mechanism design in terms of actors' engagement?

Research question 4: To what extend strategies of contextualization and participation are foreseen or embedded in monitoring and evaluation mechanisms' design of RRI?

The second objective sought to identify the degree of actors' inclusion in the different research processes carried out to develop RRI evaluation and monitoring mechanisms. To this end, a methodology was designed, using a systematic review of the literature, to identify how actors have been included in these research processes to date.

In Chapter 3 we present the results of this study. On the one hand, the identification of 25 processes for the development of RRI assessment and monitoring mechanisms confirms the growing interest in the development of such instruments. This interest may be the result of efforts to institutionalise the concept by funding agencies such as the European Commission. The coexistence of available funding for the study of RRI and the subsequent increase in the number of research teams interested in the topic may explain the specific interest in the development of RRI evaluation and monitoring mechanisms.

The units of analysis of the mechanisms identified are diverse. In some cases, these units are well defined (such as projects and organisations) but in others, they refer ambiguously to RRI strategies or activities. Most of the mechanisms identified have projects or organisations as their unit of analysis. However, we also found some examples of mechanisms aimed at evaluating individuals or innovation systems (countries). Thus, we identified divergent positions and expectations on the object of RRI evaluation and monitoring in the existing literature, which may be due to the coexistence of different approaches to RRI and the difficulty of assigning roles of responsibility in research and innovation.

The study proposed three types of arguments to justify stakeholder involvement in the development of these mechanisms: substantive, instrumental and normative (Fiorino, 1990; Stirling, 2007). The substantive arguments refer to the increase in the quality of the results of the process; the

instrumental arguments argue for greater legitimacy and reliability of the results resulting from the participation of these actors; finally, the normative arguments refer to what should be done.

The analysis of the mechanisms identified in this study included the identification of the arguments used by research teams to justify (past or future) actor's participation in the design and implementation of M&E mechanisms for RRI. Our results show that all three types of arguments are used in the literature analysed. The substantive argument was the most frequently mentioned in the analysed documents. One would expect higher levels of consideration of the normative argument as this argument refers to a central aspect in the different operationalisations of the RRI concept. In this regard, we also observed that in those processes that reflected on why actors should be involved throughout the process, participation of some kind existed or was foreseen at some stage of the process.

With regard to the existence or foreseen participation in the different phases of the mechanism design processes, we observed that higher levels of participation would be appropriate, especially in the initial phases. The limited and scarce evidence found on stakeholder participation in this phase leads us to conclude that, on the one hand, there is space for aligning the design of RRI evaluation and monitoring with the principles of inclusiveness and public engagement. Moreover, the lack of stakeholder participation at this key stage limits the possibility of debate on the objectives and purposes of evaluation and monitoring, and even the contestation of the need to develop such mechanisms in a specific context or its characteristics.

The participation of actors in the research and implementation phases in real settings was mainly identified through consultation or deliberation strategies on the operationalisation of RRI and the selection of evaluation criteria. However, the processes analysed were again heterogeneous with respect to the duration of participation, number of actors involved and techniques used. One could hypothesise that the actual participation of actors in the research might be linked to the existence of more or fewer resources to carry out research. However, our analysis also explored the expected participation for the contextualisation of research results in application in real settings. Even if there are material constraints to stakeholder participation in certain research processes, the lack of consideration of this participation in the future cannot be explained by budgetary or temporal limits, leading us to assert that more reflexivity and alignment with the RRI concept is possible in the processes of developing monitoring and evaluation tools.

Objective 3: Explore the potential contribution of the AHP technique to contextualize and promote engagement of actors in monitoring and evaluation mechanism design of RRI.

Research question 5: How can AHP contribute to prioritize a specific set of RRI indicators in a specific context?

Research question 6: How can AHP contribute to identify relevant (environmental) issues and their importance at project and programme level to promote anticipation and reflexivity?

Research question 7: How can AHP contribute to identify new criteria for monitoring and evaluation of RRI?

The third objective of the dissertation was to explore how the AHP technique could be used to contextualise and promote actors' participation in the design of monitoring and evaluation mechanisms of RRI. To this end, three exploratory studies were carried out within the framework of the INPERRI project presented in Chapters 4, 5 and 6.

In Chapter 4, we explored the use of the AHP technique with a group of experts in each of the six areas considered. As a result, we obtained a first approximation of how sets of indicators proposed at the European level could be contextualised through prioritisation adjusted to the needs of a specific context such as the Spanish case. Our aim was to explore how the AHP technique could be used to prioritise an existing list of indicators based on expert knowledge in order to adapt large sets of indicators to specific contexts. As a result of this study, we defined a process to involve actors in the prioritisation of indicators and to apply different strategies for the selection of reduced sets of indicators.

The first proposed strategy was called "Best in class" and consisted of selecting a small number of indicators and identifying those that are most relevant in a particular area. The main advantage of this strategy is also its main limitation, as it results in a drastic reduction in the number of indicators. Moreover, the outcome of the application of this method is highly conditioned by the structure and categories included in the hierarchical model. The second strategy was based on the consideration of a cut-off percentage that allows the selection of indicators in the first positions until this percentage is reached. This strategy facilitates the identification of a reduced set of indicators, while considering the prioritisation by the experts. The third strategy was based on the reduction of indicators based on a pre-determined number of indicators. The main limitation of this strategy is that the number of indicators in each category responds only to a numerical value and does not consider the amount of importance given by the experts. The value to be assigned to the percentage of indicators to be selected should be justified by the reasons that lead to the need to reduce long lists of indicators. Thus, for example, if it were a budgetary motivation, this criterion could be combined with the inclusion of the costs of measuring indicators. The maximum budget available to evaluate and monitor RRI policies could be a criterion for selecting the cut-off percentage in this approach. Finally, the fourth proposed strategy was to select those indicators with normalised geometric means higher than the difference between the highest and the lowest normalised geometric mean in the respective category. The application of this criterion would have a major advantage in that it would not a priori limit the number of indicators, but the result would depend on the differences between the highest and lowest normalised geometric mean and the position of each indicator in relation to this difference.

The application of these four methods showed that the AHP technique can be used to integrate prioritisations by different experts in order to adapt and reduce extensive lists of indicators to a specific context.

However, this exploratory study was limited in some aspects that we considered necessary to further align the contribution of the AHP technique to the RRI concept, aspects that were incorporated in the research in chapters 5 and 6.

In Chapter 5, we incorporated into the methodological design relevant aspects to explore the possibilities of AHP in the design of evaluation and monitoring mechanisms.

In this case, we wanted to explore the contribution of the technique to identify environmental issues relevant to projects and programmes that could be prioritised to foster the anticipatory and reflexive dimensions in the teams working in certain projects and programmes. We proposed the creation by experts in environmental issues of a general hierarchical structure on environmental issues. That structured could be used later on to identify the most relevant elements to specific areas of knowledge or application in projects and programmes. Given the complexity and breadth of the possible environmental consequences of research and innovation results, the Global Reporting Initiative categories were used to structure and identify the possible environmental elements to be considered. Subsequently, the participating experts prioritised the elements to be considered for a specific type

of projects, those that develop information and communication technologies for active and healthy ageing (ICT for AHA). The study was based on the premise that in a context of increasing research and development on ICT tools for the promotion of active and healthy ageing, the environmental impacts of the results of projects in this field would be relevant in case of their massive use.

This application of the expert-participatory methodology and use of the AHP technique made it possible to explore the possibility of introducing a short list of environmental elements to be considered in research projects whose focus was not on environmental aspects (as in the case of ICT for AHA) but whose research results could have a high impact if their use were widespread. However, there are limitations to this approach. On the one hand, the results are temporary and need to be updated as the understanding of environmental causes and consequences and the main challenges in each context evolves. On the other hand, while the hierarchy of environmental elements is fairly consistent with the literature, the outcome of the prioritisation of elements is case-specific and with great divergence among experts. This situation is normal and does not invalidate the procedure, but reflects uncertainty about future environmental impacts. It thus has the positive effect of highlighting the intrinsic difficulties in anticipating certain environmental considerations and encouraging reflexivity in this regard. In fact, prioritisation exercises for a specific line of research, such as the one carried out in this study, could form part of training content to increase the capacities of research and innovation teams to promote innovations with lower environmental impacts or as a starting point to focus the elements to be reviewed in interdisciplinary collaborations.

Finally, in Chapter 6, we integrated the experience of the different experiments carried out in the INPERRI project and introduced methodological improvements to explore the potential of the AHP technique. The application of RRI to the area of ethics was used as an element of analysis. A new category of actors was introduced, which we called stakeholders, who collaborated together with profiles corresponding to the category of experts. During this process, we focused on identifying the contribution of the technique to the implications of considering civic ethics as a normative framework and identifying barriers and limitations to be considered. The process of defining the hierarchy of elements to be considered for the design of RRI evaluation and monitoring mechanisms incorporated new activities and enriched the hierarchy development and prioritisation processes. Thus, we found that the proposed methodology allowed us to open a debate on the specific needs of ethics in the framework of RRI in the Spanish context, enriching the structure of indicators used as a reference. Furthermore, we observed difficulties in the application of the AHP technique and identified the need to increase the communication and feedback provided to participants in order to align the process to the requirements of civic ethics proposed in Chapter 1. Thus, we conclude that the AHP technique together with the application of the proposed methodology offers the possibility of opening a rich debate when designing mechanisms for the evaluation of RRI, but to develop it in accordance with the principles of inclusion, symmetry, non-coercion, publicity and accountability, a careful calculation of time and financial resources for its implementation is required.

7.2 Conclusions

This doctoral thesis aims to answer the question of how a decision-making methodology using the AHP technique can support stakeholder participation in research and innovation processes towards monitoring and evaluation of RRI. To answer this question, three research processes of a normative, descriptive and exploratory nature have been designed. Thus, we have addressed the question by

considering the normative aspects that justify actors' participation in RRI monitoring and evaluation processes, by reviewing the characteristics of stakeholder participation in research processes in this area and by applying three exploratory cases involving experts and interest groups using the AHP multi-criteria decision-making technique.

In this section we present reflections on the main contributions and limitations of this study.

Firstly, we can conclude that the study of participation in decision-making processes on the design of RRI evaluation and monitoring is an area of growing interest. The technological and innovative capacity of our society poses challenges as well as opportunities for the construction of a liveable future aligned with the values of our society. The growing interest in articulating theoretical proposals that address the inclusion of diverse actors in decision-making and the incorporation of diverse knowledge has crystallised in different proposals that explore the relationship between science and society in recent decades. In this framework, RRI has been a proposal linked to supra-national entities that, through their efforts to institutionalise the concept, have fostered the emergence of mechanisms for evaluating and monitoring RRI. Regardless of whether the use of the term RRI is sustained over time or replaced by other terms, the inherent concern of how to incorporate the needs, values and concerns of society into the governance of science and innovation will survive, especially given the magnitude of the challenges facing humanity in the early 21st century.

Secondly, it can be said that the rationale for stakeholder participation in decision-making requires philosophical foundations that go beyond pure utilitarianism and are based on the idea of justice linked to stakeholder participation in decisions that affect them. In this sense, the ethics of discourse and the incorporation of the values of civic ethics serve as a regulative idea that makes it possible to justify the development of participatory processes as an inalienable characteristic of post-conventional societies.

Thirdly, we conclude that the difficulties of incorporating the inclusivity and public engagement of actors in research processes into RRI evaluation and monitoring mechanisms are still evident. The scientific community that has been developing these processes is aware of the theoretical and conceptual framework that justifies such incorporation. However, in the review carried out in this research, we conclude that there is still room for greater reflexivity and the search for strategies to incorporate different actors. In particular, there is a need to reflect on the lack of stakeholder inclusion in the early stages of research and the development of spaces for debate and discussion on the use, appropriateness, purposes and alternatives to RRI monitoring and evaluation mechanisms.

Fourthly, we conclude that the design of methodologies involving actors, both experts and stakeholders, through the use of the AHP technique, allows for the opening of debates and the identification of issues and challenges regarding the evaluation and monitoring of RRI. However, the use of the technique requires a cautious calculation of the material and temporal resources needed in its application in order to align with the principles of civic ethics proposed in this work. A correct accompaniment and communication of the process developed with the participants is necessary to ensure that the principles of inclusion, symmetry, non-coercion, publicity and accountability are met. In order to be able to integrate diverse groups in these processes, it is necessary to consider the possible existence of difficulties in understanding the processes and to dedicate the necessary time so that the methodological and technical application is possible.

Anexos

A. Capítulo 3. The mechanisms and reviewed documents

Code	Mechanism name	Authors	Title	Source	Year	Type of document	DOI
1	Five-stage societal process model	Voeten, J., Roome, N., Huong, N. T., de Groot, G., & de Haan, J.	Conceptualizing Responsible Innovation in Craft Villages in Vietnam	Book: Responsible Innovation 1: Innovative Solutions for Global Issues	2014	Book Chapter	10.1007/978-94-017-8956-1_9
2	Quality criteria and indicators for RRI	Wickson, F., & Carew, A. L.	Quality criteria and indicators for responsible research and innovation: learning from transdisciplinarity	Journal of Responsible Innovation	2014	Article	10.1080/23299460.2014.963004
3	Guide to entrepreneurs and innovation support organizations on RI criteria	Hin, G., Daigney, M., Haudebault, D., Raskin, K., Bouché, Y., Pavie, X., & Carthy, D.	Introduction to Responsible Innovation Criteria a Guide to Entrepreneurs and Innovation Support Organizations.	http://www.nweurope.eu/media/1118/guide_online.pdf	2014	Report	
4	RRI Tools - Self-reflection Tool	Kupper, F., Klaassen, P., Rijnen, M., Vermeulen, S., & Broerse, J. E. W	Report on the Quality Criteria of Good Practice Standards in RRI	http://www.rri-tools.eu/documents/10182/18424/D1.3_QualityCriteriaGoodPracticeStandards.pdf/f7a1d707-5e54-48cb-949b-053dc7c6f36f	2015	Report	
4	RRI Tools - Self-reflection Tool	Schrammel, M., Hofer, M., Unterfrauner, E., Marschalek, I., Voigt, C., Siller, C., Schuch, K., & Handler, K.	D5.4 - Proof of concept self-reflection tool	https://rri-tools.eu/documents/10184/193151/RRITools_D5+4-Proof+of+concept+self-assessment+benchmarking+tool_M36.pdf	2016	Report	
5	Responsible Port Innovation	Ravesteijn, W., Liu, Y., & Yan, P.	Responsible innovation in port development: The Rotterdam Maasvlakte 2 and the Dalian Dayao bay extension projects	Water Science and Technology	2015	Article	10.2166/wst.2015.272
6	EC Expert Group Indicators	Strand, R., Spaapen, J., Bauer, M. W., Hogan, E., Revuelta, G., Stagl, S., Paula, L., & Guimaraes Pereira, A.	Indicators for Promoting and Monitoring Responsible Research and Innovation Report from the Expert Group on Policy Indicators for Responsible Research and Innovation	Publications Office of the European Union	2015	Report	10.2777/9742
7	MORRI Indicators	Ravn, T., Nielsen, M. W., & Mejlgaard, N	Metrics and Indicators of Responsible Research and Innovation. Progress Report D3.2	https://www.technopolis-group.com/report/metrics-and-indicators-of-responsible-	2015	Report	

				research-and-innovation-progress-report-d3-2/			
7	MORRI Indicators	Peter, V., Maier, F., Mejlgaard, N., Bloch, C., Madsen, E. B., Griessler, E., Wuketich, M., Meijer, I., Woolley, R., Lindner, R., Bührer, S., Jäger, A., Tsipouri, L., & Stilgoe, J.	Monitoring the evolution and benefits of responsible Research and Innovation: summarising insights from the MoRRI project	Publications Office of the European Union	2018	Report	10.2777/207020
7	MORRI Indicators	Mejlgaard, N., Bloch, C., & Madsen, E. B	Responsible research and innovation in Europe: A cross-country comparative analysis	Science and Public Policy	2019	Article	10.1093/scipol/scy048
8	KPIs for industry	Flipse, S M, Van Dam, K. H., Stragier, J., Oude Vrielink, T. J. C., & Van der Sanden, M. C. A	Operationalizing responsible research & innovation in industry through decision support in innovation practice	Journal on Chain and Network Science	2015	Article	10.3920/JCNS2015.X004
8	KPIs for industry	Van de Poel, I., Asveld, L., Flipse, S., Klaassen, P., Scholten, V., & Yaghmaei, E.	Company Strategies for Responsible Research and Innovation (RRI): A Conceptual Model	Sustainability	2017	Article	10.3390/SU9112045
8	KPIs for industry	Flipse, S. M., & Yaghmaei, E.	The Value of 'Measuring' RRI Performance in Industry	Book: Governance and Sustainability of Responsible Research and Innovation Processes: Cases and Experiences	2018	Book Chapter	10.1007/978-3-319-73105-6_6
8	KPIs for industry	Flipse, S.	Best practice IV: PRISMA KPI analysis tool	Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-18
9	Res-AGORA Tools: Responsibility Navigator (complemented by RRI Trends and the Co-construction method)	Lindner, R., Kuhlmann, S., Randles, S., Gorgoni, G., Griessler, E., Loconto, A., & Mejlgaard, N.	Navigating Towards Shared Responsibility in Research and Innovation Approach, Process and Results of the Res-AGorA Project	http://prores-project.eu/wp-content/uploads/2020/05/RES-AGorA_Responsible_Navigator_epaper2016.pdf	2016	Report	10.13140/RG.2.1.4037.5440

10	Responsible Project Management	Tinoco, R. A., Sato, C. E. Y., & Hasan, R.	Responsible project management: Beyond the triple constraints	Journal of Modern Project Management	2016	Article	10.3963/JMPM.V4I1.179
11	PERFORM analytical framework for science education	Heras, María, Ruiz-Mallén, I., Berrens, K., & Lemkow, L	D4.1 Research Report: Methodological aspects of science education assessment.	http://www.perform-research.eu/wp-content/uploads/2016/07/D4.1-Methodological-Aspects-of-Science-Education-Assessment.pdf	2016	Report	
11	PERFORM analytical framework for science education	Heras, Maria, & Ruiz-Mallén, I	Responsible research and innovation indicators for science education assessment: how to measure the impact?	International Journal of Science Education	2017	Article	10.1080/09500693.2017.1392643
12	Framework aligning activities, aspirations and stakeholders	Foley, R. W., Bernstein, M. J., & Wiek, A.	Towards an alignment of activities, aspirations and stakeholders for responsible innovation	Journal of Responsible Innovation	2016	Article	10.1080/23299460.2016.1257380
13	RRI Maturity Models	Stahl, B. C., Obach, M., Yaghmaei, E., Ikonen, V., Chatfield, K., & Brem, A.	The Responsible Research and Innovation (RRI) Maturity Model: Linking Theory and Practice	Sustainability	2017	Article	10.3390/SU9061036
13	RRI Maturity Models	Yaghmaei, E	Responsible research and innovation key performance indicators in industry: A case study in the ICT domain	Journal of Information Communication & Ethics in Society	2018	Article	10.1108/JICES-11-2017-0066
14	INPERRI AHP participatory approach	Monsonís-Payá, I., García-Melón, M., & Lozano, J.-F.	Indicators for Responsible Research and Innovation: A Methodological Proposal for Context-Based Weighting	Sustainability	2017	Article	10.3390/SU9122168
14	INPERRI AHP participatory approach	Otero-Hermida, P., & García-Melón, M.	Gender Equality Indicators for Research and Innovation from a Responsible Perspective: The Case of Spain	Sustainability	2018	Article	10.3390/SU10092980
15	Analytical framework of RRI in Smart Farming	Eastwood, C., Klerkx, L., Ayre, M., & Dela Rue, B.	Managing Socio-Ethical Challenges in the Development of Smart Farming: From a Fragmented to a Comprehensive Approach for Responsible Research and Innovation	Journal of Agricultural & Environmental Ethics	2019	Article	10.1007/S10806-017-9704-5

16	ENRRICH Peer evaluation approach	Vargiu, A	Evaluating the Embedding of RRI in Higher Education Curriculum: The EnRRICH Experience	Book: Responsible Research and Innovation Actions in Science Education, Gender and Ethics: Cases and Experiences	2018	Book Chapter	10.1007/978-3-319-73207-7_3
17	Responsible Innovation in Health Tool	Silva, H. P., Lehoux, P., & Hagemeister, N.	Developing a tool to assess responsibility in health innovation: Results from an international delphi study	Health Policy and Technology	2018	Article	10.1016/J.HLPT.2018.10.007
17	Responsible Innovation in Health Tool	Silva, H. P., Lehoux, P., Miller, F. A., & Denis, J.-L.	Introducing responsible innovation in health: a policy-oriented framework	Health Research Policy and System	2018	Article	10.1186/s12961-018-0362-5
17	Responsible Innovation in Health Tool	Lehoux, P., Silva, H. P., Oliveira, R. R., & Rivard, L.	The responsible innovation in health tool and the need to reconcile normative and summative ends in RRI tools for business	Journal of Responsible Innovation	2020	Article	10.1080/23299460.2020.1844974
17	Responsible Innovation in Health Tool	Silva, H. P., Lefebvre, A.-A., Oliveira, R. R., & Lehoux, P	Fostering Responsible Innovation in Health: An Evidence Informed Assessment Tool for Innovation Stakeholders	International Journal of Health Policy and Management	2021	Article	10.34172/IJHPM.2020.34
18	RRI index	Nazarko, L.	Responsible Research and Innovation in Enterprises: Benefits, Barriers and the Problem of Assessment	Journal of Open Innovation: Technology, Market, and Complexity	2020	Article	10.3390/joitmc6010012
19	COMPASS self-check tool	Tharani, A., Jarmai, K., Schönherr, N., & Urban, P.	The COMPASS self-check tool: enhancing organizational learning for responsible innovation through self-assessment	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-13
20	Future-oriented RRI evaluation	Nieminen, M., & Ikonen, V	A future-oriented evaluation and development model for Responsible Research and Innovation	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-17
21	RRI intensity level	Heaver, M. De, Jirotka, M., Nulli, M., Stahl, B. C., & Holter, C. Ten.	RRI intensity: a proposed method of assessing the requirement for responsible innovaiton in ICT projects	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-21
22	Responsible creativity and innovation scale	Verburg, R., Rook, L., & Pesch, U.	The responsible side of innovation: towards measurement of a new construct	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-23

23	Reflexive Monitoring in Action	Klaassen, P., Verwoerd, L., Kupper, F., & Regeer, B.	Reflexive monitoring in action as a methodology for learning and enacting Responsible Research and Innovation	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-15
24	Qualitative Multicriteria Self-Questionnaire	Porcari, A., Pimponi, D., Borsella, E., Klaassen, P., Maia, M. J., & Mantovani, E.	Supporting RRI uptake in industry: a qualitative and multi-criteria approach to analising the costs and benefits of implementation	Book: Assessment of Responsible Innovation	2020	Book chapter	10.4324/9780429298998-8
25	Societal Readiness Thinking Tool	Bernstein, M. J., Nielsen, M. W., Alnor, E., Brasil, A., Birkving, A. L., Chan, T. T., Griessler, E., de Jong, S., van de Klippe, W., Meijer, I., Yaghmaei, E., Nicolaisen, P. B., Nieminen, M., Novitzky, P., & Mejlgaard, N.	The Societal Readiness Thinking Tool: A Practical Resource for Maturing the Societal Readiness of Research Projects	Science and Engineering Ethics	2022	Article	10.1007/s11948-021-00360-3

B. Capítulo 3. Review protocol for data selection

Title of the review	Participation in monitoring and evaluation of RRI: a review of research approaches towards the development of monitoring and evaluation mechanisms
Main reviewer	Irene Monsonís Payá
Supporting reviewers	Dr Edurne Iñigo
1. Background to review and specific objectives	
There are three arguments supporting the involvement of different actors in the design and implementation of the Monitoring and Evaluation (M&E) of Responsible Research and Innovation (RRI). First, it strengthens the evaluation; second it allows taking advantage of the performative function and third, it is aligned with the concept of RRI. In Europe, the idea of RRI triggered an interest in developing M&E methods and tools of RRI, but how actors participate in these research processes is still being determined. This paper investigates the extent to which the participation of actors is considered in research on M&E of RRI by using the three stages of translation proposed by Callon and colleagues - problematization, development of the research and transfer to a real setting.	
2. Criteria for including literature in the review	
a) Type of documents	Peer-reviewed literature, books and reports from projects
b) Outcomes of interest	Processes towards the development of monitoring and evaluation mechanisms of Responsible Research and Innovation. Monitoring and evaluation (M&E): refers to all the activities with an evaluation or monitoring purpose. M&E mechanism: refers to the tool or method used for evaluation or monitoring purposes. It can be of different types, such as a set of quantitative indicators, qualitative questions, evaluation grids, etc.
c) Inclusion and exclusion criteria	Inclusion criteria: Articles, books, book chapters and project reports that propose a mechanism of M&E of RRI of any type, purpose and aggregation level. Exclusion criteria: Duplicates Certain types of documents (i.e. books and conference reviews, conference papers, editorial materials or meeting abstracts) Theoretical articles and reports not developing M&E Mechanisms. Articles and reports dealing with related concepts but not directly referring to RRI (i.e. Technology Assessment)
c) Study design	Any study design
d) Time frame	2003 - to date
3. Search methods	
Electronic databases	ISI Web of Science Scopus

Keywords	"responsible innovation" OR "responsible research" OR "responsible research and innovation" AND "account*" OR "assess*" OR "evaluat*" OR "indicator*" OR "monitor*"
Other methods used for identifying relevant research	Snowballing by reference and citation checking of the articles addressing the inclusion criteria in the electronic databases search. Literature suggested by experts in this field
Journals hand searched	Journal of Responsible Innovation
4. Methods of review of the data selection	
Details of methods	Phase 1. Title and abstract screening: The main reviewer will check the inclusion and exclusion criteria of the abstracts. Phase 2. Full paper analysis: The main reviewer will perform the full paper analysis and the supporting reviewer will check the included and excluded abstracts. The reviewers can read in English, Spanish, French, Basque and Catalan. Additional reviewers will be contacted if any document was written in other languages.
Data extraction	The results of the search will be extracted in an Excel file. Title and abstract screening and full paper analysis will be performed within the Atlas.ti software.

C. Capítulo 3. Codebook for content data analysis

This codebook includes three sections: a glossary of terms, a codification tree and a deductive and inductive codes list.

- The deductive codes are structured around the conceptual structuring model. The list of codes includes inputs from the three translations by Callon et al (2009). The authors included in the model additional elements and concepts from a diverse set of previous relevant research that facilitated the categorization of concepts. References to theory are included in the corresponding code description.
- The inductive codes were developed during the analysis process when relevant information for the model did not fit in any of the deductive codes.

Glossary of terms

- **Monitoring and evaluation (M&E):** Refers to any activities with an evaluation or monitoring purpose. In our study, we refer to monitoring and evaluation with the acronym M&E even though its use has been disapproved, arguing that it can lead to confusion about these terms that differ in "objectives, reference periods, requirements for comparative analysis, and primary users" (Casley and Kumar, 1987:8). So in our study we consciously decided to presuppose that a clear distinction between both terms might not always be expected in the studies reviewed, primarily because "in many cases, the same data collection and analysis system will be used for both, and the indicators for monitoring may be included in the range of information required for evaluation [...]"(Casley and Kumar, 1987:8).
- **M&E Mechanism:** The term mechanism refers to the methodology, instrument or tool designed and/or used for evaluation and monitoring purposes. It can be of different types, quantitative and qualitative, taking the form of indicators and metrics, evaluation grids or qualitative questions.

Codification tree (black: deductive; green: inductive)

Aggregate codes	Code category	Code subcategory
Macrocosm 1 (M1)	Arguments for participation (M1)	- Adequacy and Risk Management - Ownership and performative function - RRI Alignment
Translation 1 or Problematization (T1)	Purpose of M&E (T1.1)	- Knowledge creation - Decision-making and accountability - Learning and reflexivity - Trust and cooperation
	Unit of analysis (evaluand) (T1.2)	- Programme - Product - People

	Participation (T1.3)	- Time qualifiers
		  ○ Embedded
		  ○ Foreseen
		- Participating actors
		  ○ Organizations
		  ○ People related to research and innovation processes
		  ○ Other groups of people and stakeholders
		- Role of actors
		  ○ Commissioning client
		  ○ No commissioning client (end-user)
		  ○ Evaluator coordinator
		  ○ Criteria provider
		  ○ Designer
		  ○ Design reviewer
		  ○ Respondents or data providers
		- Method of participation
		- Duration of participation
		- Contextualization through participation
		  ○ Actor/client
		  ○ Epistemic/sectorial
		  ○ Geographical
		  ○ Social
		  ○ Purpose

Translation 2 or Development of the research (T2)	Scope of the M&E research (T2.1)	- Design - Design and implementation - Implementation
	Funding (T2.2)	- EU research projects - National research projects
	Operationalization (criteria) (T2.3)	- AREA dimensions - EC Key areas - Other criteria
	Structure of the M&E mechanism (T2.4)	
	Participation (T2.5)	Same as code 1.3
Translation 3 or Implementation in real settings (T3)	Participation (T3.1)	Same as code 1.3
Macrocosm 2 (M2)	Challenges and trade-offs (M2)	- Performative function - Imposition of normative frameworks

List of deductive and inductive codes

Code level	Code type	Description and references
Aggregate	Deductive	**Macrocosm 1 (M1)**: Refers to the "big world of common experience, the macrocosms that we inhabit, that has been replaced in the laboratory by the small world, the microcosm of the equipped laboratory" (Callon et al., 2009:49).
Category	Deductive	**Arguments for participation and contextualization**: Refers to any of the three arguments identified in our research for the inclusion of participation and contextualization strategies in the development of the M&E mechanism (Fiorino, 1990).
Subcategory	Deductive	**Adequacy and Risk Management**: Refers to arguments calling for participation and contextualization to increase the adequacy of the M&E mechanisms to their evaluative purpose and to identify and reduce risks, negative impacts and trade-offs of their implementation.
Subcategory	Deductive	**Ownership and performative function**: Refers to arguments calling for participation and contextualization to increase ownership and the performative function of the M&E mechanisms.
Subcategory	Deductive	**RRI Alignment**: Refers to arguments calling for participation to align the process and outcomes of the M&E design to the core values of RRI.
Aggregate	Deductive	**Translation 1 or Problematization (T1)**: Refers to the process in which the researchers extract elements of reality to bring them to the laboratory. "The first [stage] is that of the reduction of the big world (the macrocosm) to the small world (the microcosm) of the laboratory" (Callon et al., 2009:48). "The macrocosm selected as starting point […] has been replaced by successive extractions, abstractions and reductions to a microcosm that represents it […]"(Callon et al., 2009:49) "This mobilization of the world, which after being reduced, is transported into the laboratory to the subjected to the tests of experimentation, is common to the natural and life sciences, but also to the social sciences." (Callon et al., 2009:49).
Category	Deductive	**Purpose of M&E (T1.1)**: Refers to the possible purposes that the researchers mention regarding the use of the M&E mechanisms they are designing and/or testing.
Subcategory	Deductive	**Knowledge creation on RRI**: Refers to purposes related to knowledge creation to provide a theoretical and practical understanding of RRI and the unit of analysis and to operationalize the concept of RRI. This category is an adaptation of the purpose defined by Jennifer Greene for programme evaluation (Greene, J 2007 retrieved from Ligero Lasa, 2015).
Subcategory	Deductive	**Decision-making and Accountability**: Refers to purposes related to the decision-making process, distribution of and control of resources, accountability and control and comparison of the performance of the unit of evaluation. Under this type of purpose, M&E respond to "*the informative needs and interest of political actors or actors with decision capability on the intervention object of the evaluation* (unit of analysis)" (Greene, J 2007 retrieved from Ligero Lasa, 2015:25). Under this code, sub-classifications could be done: • **Distributing:** A quote referring to this purpose is provided by Molas-Gallart (2012:289): "A distributive use will seek to inform or determine the distribution of resources across the potential actors and beneficiaries of a specific policy or program. The allocation of resources can be decided according to the merit attributed by the evaluation to different individuals, groups, or organizations. Examples of this type of evaluation include, but

Code level	Code type	Description and references
		are not limited to, the ex-ante evaluation of research projects, and the distribution of rewards to individuals or groups that have done well according to performance assessments based on pre-established criteria." • **Accounting and controlling**: "Ensuring accountability of policy-makers and project managers" (Hanberger, 2011; Magro & Wilson, 2015; retrieved from Kleibrink et al., 2016:1440) and "A controlling use will scrutinize how organizations and individuals use public resources to carry out activities to achieve public policy objectives. It focuses on the direct audit of how resources are spent. In the case of research policy, the controlling purpose will typically focus on the analysis of inputs and the audit of direct research outputs, and will fit with traditional bureaucratic models of administration." (Molas-Gallart, 2012:289). • **Comparing and bench-marking**: Refers to purposes of M&E that relates to comparing different units of evaluation: "Making appropriate comparisons, including bench-marking" (Woolley et al., 2020:12).
Subcategory	Deductive	**Learning and reflexivity**: Refer to purposes of M&E related to learning and transforming, improving performance or increasing awareness and reflexivity. Under this code, classifications proposed by different authors are included, such as: • "Learning about actual transformation processes and informing policy responses accordingly" (Floc'hlay & Plottu, 1998; retrieved from Kleibrink et al., 2016:1440). • "An improvement use will focus on deriving lessons from the past experience to adapt the activities conducted to what evaluation studies will conclude is better practice. The improvement purpose is therefore relying on the existence of feedback mechanisms and the operational flexibility needed to function as a learning organization." (Molas-Gallart, 2012:289). • "Program improvement and organizational development provides valuable information for managers or others responsible for the regular operations of the program." (Greene, J 2007 retrieved from Ligero Lasa, 2015:25). • "Reflexively engaging with own assumptions" (Woolley et al., 2020:12).
Subcategory	Deductive	**Trust and cooperation**: Refer to purposes of M&E related to strengthening trust and cooperation with stakeholders. It has been categorized as follows: "Building and reinforcing trust and cooperation with and among stakeholders and citizens" (Gianelle & Kleibrink, 2015; Saltelli, 2007; retrieved from Kleibrink et al., 2016:1440)
Category	Deductive	**Unit of analysis (evaluand) (T1.2)**: Refers to the unit of analysis of the M&E mechanism, to what will be evaluated or monitored. The initial code subcategories include a combination of categories proposed form different disciplines and authors: • The one proposed by Marvin Alkin (2011) in the field of professional evaluation: Evaluation of policies, evaluation of

Code level	Code type	Description and references
		products, evaluation of people and evaluation of programmes (policy, projects, services, institution, etc.). • The one proposed by Bustelo (1999) refers to the inclusion of the following evaluand in the concept of programme evaluation: policies, plans, programs, projects, services, measures, institutions and materials. • The one proposed by Molas-Gallard in the field of research evaluation: "Research evaluation can involve different evaluands. The focus may be on: individual researchers, groups of researchers, whole institutions, research projects, groups of projects ''wrapped'' in a program, research support policies, or on the research system as a whole." (Molas-Gallart, 2012:586). This code has similarities with the role of innovator proposed by van de Poel (2020:341): "the actor that is the object of the RRI assessment". To the list of deductive codes, inductive ones have been added.

Subcategory	Deductive	**Programme:** Refers to the evaluation of:
		• **Research system**: Refers to a whole research system (Molas-Gallart, 2012:586).
		• **Policies**: Refers to policies defined by any public or private organization. It includes **research support policies**(Molas-Gallart, 2012:586).
		• **Institutions**: Refers to public or private institutions (Molas-Gallart, 2012:586). Two inductive codes have been included:
		  ○ **Companies**: refers to companies, this is private for-profit organizations
		  ○ **Industry: "***company of a certain size, which usually produce something"* (Stahl et al 2017)
		• **Projects** Refer to projects of any type. The code has been split into the following codes.
		  ○ **Research project**: refers to research projects (Molas-Gallart, 2012:586).
		  ○ **Innovation project**: refers to projects consisting in introducing any type of innovation (technological, product, process, among others).
		  ○ **Megaprojects**: refers to large-scale projects.
		  ○ **Group of projects ("wrapped" in a programme)**: refers to groups of projects from the same (funding, promoted or commissioned) programme (Molas-Gallart, 2012:586).
		• **R&I strategies and activities.** Under this category were codified M&E mechanisms assessing day-to-day working environments (as defined in RRI Tools) and activities and strategies not wrapped in a project.
		• **RRI initiatives.** Under this category were codified M&E mechanisms assessing policies or activities and strategies not wrapped in a project and described as RRI activities by the authors of the documents reviewed.

Subcategory	Deductive	**Product:** Refers to the evaluation of products. The previous subcategory, "Programme", can also analyse products as part of a programme. Within this

Code level	Code type	Description and references
		category will be classified M&E mechanisms addressed to evaluate or monitor products as the main unit of analysis.
Subcategory	Deductive	**People** • **People (researchers, innovators, employees, students)**: Refers to individual persons performing research (Molas-Gallart, 2012:586), innovators, employees or students. • **Groups of researchers**: Refers to a group of researchers that formally or information have a track record of collaboration (Molas-Gallart, 2012:586).
Category	Deductive	**Participation (T1.3)**: Refers to any reference to the participation of different actors in the whole research and innovation process. In this article, such processes refer to the process analysed in our analytical framework that includes the three stages of Callon et al. Therefore, these codes will be defined in this section and apply for the participation codes in T2.5 and T3.1.
Subcategory	Inductive	**Time qualifiers**: ○ **Embedded**: Refers to participation that effectively implemented within the research. ○ **Foreseen**: Refers to foreseen or recommended participation strategies for future stages of the research. In these cases, the current research still needs to include participation.
Subcategory	Inductive	**Actors**: The different groups or profiles of people participating in the research and innovation process. Organizations - Research Funding Organizations (RFOs) - Research Performing Organizations (RPOs) - Business and Industry (large companies) - Companies and SMEs - Civil Society Organizations (CSOs) People related to the research and innovation processes - Policy representatives and decision-makers - Research and project managers and administrators - Scientists and researchers - Innovators - Experts Other groups of people and stakeholders - Stakeholders - Local community - Publics - Students - Evaluator specialist - Journal editors and reviewers
Subcategory	Deductive	**Role of actors**: The different roles of the actors participating at some stage in the research and innovation process towards M&E mechanism design and use. We initially used the 12 roles proposed by Stufflebeam and Shinkfield (1984) (see the following table). *Table: Role of actors by Stufflebeam and Shinkfield (1984)*

<table>
<tr><th>Code level</th><th>Code type</th><th>Description and references</th></tr>
<tr><td></td><td></td><td>
<table>
<tr><td>Evaluation client</td><td>The person or group who commissioned the evaluation and those who will attend to and use its results.</td></tr>
<tr><td>Evaluation designer</td><td>The person or group who conceptualised and designed the evaluation.</td></tr>
<tr><td>Evaluation coordinator</td><td>The person or group who coordinates and manages the evaluation project.</td></tr>
<tr><td>Evaluation caseworkers</td><td>The person or group who interacts directly with other persons to carry out the evaluation</td></tr>
<tr><td>Evaluation respondents</td><td>The person or group who provide evaluation information.</td></tr>
<tr><td>Technical support specialists</td><td>The person or group who provides specialized expertise in tasks such as analysing quantitative or qualitative data or produce Audi visual presentation of findings, among others.</td></tr>
<tr><td>Information specialist</td><td>The person or group who is specialized in information sciences.</td></tr>
<tr><td>Communication specialist</td><td>The person or group who is specialized in communication technology.</td></tr>
<tr><td>Evaluation trainer</td><td>The person or group who is specialized in evaluation training.</td></tr>
<tr><td>Evaluation researcher</td><td>The person or group who researches on the history of the evaluation field and theorize conduct studies about evaluation practice.</td></tr>
<tr><td>Evaluation developer</td><td>The person or group who attain and maintain the status s of the evaluation profession.</td></tr>
<tr><td>Metaevaluator</td><td>The person or group who evaluates the evaluation.</td></tr>
</table>

The sub-code list was actualized, reducing the initial list and including new inductive codes.

Commissioning client: The person or group who commissioned the evaluation (or development of the M&E mechanism). This role as overlapping features with the role of the regulator or standard setter proposed by van de Poel, especially about the role of “deciding how the RRI assessment is to be carried out and by whom” (van de Poel, 2020:342)
No commissioning client (end-user): the person or group who, without having commissioned the evaluation, will attend to and use its results (the M&E mechanism).
Evaluator coordinator: The person or group coordinating and managing the evaluation project.
Criteria providers: The person or group that participates in the process to define the operationalization and evaluative criteria.
Designer: The person or group who conceptualized and designed the evaluation. This role is similar to the one van de Poel (2020) defined as RRI assessor as the actor doing the actual RRI assessment.
Design reviewers: The group of people that participate in the research process to provide feedback to the M&E design (i.e. usability tests)
Respondents or data providers: The person or group who provides evaluation information in the implementation phase.

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Code level	Code type	Description and references
Subcategory	Inductive	**Method**: Refers to the methods used to involve actors in participation processes. No classification is proposed under this code to capture the description provided by the authors of the documents analysed.
Subcategory	Inductive	**Duration**: Refers to the duration of the activities in which actors are involved in participation processes. No classification is proposed under this code to capture the description provided by the authors of the documents analised.
Subcategory	Inductive	**Contextualisation through participation**: Refers to any strategy used to provide into the research and innovation process elements to adapt the M&E mechanisms to specific contexts through participation of actors. The sub-codes referring to the type of contextualization referred have been inductively created. **Type of contextualization:** ○ **Actor/client's needs:** refers to contextualization focused on the needs of the actor using the M&E mechanism. ○ **Epistemic/sectorial**: refers to contextualization focused on specific sectors (i.e. industrial sectors) or epistemic disciplines. ○ **Geographical:** refers to contextualization focused on a geographical area. ○ **Social**: refers to contextualization focused on a social perception or context. ○ **Purpose:** refers to contextualization focused on the purpose of the M&E mechanism.
Aggregate	Deductive	**Translation 2 or development of the research (T2)**: "The second stage is that of the formation and setting to work of a restricted research group that, relying on a strong concentration of instruments and abilities, devises and explores simplified objects" (Callon et al., 2009:48). In translation 2 we consider the existence of two inscriptions: criteria for M&E and M&E mechanisms. Considerations regarding inscriptions: "The laboratory is a machine for producing inscriptions, for making possible their discussion, interpretation, and mobilization in learned controversies. The famous data (givens) of experience are never given; they are obtained, "made", fabricated. And they take the form of inscriptions, that may equally well be photos, pas, graphs filmed or electronically recorded traces, direct visual observations recorded in a laboratory, notebook, diagrams, illustrations, printed samples 3D models, ultra sound scans, or sonorous spectrums arranged and filtered by techniques enable them to be visualized. This, and only this, is what the scientist registers, describes exhibits, analyses, compares, and measures." (Callon et al., 2009:52).
Category	Deductive	**Scope of the research (T2.1)**: refers to the scope of the research regarding if it includes just the M&E mechanism design, the design and the implementation of the mechanism or just the implementation of the previously designed mechanism. The codes in this category refer to the two blocks of phases of evaluation proposed by Bustelo and Ligero (2017, retrieved from Ligero Lasa, 2015).
Subcategory	Deductive	**M&E Mechanism's Design**: Refers to studies that develop and design an M&E Mechanism, including the phases of evaluation under the category "Evaluation design" by Bustelo and Ligero (2017, retrieved from Ligero Lasa, 2015), that include:

Code level	Code type	Description and references
		• Purpose and motivation to evaluate • Definition of the unit of analysis • Selection of evaluative approach • Operationalization • Selection of techniques for data gathering • Methodological design
Subcategory	Deductive	**M&E Mechanism's Design and Implementation**: Refers to studies that develop an M&E Mechanism and implement it. Under this category, the phases under the category "Evaluation design" by Bustelo and Ligero (2017, retrieved from Ligero Lasa, 2015) are complemented by the following phases under the category "Implementation": • Fieldwork (data gathering) • Data analysis • Interpretation • Judgement • Recommendations • Communication and influence
Subcategory	Deductive	**M&E Mechanism's Implementation**: Refers to studies that implement a previously developed M&E Mechanism, developing the activities under the category "Implementation" of Bustelo and Ligero (2017).
Category	Inductive	**Funding (T2.2)**: refers to the origin of the funding for developing the research.
Subcategory	Inductive	The inductive codes created by the analysis of the funding declared in the documents is the following: • Research project funded by EU institutions • Research project funded by Canadian institutions • Research project funded by Chinese institutions • Research project funded by German institutions • Research project funded by Lithuania institutions • Research project funded by New Zealand institutions • Research project funded by Norwegian institutions • Research project funded by Spanish institutions • Research project funded by United Kingdom institutions • Research project funded by United States institutions • No reference to the funding institution
Category	Inductive	**Operationalisation and criteria (T2.3):** refers to the elements and components of the concept of RRI that are considered to build the research question that the M&E mechanism will analyse (criteria).
Subcategory	Deductive	**AREA dimensions**: Refers to the dimensions proposed by Stilgoe et al. (2013): Anticipation, reflexivity, inclusive deliberation, and responsiveness.
Subcategory	Deductive	**EC key areas**: Refers to the key areas proposed by the European Commission (2012): Governance, Ethics, Gender, Public Engagement, Science Education, and Open Access/Science. Sub-codes were created when the M&E Mechanism referred to just one key, as in the case of Gender and Science Education.
Subcategory	Inductive	**Other criteria**: Under this code, constructs, dimensions and criteria of RRI specifically created for the M&E mechanism are included. It also includes sub-codes when the new dimension, component or criteria comes from other disciplines: • Elements of accountability in megaprojects.

Code level	Code type	Description and references
		• Degree of responsibility • Responsible creativity and innovation • Societal progress towards Responsible Innovation. This code refers to the model developed by Voeten et al. (2015) that includes a 5-stage societal process towards Responsible Innovation: 1) Perception of Societal Change; 2) Linking innovation with Societal Change; 3) Dissatisfaction with the Trade-Offs, emerging conflict; 4) Escalating Conflict; Opportunism or Altruism; 5) Enforcement of Responsibility by Third Party. • Sustainable development goals. This code refers to dimensions, components and criteria related to the Sustainable Development Goals of the United Nations. • Sustainable development. This code refers to dimensions, components and criteria related to the concept of sustainable development at its triple dimension: social, economic and environmental.
Category	Inductive	**Structure of the M&E mechanism (T2.4)**: Refers to the structure of the M&E mechanisms: their components and sub-components. No classification is proposed under this code to capture the exact description provided by the authors of the documents analysed.
Category	Deductive	**Participation (T2.5)**: see codes in T1.3.
Aggregate	Deductive	**Translation 3**: Refers to the process in which the research output will be introduced (used or transferred) to the "big world". "The third stage is that of the always perilous return to the big world: Will the knowledge and machines produced in the confined space of the laboratory be able to survive and live in this world?" (Callon et al., 2009:48).
Category	Deductive	**Participation (T3.1)**: see codes in T1.3.
Aggregate	Deductive	**Macrocosms 2**: References to characteristic foreseen in macrocosms 2 after TRANSLATION (translation 1, 2 and 3).
Category	Deductive	**Challenges and trade-offs**: Refers to reflections and warnings on unintended consequences of uses and misuses of the M&E mechanism and the provision of guidelines and recommendations to counterbalance them (Hicks et al., 2015; Wilsdon et al., 2017).
Subcategory	Deductive	**Imposition of normative frameworks (or colonization):** "*To be responsible requires autonomy to act in the responsible mode. However, the required compliance with a set of criteria reduces this autonomy, and it might in the end no longer be clear whether the actor has retained autonomy or only compliance. In other words, the imposition of a system of performance indicators is always the imposition of external control. This attempt to gain external control over a set of activities will create resistance and attempts to counter-control. Colonisation is not only an imposition from outside, but might be welcomed by some insiders who will use the indicators to try to change the organisation in line with their own design. Indicator systems are often welcomed as setting the right incentives, putting significance on things that were hitherto neglected and helping create new mentalities and a culture change, which are all considered good things in the right direction. However,*

Code level	Code type	Description and references
		as the saying goes, the road to hell is paved with good intentions." (Strand et al., 2015:14) **Decoupling: Perception, no Performance:** "*This refers to cases when a system is entirely compliant to external criteria and thus changes its behaviour, but only in relation to the indicators, not in the direction the indicators actually want to achieve. Behaviour is changed, not in line with responsibility, but in a perfunctory ritual of compliance. In extreme cases, an organisation can set up a team of people to produce data for the indicators, but these data have little or nothing to do with what happens on the ground. The changing behaviour is not correlated to the overall goal.*" (Strand et al., 2015:14) **Strategic behaviour and goal displacement**: "*An effect of measuring human activities relates to the fact that performance measures are always approximations of a goal concept; it is an operationalisation that is convenient and cost- effective, rather than perfect. This leaves any measure with a gap between data and concept/goal. But the measure easily becomes the goal, and the original purpose gets lost and falls out of sight. The measure takes the place of what it purports to measure; the means becomes the goal*." (Strand et al., 2015:14) **Unintended consequences of indicator systems**: "*Measuring an activity on something that is measurable can have perverse effects by setting incentives for part activities that were not intended to be enhanced. For example, in the university sector, the quest for measuring research excellence as a fair way of distributing money to the right people has led to the incentivising of 'write more and teach less' to such an extent that teaching quality has collapsed, which requires another set of indicators on teaching quality, which then separates teaching excellence from research excellence and leaves little time to be good citizens of the university, which then requires an increase in administrative staff, who operate to different performance criteria such as providing performance indicators for academic staff, and so on*." (Strand et al., 2015:14) **Erosion of intrinsic motivation with incentive schemes:** "*A psychological effect of measuring activities by an external criterion is the erosion of intrinsic motivation. If someone does something naturally and in an unquestioned manner out of habit, pleasure or conviction, that is called intrinsic motivation. If a system now begins to assess and reward these actions, the person may begin focusing on the assessment, and the pleasure in the activity as such is eroded. In substituting intrinsic motivation with reward, it will become much more costly to sustain the same level of achievement. This is well known in the logic of work design and work incentive systems. Economists talk of the crowding out of intrinsic motivation (Sandel, 2012, p. 61 et seq.)*." (Strand et al., 2015:14) **The cost of collection indicator data:** "*Collecting indicator data will have costs either for the agency which collects the data, for example the Commission, or for the institution that is to provide these data, for example via a questionnaire to fill in. Filling in a questionnaire will take somebody's time and effort. Costs arise from the types of data but also the level of precision that is asked for. More precise data will take more time to collect and its collection is likely to be more costly. Any audit process at some point will cost more than the additional benefits that can be expected from using the data. Auditing follows the rule of diminishing returns: to have some data is better than no data; to have more*

Code level	Code type	Description and references
		data is not necessarily cost-effective (see Power, p. 77)." (Strand et al., 2015:15)

D. Capítulo 3. Proof quotes for findings

Table 33 *Finding a: Proof quotes for arguments calling for participation and contextualization to increase the adequacy of the M&E mechanisms to their evaluative purpose and to identify and reduce risks and negative impacts and trade-offs of their implementation*

Code	Proof quote
1	"In regard to the first issue, from our assessment as researchers, we were inclined to asses that Bat Trang village could be labelled as experiencing responsible innovation. During our discussions in later rounds of validating our tentative field assessments, we were confronted with the views of innovators and villagers in the other villages who had a different judgement than us about the whether the outcomes were negative or positive. In Duong Lieu and Van Phuc the villagers considered the emerging pollution problem as an acceptable trade-off for the benefits of the innovation. In Phu Vinh, our normative framework reflecting universally agreed ILO conventions saw some practices as child labour, a view not shared by the villagers. Any attempt that we - as western researchers, not living in the village - might make to define threshold values for these criteria, would involve imposing our normative framework about what is acceptable and what is not. This was particularly critical in the qualitative outcomes include labour conditions, the quality of products and the living environment, the position of employees and the consequences of innovation for cultural and traditional values. It is difficult to measure these criteria in an objective positivist fashion, as they are largely socially constructed, context specific (Adcock and Collier 2001)" (Voeten et al., 2014:165)
2	"For us, the process of developing the rubric in co-operation with colleagues who might one day (need to) apply it to evaluate their own projects demonstrated the range of benefits it might offer, including this identification of obstacles, barriers and limitations to the practice of RRI that stem not just from within particular projects or initiatives but are connected to broader and more deeply rooted socio-political factors and institutional cultures." (Wickson & Carew, 2014:269)
8	"The KPI we use below are based on earlier studies, in which these KPIs are identified, analysed and validated (Flipse et al., 2013a,b). Their relevance to RRI needed to be discussed in collaboration with the organization in which the KPIs are identified; yet mostly these KPIs can be framed in terms of RRI-relevant aspects, i.e. inclusion, anticipation, reflexivity and responsiveness. Namely, the KPIs only become relevant when people talk about these in relation to their work, thereby actively considering also the socio- ethical and socio-economic aspects of their work (reflexivity, anticipation) and translating these considerations into concrete actions (inclusion and responsiveness). Of course, these aspects partially overlap, but still we consider reflection and anticipation only to be operationalized through discussions (with colleagues and outsiders), and we consider responsiveness and inclusion only to be possible through explicit innovation actions (decisions in innovation practice)." (Flipse et al., 2015:138)
10	"The framework brings together the dimensions of responsible innovation (Stilgoe et al., 2013), the instruments of accountability for megaprojects (Flyvbjerg et al., 2013), and the principles of sustainability (Silvius et al., 2013, Silvius et al., 2012) as a starting point to fleshing out in practice the areas of concern when the conception of a project emerges and evolves towards an outcome (e.g., new industrial facilities and infrastructure for

	transportation and water supply). This requires an inclusive approach and increasing participation of all stakeholders involved in the process (i.e. members of society and their representatives, investors, project developers and integrators, government organisations, etc.). They are of social, economic, and political importance for the success and the legacy of developmental megaprojects and the avoidance of unintended consequences." (Tinoco et al., 2016:82)
11	"A third methodological implication derived from the review findings is the opportunity for broadening and enriching data collection sources by including more actors beyond students in the PERFORM assessment. PERFORM aims to enhance the robustness of the assessment by integrating different perspectives and sensibilities through the inclusion of the participating secondary school students, but also of their teachers, the facilitators of PERSEIAs and early career researchers contributing to the generation of PERSEIAs. The involvement of these actors in the PERFORM assessment will be key not only to enrich the collection of data but also to ensure that it can be formatively integrated into the learning process. The guiding role of teachers and early career researchers during the process will provide a constant conceptual support and assessment of contents. Furthermore, their involvement in the performance-based participatory process will be a key element to address and assess the public engagement required for RRI." (Heras et al., 2016:58)
13	"The levels of maturity in any maturity model need to be relevant to that given situation and are thus decided upon by those who develop the model. Additionally, the development of maturity does not conform to a particular number of stages; there is no set number of levels. Boundaries between levels tend to be continuous rather than discrete. One key quality of good maturity models is the selection of intuitively clear and convincing levels. Once established, it is vital that these levels are shown to be empirically relevant. Following consultation with industry representatives, we decided upon use of the widespread approach of five levels of maturity for the RRI model." (Stahl et al., 2017:7)
14	"In light of the diverse notions involved in the measurement of gender issues, participation appears important. The difficulties related to gender policies include lack of resources, resistance, and lack of clarity [34] on the integration of different actors and dependence on gender experts' knowledge in the development of a gender perspective in policy. Participatory dynamics have been suggested to overcome these risks and achieve the implementation of successful policies [35]." (Otero-Hermida & García-Melón, 2018:6)
16	"The EnRRICH project seeks to building learning and understanding by embedding evaluation in the heart of the project. A specific set of the project's tasks provided for formative evaluation through peer-to-peer activities, sharing learning and building horizontal links across different work packages and with the stakeholder group in order to accomplish a learning function (Scriven 1967; MEANS 1999). The formative evaluation is approached by examining methods to evaluate RRI embedding in HEIs curricula. Our approach to such a task implies the wide involvement of stakeholders in evaluation by means of participatory techniques that are built on a bottom-up approach. That also implies an explicit link between the EnRRICH evaluation activities and RRI guiding principles and requirements. Therefore, formative evaluation activities have been based on the effective involvement of evaluees in the definition of observation standards and methods." (Vargiu, 2018:16)

23	"Thus, even if hypothetically it would be possible to define rules for behaving responsibly in R&I, we would still see these rules in themselves as being of little or no value. In our view, such a 'sterile' theory-driven code-book would be self-contradictory, as it would absolve those applying the model from the very kind of responsibility it seeks to instil. Rather, the burden of deciding what are responsible decisions and actions always remains with those directly or indirectly taking part in R&I processes. These actors themselves need to reflect upon what is responsible in the specific contexts of their work, and this requires careful and systematic refection on a case-by-case basis. To give expression to this view, the criteria that emerged as our answer to the question 'What is RRI?' were eventually translated into questions inviting reflection and deliberation, rather than assertions." (Klaassen et al., 2020:225)

Table 34 *Finding a: Proof quotes for arguments calling for participation and contextualization to increase ownership and the performative function of the M&E mechanism*

Code	Proof quote
1	"In reality, perceptions of the relevance and legitimacy of these thresholds may vary considerably, according to the situation of the people concerned. Given the growing view that sustainability should be owned by people; that it should be participatory (Bell and Morse 2003), it is essential to include the judgments of the actors involved (in this case the villagers). This made it problematic to conclude that the innovations in Van Phuc, Duong Lieu and Phu Vinh should not be viewed as responsible innovation." (Voeten et al., 2014:167)
6	"An additional value of involving stakeholders in indicator development will be the fact that if the stakeholders become the 'owner' of the monitoring they will be more ready to accept this as a valuable instrument to improve their performance." (Strand et al., 2015:5)
11	"Participatory action research is especially relevant in the context of RRI assessment, mainly due to two reasons. First, as already highlighted (Strand et al. 2015, p.9), 'the concept of responsibility is easy to endorse and difficult to define'. To be operative, RRI requires, thus, a conceptual and practical grounding which might take different shapes depending on the context of implementation and the actors involved and participatory action research methods can be supportive in defining such grounding. Second, to strengthen the legitimacy and use of assessment indicators it is necessary that the actors involved –in this case, in the educational process, assume a sense of ownership (ibid)." (Heras et al., 2016:7)
14	"In light of the diverse notions involved in the measurement of gender issues, participation appears important. The difficulties related to gender policies include lack of resources, resistance, and lack of clarity [34] on the integration of different actors and dependence on gender experts' knowledge in the development of a gender perspective in policy. Participatory dynamics have been suggested to overcome these risks and achieve the implementation of successful policies [35]. Participation is a first step toward generating deliberative democratic models. These models can foster more transformative versions of gender policies, and in particular, transformative gender mainstreaming [36]." (Otero-Hermida & García-Melón, 2018:6)
15	"After diagnosing actual RRI efforts, innovation systems actors will require guidance regarding how and where they should embed RRI in R&D and innovation activities—

	particularly in contexts where the RRI process is acknowledged only to a limited extent and where innovation systems do not enable collective refection processes. […] In addition, such leadership should bring in civil society, which in our case study was almost fully neglected. Bringing diverse actors, such as private companies and citizens, together to consider future implications requires a high degree of trust (Asveld et al. 2015), but examples provided in this paper (e.g. workshops with different technology developers) show that, in the right context, this can result in positive interactions. Greater use of existing peer communities (e.g. technology sector representative groups, environmental groups, animal ethics groups), as suggested by Hellström (2003), could help a wide range of actors to engage in RRI activities." (Eastwood et al., 2017:22)
20	"Thus, there are critical questions that need to be kept in mind and solved when the model is applied. […]. Thirdly, the evaluation process should be as open as possible and include widely different values. A critical issue here is that these different viewpoints must be genuinely taken into account in the process, not only as a legitimizing element to increase the social acceptability of previously made "top-down" decisions." (Nieminen and Ikonen, 2020:265)

Table 35 *Finding a: Proof quotes for arguments calling for participation to align the process and outcomes of the M&E design to the core values of RRI*

Code	Proof quote
4	"In the development of the tool we wanted to apply the RRI approach itself, thus involving members from different stakeholder groups from the very first draft to the final prototype"·. (Schrammel et al., 2016:5)
9	"This fluid and contested nature of responsible research and innovation is the starting point of Res-AGorA. Rather than constructing yet another framework to specify the normative content of what responsible research and innovation should be, Res-AGorA developed a framework to guide the process of governing towards higher levels of responsibility in research and innovation, where the normative content is negotiated by the actors themselves as part of a continuous process of reflexive, anticipative and responsive adaptation of research and innovation to changing societal challenges. The aim of Res-AGorA was to develop a framework of principles intended to harness the self-governing capacities and capabilities of actors within Europe. This orienting framework will help actors to understand their responsibility challenges and to design, negotiate and implement their own context-specific understanding of responsibility in research and innovation." (Lindner et al., 2016:4)
11	"A third methodological implication derived from the review findings is the opportunity for broadening and enriching data collection sources by including more actors beyond students in the PERFORM assessment. PERFORM aims to enhance the robustness of the assessment by integrating different perspectives and sensibilities through the inclusion of the participating secondary school students, but also of their teachers, the facilitators of PERSEIAs and early career researchers contributing to the generation of PERSEIAs. The involvement of these actors in the PERFORM assessment will be key not only to enrich the collection of data but also to ensure that it can be formatively integrated into the learning process. The guiding role of teachers and early career researchers during the process will

	provide a constant conceptual support and assessment of contents. Furthermore, their involvement in the performance-based participatory process will be a key element to address and assess the public engagement required for RRI." (Heras et al., 2016:58)
14	"Considering this early stage a participatory approach is required to explore the national Spanish RRI reality. Gender equality initiatives depend crucially on an open perspective toward conceptions that shape the priorities of the different actors participating in equality policies [9]. The RRI perspective encourages co-creation and public engagement research practices, and a participatory methodology allows discussion of coherent internal processes for RRI practice. Finally, a participatory approach can lead to new indicators if European-level indicators are not suited to the national reality." (Otero-Hermida & García-Melón, 2018:2)
16	"The EnRRICH project seeks to building learning and understanding by embedding evaluation in the heart of the project. A specific set of the project's tasks provided for formative evaluation through peer-to-peer activities, sharing learning and building horizontal links across different work packages and with the stakeholder group in order to accomplish a learning function (Scriven 1967; MEANS 1999). The formative evaluation is approached by examining methods to evaluate RRI embedding in HEIs curricula. Our approach to such a task implies the wide involvement of stakeholders in evaluation by means of participatory techniques that are built on a bottom-up approach. That also implies an explicit link between the EnRRICH evaluation activities and RRI guiding principles and requirements. Therefore, formative evaluation activities have been based on the effective involvement of evaluees in the definition of observation standards and methods." (Vargiu, 2018:16)
20	"As stakeholder and/or citizen participation is the "cornerstone" of our evaluation approach – and of any RRI approach – a specific critical factor for further development of the model is theoretical and practical enquiry into the stakeholder concept. Further studies are needed to clarify its theoretical relevance as well as practical usefulness in implementation situations. Correspondingly, the model as a whole needs to be tested in diverse social contexts and organizations in order to secure sufficient empirical feedback on its elements." (Nieminen and Ikonen, 2020:266)

Table 36 *Finding b: Proof quotes of explicit participation of actors in translation 1*

Code	Proof quote
6	"Consequently, the European Commission appointed in 2014 an expert group 'to identify and propose indicators and other effective means to monitor and assess the impacts of RRI initiatives and evaluate their performance in relation to general and specific RRI objectives' (terms of reference). This report presents the results of the work of the expert group." (Strand et al., 2015:9) "The Commission then went on to specify that the RRI framework consists of six keys, as shown below. 1. Public engagement. 2. Gender equality. 3. Science education. 4. Open access. 5. Ethics. 6. Governance. This expert group has been asked to propose indicators for these six keys." (Strand et al., 2015:10)
7	"With regard to the latter, the main conclusions were as follows: · Based on discussions about current indicator availability and the EC objectives for the study, it was decided to focus on fewer categories in the RRI monitoring part of the project (noting that an empirical programme will also be rolled out on impacts/benefits monitoring). Therefore, the indicators for RRI monitoring were to focus on the 'input' and 'output' categories of the intervention logic model. In relation to levels of aggregation, the final set of indicators will focus on the 'national' level in order to provide a foundation for potential cross- country comparisons." (Ravn et al., 2015:22) "As described above, the identification of indicators in the MoRRI project revolve around the six key areas outlined by the European Commission in its pursuit of an operational definition of RRI." (Mejlgaard et al., 2018:25)
9	"Res-AGorA is a response to a call for research proposals included in the European Commission's Science-in-Society Work Programme for 2012 (European Commission 2011). The call text specifically required the development of a governance framework for RRI, and emphasised that: "[r]esearch should take into account the role of various actors, such as legislative, standard setting and certification bodies, regulatory bodies, civil society organisations, research institutions and business operators." (European Commission 2011b: 7f.) Furthermore, the call explained that a: "[…] comprehensive governance model for Responsible Re- search and Innovation does not yet exist at the European Level. The availability of such a model and information on the practical role of public engagement can make it possible for policymakers to start working on its implementation, thereby allowing stakeholders and interested citizens to participate and co-design an innovation process for which they can share responsibility." (European Commission 2011b:8). In addition to the challenging mission of developing such a comprehensive governance framework for Europe, the call also required applicants to propose a monitoring exercise to observe trends and developments in RRI in Europe, thereby building on the work of the MASIS project." (Lindner et al., 2016:10)

Table 37 *Finding b: Proof quotes for embedded participation of actors in translation 2*

Code	Proof quote
1	"The cases showed essential differences in that respect. By comparing various aspect of the perceptions and attitudes of the villagers and innovators in the four cases we identified patters that we modelled into a five-stage societal process towards responsible innovation." (Voeten et al., 2014:168)
2	"The quality criteria and indicators for RRI that we propose were derived through a series of events and activities over several months. These events and activities were aimed at elucidating through conversation and deliberation with a range of stakeholders what criteria might be used to understand, explain, judge and approach 'RRI' in the context of the development and use of nanoparticles for environmental remediation (nanoremediation)." (Wickson & Carew, 2014:257)
4	"The tool is developed in an iterative design process, from firstly desk research to several events with RRI experts, and different stakeholder groups that were hold specifically for the development and validation of the self-reflection tool. The first online version of the tool was launched in June 2016 (1st prototype). By active user feedback and integrated comments from the users as well as from power user groups, the prototype was revised in line with the identified needs and requests and finalised in November 2016 (2nd prototype)." (Schrammel et al., 2016:4) "To adequately co-create the SR tool a multi-level design process was necessary: Feedback was gathered through several feedback rounds with internal and external experts as well as with potential future users. Therefore different participatory methodologies were developed. Various workshop formats, such as focus groups or world cafés helped to improve the concept of the self-reflection tool." (Schrammel et al., 2016:8)
7	"RRI will inevitably mean different things to different people, and demand different forms of engagement in different countries, cultures and scientific disciplines. As with any agenda that proposes changes to cultures and practices, RRI activities will encounter resistance. RRI, if it is to succeed, should be seen as a set of activities that are done with and by the research and innovation community rather than to it. With this in mind, our project's visioning workshop looked for desirable futures that could be a basis for ongoing dialogue between research and innovation communities, stakeholders and the generic public. These visions were articulated with respect to RRI in general, as well as its constituent policy agendas. The following visions and perspectives on RRI emerged: [...] The vision, jointly developed by the participants, provided both initial substantive and normative orientation for the project's ensuing research process of developing an improved understanding of the benefits of RRI and possible indicators for their measurement." (Mejlgaard et al., 2018:10) "These questions became the focal points in a joint workshop among the project partners in Brussels in May 2015. This workshop also addressed the following issues: […] The joint deliberations of the Brussels workshop resulted in a common understanding of the framework for the final indicator design, including the subsequent procedural steps. Against the backdrop of this meeting, and in view of a number of EC recommendations, the partners

	agreed upon the following main criteria to guide the identification and construction of the final set of indicators: […]." (Ravn et al., 2015:23)
8	"In order to help derive our organizational and RRI indicators for companies, companies identified relevant indicators within their projects from 49 organizational and 43 RRI indicators. Companies might show a variation in their selection of relevant indicators under organizational indicators and RRI counterparts. These variations probably reflect differences in the stage of implementation of RRI within companies. Considering that not all our identified statements are relevant for each company, we developed a method to identify and select elements that play a role in the individual pilot projects. Table 4 provides an overview of how we envision this to work in practice." (van de Poel et al., 2017:14)
9	"Second, an intensive co-construction process with high-level stakeholders from science, industry, civil society and policy-making was to be conducted with the aim of testing, further developing and refining the building components for a governance framework for RRI." (Lindner et al., 2016:10)
11	"At this stage of the project (Month 7), participant students have been already included in the assessment design, through the explorative workshops and the identification and validation of criteria and indicators relevant to them. This is a rather basic level of participation, represented by the implementation of methods to gather participants' opinions and insights about topics of their own interest to be included in the assessment design; such as exploratory workshops or focused discussions." (Heras et al., 2016:59)
13	"The levels of maturity in any maturity model need to be relevant to that given situation and are thus decided upon by those who develop the model. Additionally, the development of maturity does not conform to a particular number of stages; there is no set number of levels. Boundaries between levels tend to be continuous rather than discrete. One key quality of good maturity models is the selection of intuitively clear and convincing levels. Once established, it is vital that these levels are shown to be empirically relevant. Following consultation with industry representatives, we decided upon use of the widespread approach of five levels of maturity for the RRI model." (Stahl et al., 2017:7) "For this, an interpretive research approach, conducting qualitative techniques and a single case study were applied. The work needed to be broken into relevant components, first specifying RRI indicators and then determining the levels of implementation of RRI within the research and innovation design process. Qualitative research was used to build the RRI key performance indicator list, with 30 interviews conducted in 11 countries with ICT thought leaders. A single case study was also conducted after the analysis of interviews in a company to identify the levels of responsible innovation. The case study corroborates knowledge gained from the interviews, helps us design an integrative model for managing RRI principles in industry and permits iteration and triangulation during the study." (Yaghmaei, 2018:7) "Once RRI indicators were set, after the interviews with ICT thought leaders, a case study was conducted with five members of a Danish company who were perceived to be actively engaged in R&I activities and who were interviewed. Two rounds of interviews with each company member permitted replication and mitigated the bias of the study. In total, ten

	interviews were conducted over a time span of 12 weeks, in two rounds." (Yaghmaei, 2018:7)
14	"This study presents the results of a participatory methodology that was used to determine a set of RRI gender indicators generated by experts in a Spanish S&T policy-making context. The final list obtained could be used to develop further policy-making initiatives in Spain from an RRI perspective. It differs from existing sets of indicators at the EU level and for Spain." (Otero-Hermida & García-Melón, 2018:17)
16	"This implied that relevant resources have been dedicated to the development of a shared evaluation framework for assessment criteria and method. The methodological process aimed at working out a common understanding of evaluation objectives and procedures that would orient peer evaluation can be summarized in the following steps: 1. First definition of self-evaluation criteria. 2. Criteria refinement and clustering. 3. Definition of a common set of peer evaluation procedures and instruments. All steps were conceived, designed and implemented in order to ensure highest levels of participation by all concerned actors. Early stage involvement in the evaluation exercise was actively sought. Notably, participation in the definition of evaluation criteria can be considered a crucial issue as it can be regarded as the core of evaluation which—unlike other forms of research—is explicitly value driven (see discussion, below). Based on such premises, in the following pages, steps 1 and 2 will be briefly presented as they are at the very heart of the RRI approach to evaluation within the EnRRICH project." (Vargiu, 2018:16)
17	"While RRI offers relevant principles to address health policy challenges, there are no tools to assess whether an innovation qualifies as a Responsible Innovation in Health (RIH). The purpose of this article is to share the results of a modified Delphi study, which aimed at critically evaluating, improving and reaching consensus on a RIH Tool. International experts were asked to examine: (1) the inclusion and exclusion criteria that should be used to identify whether an innovation may potentially qualify as a RIH (screening); (2) the responsibility dimensions and attributes that should be measured in more detail (assessment); and (3) the scoring system that should be applied (rating)." (Silva et al., 2018:389)
19	"This first complete draft was then shared and discussed with the experts of the COMPASS project's high-level advisory board in February 2018. The main purpose of this exercise was to receive an external expert assessment of the contents of the tool, ensure its completeness in terms of the responsible innovation concept and to eliminate redundancies and unnecessary components. A content-related change that was implemented based on the advisory board's advice was, for example, the integration of gender analysis and gender responsibility in all innovation process sections dealing with anticipating impacts, testing products, monitoring innovation effects and stakeholder involvement." (Tharani et al., 2020:206) "In the third step, an offline prototype of the envisioned online tool was tested in bilateral interviews or group discussions with 84 individuals representing small and medium-sized enterprises (SMEs), civil society organizations, business support organisations, consultancies, a funding agency and a research organization in the second half of the year 2018. The objective of this round of testing was to receive feedback on general usability and comprehensibility of the questionnaire and to, subsequently, improve wording and terms

	to maximize understandability and usability for the target group. […] As the fourth and last step of development, a beta version of the online self-check tool was published on the COMPASS project website in February 2019. Another 30 individuals representing SMEs from across Europe provided their feedback on usability of the online tool." (Tharani et al., 2020:208)
20	"In order to further develop and validate the model, the premises of the model were discussed in a separately organized international workshop of regional developers of RRI participating in the meeting of the EU-funded MARIE consortium (2017–202110) in Tampere, Finland on 29 May 2018. In total, 20 people from eight European regions participated in the workshop. The group consisted of people with diverse backgrounds dealing with regional developmental activities and supporting the implementation of RRI in their own regions in the context of the MARIE project. MARIE's objective was to improve regional public policy by supporting the dissemination and uptake of RRI among enterprises. Using interregional activities, communication and stakeholder engagement, the partners worked to develop new action plans and strategies for the implementation of RRI. The rationale behind the project was a common experience of challenges related to RRI including, for example, the complexity of the concept and lack of appropriate approaches to implement it in public policies. One of the pilots of the MARIE project was the development of open innovation platforms in one of the 6Aika cities in Finland (Tampere). The MARIE workshop thus created an opportunity for feedback on the RRI evaluation approach and supported the overall goals of MARIE in the implementation of RRI." (Nieminen and Ikonen, 2020:263)
23	"To arrive at a comprehensive model of RRI and its criteria, we engaged in a process of iterative conceptual modelling (Figure 9.1, and see Klaassen et al. 2017 for a more extensive description). Central to this methodology for concept development are different and disparate forms of expertise, confronted in a series of iterative steps which, in this case, sought to answer our question 'What is RRI?'." (Klaassen et al., 2020:225)
25	"Conceptual development of the SR Tool consisted of a comprehensive literature survey of peer-reviewed scholarly papers using Web of Science, Scopus, and CORDIS (supplement 2.1, Table S1, Figure S1). A total of 1,026 titles and abstracts yielded 171 relevant articles, the contents of which were organized into RRI conditions and keys across research design, data collection, analysis, and dissemination phases and further refined through co-creation sessions with 25 RRI experts from the NewHoRRIzon project. Subsequently, in a two-day Design Sprint (Knapp et al., 2016), the team developed the architecture and web-design concept for the tool." (Bernstein et al., 2022:6)

Table 38 *Finding b: Proof quotes for foreseen participation of actors in translation 3*

Code	Proof quote
2	"In the case and process we were working within, we arrived at the elements listed below as important components for consideration under each of the criteria. It is entirely possible, however, that alternative elements for each criterion could (and arguably should) be developed in specific relation to different contextual situations and by different actors, and

	ideally through deliberative processes involving a range of relevant stakeholders to the identified problem and context." (Wickson & Carew, 2014:262) "We specifically see scope for different research groups, innovation organizations, funding bodies and interested stakeholders to engage in analytic-deliberative processes to create their own criteria, and/or indicators for the quality criteria we present, and to articulate these statements across an evaluative scale." (Wickson & Carew, 2014:270)
6	"These stakeholders should jointly decide what indicators best represent the kind of R & I that takes place in their particular network." (Strand et al., 2015:6) "In part 3, the group concludes that it cannot offer a general prioritised list of indicators for actors in the European Research Area. National and regional actors, universities and research institutes, civil society organisations, funding agencies and others should devise their own process of deliberation in order to choose and tailor the indicators proposed in Chapter 2, and add their own indicators according to their own needs, goals and concerns." (Strand et al., 2015:7)
8	"After innovation-process relevant KPIs are identified, a model is developed that helps innovators operationalize these KPIs in their daily practices and link them to RRI. This can only work if the innovators using the model communicate with one another about RRI concepts in relation to project success. This model is the basis of a tool for decision support for industrial innovation practices aimed at stimulating RRI, through active communication between stakeholders about RRI-relevant aspects." (Flipse et al., 2015:137) "The KPI we use below are based on earlier studies, in which these KPIs are identified, analysed and validated (Flipse et al., 2013a,b). Their relevance to RRI needed to be discussed in collaboration with the organization in which the KPIs are identified; yet mostly these KPIs can be framed in terms of RRI-relevant aspects, i.e. inclusion, anticipation, reflexivity and responsiveness. Namely, the KPIs only become relevant when people talk about these in relation to their work, thereby actively considering also the socio- ethical and socio-economic aspects of their work (reflexivity, anticipation) and translating these considerations into concrete actions (inclusion and responsiveness). Of course, these aspects partially overlap, but still we consider reflection and anticipation only to be operationalized through discussions (with colleagues and outsiders), and we consider responsiveness and inclusion only to be possible through explicit innovation actions (decisions in innovation practice)." (Flipse et al., 2015:138) "The tool basically asks for indicators to be entered, clustered into key performance indicators, and given a score that determines the mathematical relative value of each of the clusters in relation to each other. We aim to determine initial similarities and differences between companies and between different projects within a company. The plan is to identify to what extent companies recognize the same individual indicators within these clusters. We also compare the clusters that the companies identify, to see whether they recognize the same clusters of indicators. Furthermore, the kinds of aspects that are considered important now, need not be relevant over time. Therefore, our approach can be repeated over time, to see whether some elements that were missed earlier can still be included, or whether items that are no longer relevant can be excluded for a certain company." (van de Poel et al., 2017:14) "The tool works in three steps: 1. Identification of relevant KPIs. In an earlier study, 92 possible success criteria (both RRI-related and innovation management-related) were identified. Companies are asked, in the form of a serious card game, to select (30–50)

	criteria relevant to their organization, sort these into (5– 8) relevant KPIs and indicate their relative importance by distributing 100 points over these KPIs. […]" (Flipse, 2020:274)
9	"A small team within the Res-AGorA consortium developed a workshop design that aims at facilitating and encouraging reflective processes between diverse and often opposing stakeholder groups. It is centered on the conceptualization and implementation of Responsible Research and Innovation (RRI) in organisations and elsewhere. The workshop design offers a unique process for organisations which want to steer research-related decision- making processes towards more responsible research and innovation. It provides an open space for reflection without normatively predefining what "responsibility" is. Rather, it is designed to "walk the talk", making it possible for stakeholders to gain first-hand experience on how to possibly promote RRI in organisations and elsewhere." (Lindner et al., 2016:55)
10	"These areas of analysis and influence to operationalise RPM are the starting questions for each of the projects and the customised variables are left open as they are defined for each project in consideration such as research projects and mega projects, industrial, infrastructure and complex projects. Customised variables could be analysed and defined by using indicators as proposed by several authors depending on the stakeholders' views, interest and responsibilities of a specific project (see examples in Table 1). These indicators are included in Table 3, that is, the framework informs the analysis of the customised variables. Moreover, the elaboration of the customised variables, as indicated in the Framework would also be informed by a project categorisation and typology, which can highlight some aspects such as the extent of the geographical impact of the project - from local, to regional, to national, to international, to global." (Tinoco et al., 2016:90)
11	"Derived of such finding, and as part of PERFORM's commitment with RRI processes and participation, the fourth and last implication for PERFORM assessment consists on paying special attention to the inclusion of the students in the whole assessment process, from design to analysis (see Figure 5). Although each case study will tailor their assessment strategy to the specific implementation context, the objective will be to reach the highest participation possible." (Heras et al., 2016:59)
14	"Additionally, a profound reflection on how to measure RRI initiatives and policies among experts from the different dimensions would be necessary to be able to include new indicators to measure relevant goals of each of the key areas responding to the specific state of the art in the country. The authors propose to arrange experts focus groups and the use of participatory methods to define in a specific context the complete list of indicators that should be weighted as a first set in the process to provide context-based indicators for any science and innovation system. In conclusion, the design of a study to select the more suitable and urgent indicators to measure RRI performance in a territory should include previous work conducted to identify new indicators that complement the proposals made so far. During the development of this study, the authors considered the suitability of the indicators proposed under a European perspective for use in national contexts without any type of adjustment. From our point of view, future study should respond to so far non-explored questions." (Monsonís-Payá et al., 2017:15)

15	"Our indicators were preliminary in nature, but they were designed to reflect specific attributes associated with smart dairying, such as the influence of private companies, changes to farmer practice, and community concerns over animal welfare and the environment. In contexts with fragmented application of RRI to smart farming, research providers, funders, and policymakers can use this framework for greater guidance of the comprehensive functional application of RRI. However, as exhibited by Wickson and Carew (2014), further effort is required to refine the indicators interactively and adapt them to specific contexts." (Eastwood et al., 2017:22)
18	"The second stage consists of determining the weights of the index components (E1, E2, G1, G2, Gov1, Gov2, O1, O2, P1, S1, S2). Weights could be determined arbitrarily by a researcher or policy maker or they may be determined collectively by the enterprises participating in the survey." (Nazarko, 2020:8)
20	"The stakeholder groups should also be involved in ex post or mid-term evaluation, in which it is assessed whether the defined targets have been reached and, if not, why they have not been achieved. Engagement in these discussions should be a mutual learning experience for all of the participants." (Nieminen and Ikonen, 2020:258)
24	"Tables 5.2–5.4 provide many examples of RRI actions that could be used in step 1 of the self-evaluation procedure. However, a company might decide to focus on a smaller or larger set of actions depending on its conditions and goals. Ideally, though, it should focus on having at least one action for each table in order to fulfil all the RRI dimensions." (Porcari et al., 2020:136)

Table 39 *Finding c: Proof quotes for primary purpose of "Knowledge creation" of the M&E mechanisms of RRI*

Code	Proof quote
1	"This led to our research question: how can we understand and conceptualize responsible innovation among small clusters of producers in Vietnam? Aside from posing a theoretical challenge, this question also has practical implications. The ability to distinguish responsible innovation (from 'irresponsible innovation') might also offer a means for operationalizing the concept within policies and programmes aimed at poverty alleviation and sustainable development." (Voeten et al., 2014:154)
2	"The rubric we have developed for RRI and presented in Table 1 is intended to represent a useful approach to clarify what is expected by and of different parties in the RRI process, and to provide inspiration, concrete guidelines and direction for improvement for those seeking to innovate in more responsible ways." (Wickson & Carew, 2014:263)
5	"This paper continues and specifies these efforts, following up with the beginnings of a practical methodological and procedural step-by-step plan with appropriate methods at every step, for research-based responsible innovations and, by implication, for evaluating innovations from a responsible innovation viewpoint. Following up on earlier conceptual and theoretical reflections, it presents and discusses case research data form port extension projects in Dalian and Rotterdam." (Ravesteijn et al., 2015:666)

	"Although basically a process-oriented approach, responsible innovation can also be used to determine whether an innovation is responsible or not and how improvements might be possible, as the examples above illustrate." (Ravesteijn et al., 2015:667)
12	"Based on this short summary, we conclude that calls for RI rarely address the questions of "to what end?" and "who should be doing what to innovate responsibly?" Accordingly, the primary aim of this article is to contribute to the discourse on RI by offering an alternative framework that aligns activities, stakeholders, and sustainability aspirations for policy-relevant decision contexts. The proposed framework builds upon many of the key concepts and practices articulated by Strand et al. (2015); rather than describing them as stand-alone elements, however, we show the critical interactions and overlaps between procedural elements and substantive outcomes. In the next sections, we define "activities," "stakeholders," and "aspirations" before providing examples of "alignment" for RI. Subsequently, we offer a case study on nanotechnology innovation governance in Phoenix, AZ to illustrate the how this framework can be employed to assess the differences between stakeholders' perceptions and the activities and aspirations espoused for RI. In conclusion, we elaborate how an alignment of activities, stakeholders, and aspirations helps address governance challenges at the core of innovation." (Foley et al., 2016:211)
15	"The paper therefore focuses on two questions: • To what extent, and why, have elements of RRI been considered to date to address socio-ethical challenges in NZ smart dairying development? • What are the broader lessons for RRI application in smart farming? We address these questions through a review of research projects focused on technology use in NZ dairy farming, in addition to interviews with stakeholders in smart dairying. We first review the literature on RRI dimensions and indicators to assess its application. From this review, we draw an analytical framework to assess smart dairying that will guide the interpretation of our findings." (Eastwood et al., 2017:3)
21	"What is less clear, however, is the degree to which it is necessary to realise and implement RRI to optimise its beneficial effects. We therefore use this chapter to discuss the following research question: • How can the level of RRI activity be optimised to suit the characteristics of an individual project? Given the variety of projects where RRI is mandated by funding bodies, the range of technology stages that may be covered and the relative experience of the project investigators in implementing RRI, this is a critical question that needs to be answered appropriately in order for practical RRI activities to be developed and implemented in a manner that suits the project variables. In order to answer this research question, we first review the definitions and current discourse on RRI. This is followed by the introduction of the concept of RIL. We show how this concept can be extended from the literature and which factors would be important to consider. We then develop this into a formal structure of RIL. The chapter closes by suggesting further research that would help to validate this idea." (Heaver et al., 2020:299)

Table 40 *Finding c: Proof quotes for the primary purpose of "Decision making and accountability" of the M&E mechanisms of RRI*

Code	Proof quote

3	"Therefore, the question is not to determine whether an innovation is responsible or not, but rather to question the related issues linked to the project and monitor their impacts throughout its lifecycle." (Hin et al., 2015:9)
8	"The tool presented here has two basic functions. First, to assess the scores of KPIs of current projects and add the results to the database on the basis of which the model (Figure 1 and 2) was made. Second, to use the model to test possible scenarios of how changes that could be implemented in currently active projects could influence project success chances. Below we describe the functionality and use of the prototype of the two parts of the tool we have prototyped." (Flipse et al., 2015:141) "They can filter per project on date, on individual KPI scores, and on different user inputs of the different team members who work on the same project. Using the comparison function, they can compare scores of different projects." (Flipse et al., 2015:142) "In order to be able to compare the development of responsible research and innovation (RRI) strategies and the deployment of RRI tools in these eight pilots, we developed a conceptual framework for responsible innovation in industry. We present the framework in this article." (van de Poel et al., 2017:1) "We now present a conceptual framework for RRI in industry. Central to this model is the RRI strategy of a company. This strategy is a reflection of the specific context in which the company operates. This RRI strategy is translated into certain RRI activities and the employment of certain RRI tools. These in turn will result in certain RRI outcomes, for which RRI key performance indicators (KPIs) can be developed so that company managers can monitor outcomes and progress." (van de Poel et al., 2017:1)
10	"Furthermore, management of megaprojects as a professional practice lacks a framework to provide lessons to support the improvement of decision-making process for the future generation of infrastructure for development, which increasingly has to be built up under sustainability and accountability premises. This paper proposes an integrative framework based on four dimensions of responsible innovation, four instruments of accountability and six principles addressing sustainability that help to define and implement megaprojects, aiming at an inclusive approach – to better inform practitioners, policy makers, academics, and the wider society - when decisions about building megaprojects are taken. This framework might help also to analyse megaprojects in order to extract lessons that might be useful in the controversial arena of infrastructure development." (Tinoco et al., 2016:80)
13	"A need is identified for a novel model to assist industry in better aligning RRI principles along the value chain. In doing so, one need to study on practical indicators that can offer managers an opportunity to map a responsible innovation agenda for industry." (Yaghmaei, 2018:5) "Overall, the integrated model provides a good starting point for future RRI research in industry. The model can assist industry in better aligning RRI principles across the value chain and offer managers RRI indicators to map responsible innovation agendas for their companies. Furthermore, the model provides opportunities for comparative research on RRI in other domains of industry. Another area for future research that emerges from this work is investigation of what leads industrial stakeholders to move from the defensive level to the inclusive level." (Yaghmaei, 2018:20) "However, and possibly even more importantly, the RRI maturity model offers the possibility of comparing organisations against each other and, assuming a larger amount of data is available, the development of specific benchmarks"·(Stahl et al., 2017:14)

14	"In this work, an explorative application of the AHP method was designed and applied to assess the importance of the indicators for six areas of RRI based on the available list of indicators. It relies on the opinion of experts in each of the six key areas of RRI proposed by the European Commission who provided different weights for the different indicators under each category (process, outcome, and perception) of the six areas. These weights are later used to propose different options to reduce a large set of indicators to a smaller one according to the experts' opinions. These smaller sets of indicators allow decision-makers to identify where efforts should be made to measure in a specific context the more relevant information of RRI performance." (Monsonís-Payá et al., 2017:5)
17	"While RRI offers relevant principles to address health policy challenges, there are no tools to assess whether an innovation qualifies as a Responsible Innovation in Health (RIH). The purpose of this article is to share the results of a modified Delphi study, which aimed at critically evaluating, improving and reaching consensus on a RIH Tool. International experts were asked to examine: (1) the inclusion and exclusion criteria that should be used to identify whether an innovation may potentially qualify as a RIH (screening); (2) the responsibility dimensions and attributes that should be measured in more detail (assessment); and (3) the scoring system that should be applied (rating)."· (Silva et al., 2018:389) "The first step in the application of the Tool is to ascertain whether an innovation may qualify as a potential RIH and whether it should be excluded from further assessment (i.e., innovations that are either unavailable to intended users or produced by irresponsible organizations)." (Silva et al., 2018:392)
18	"It should be noted that the optimal use of the index consists in benchmarking, i.e., in calculating the index with the same components and the same weights for a number of similar organizations. Such exercises may help identify leaders and followers in RRI, thus spreading best RRI practices. If used by only one organization, the RRI index may help with tracking changes over time." (Nazarko, 2020:9)
22	"With the RRI measure, more research can be done in bridging the gap between intended business strategies involving RRI and what employees actually do when creating novel and useful products, services or business models. Such multilevel approaches to study RRI are now possible by applying the RRI measure. It could be very relevant to study RRI of employees in international contexts and to compare employees from different levels and backgrounds. The RRI measure could further feature in studies on the relationship between management practices or leadership styles and innovation outcomes. As such, the RRI measure could also be applied in practice as this will enable companies to compare different departments on their level of RRI by using aggregated data. The measure could also feature as an outcome for training and development efforts in the area of RRI or be used for the assessment of employees or managers." (Verburg et al., 2020:329)
24	"Regardless of their target or method, impact analyses will likely include these main steps: • defining the target (level of maturity/commitment/investment to achieve in RRI) and selecting criteria for monitoring costs and benefits based on the RRI goals and strategy • estimating costs based on the RRI action plan and tools • evaluating benefits based on (expected or actual) RRI outcomes • monitoring RRI implementation based on selected criteria and using the results to continuously refine the RRI goals, strategy and indicators." (Porcari et al., 2020:128) "This exercise can be used to assess the impact of actions taken or to evaluate different RRI strategies before implementation in order to identify the most advantageous and cost-

	effective actions for RRI uptake with respect to the selected criteria." (Porcari et al., 2020:136)

Table 41 *Finding c: Proof quotes for main purpose "Learning" of the M&E mechanisms of RRI*

Code	Proof quote
4	"In this chapter we present and explain the quality criteria of good practice standards in RRI. This set of criteria and indicators, further specified in the form of questions, can help to get a grasp on the types of characteristics of research and innovation practices that should be targeted in assessment, monitoring or (self-) evaluation tools. It is only with such tools, subsequently, that it can be investigated whether research and innovation practices are responsible and, if so, to what extent. The list is meant to be used as a thinking aid. We urge all who will use this list that the questions posed are meant to give the criteria of good practice standards in RRI their proverbial hand and feet. Using these questions for executing tick-box exercises contradicts the reflective spirit of RRI and comes with the risk of missing the mark entirely." (Kupper et al., 2015:17) "The Self- Reflection-tool shall support users to reflect and consider RRI aspects in their day-to-day working environment and to provide hints and further suggestions towards the implementation of RRI." (Schrammel et al., 2016:4)
6	"Taking these two conclusions together, the emphasis of impact evaluation is shifting from (end) product to process, and from verdicts/judgments to learning and improving." (Strand et al., 2015:12)
7	"The results demonstrate that there is significant diversity in the European RRI landscape. Attention, efforts and priorities across the 11 sub-dimensions differ across member states. The roots of diversity may require a subtle understanding of historical trajectories in the relationship between science and society, and R&I policy approaches, as well as political and civic culture. These different patterns are not set in stone but change occurs slowly. The learning could be enriched for example through a European hub for RRI, which collects and shares learning from such activities. To do: Make use of the MoRRI indicators as a learning platform and to foster exchange; for example by integrating them in existing RRI platforms." (Mejlgaard et al., 2018:5) "We recommend making use of the MoRRI indicators as a platform for international learning. At institutional level there needs to be room for testing, setting of own goals and the use of measurements that indicate the quality of the institutional change. The country clusters based on RRI indicators can help member states as well as the European Commission to identify areas for intervention and improvement, and the results can help nurture ideas for prioritisation in the Framework Programme. For organisations, the 11 sub-dimensions may provide a helpful framework for reflection and strategic decision-making towards cultivating RRI" (Mejlgaard et al., 2018:53)
11	"A second implication is that assessment in PERFORM is conceived both as assessment for and assessment as learning (Corigan et al. 2013). The assessment for learning approach implies that assessment is understood as a process carefully integrated into the science educational activities –the PERSEIAs, as a reflective and self-reflexive dimension inherent to the students' learning process that can contribute to

	such learning as it happens. We reject, therefore, the perspective of the assessment as an external activity of summative nature, independent of the educational process developed. The adoption of formative approaches is further relevant in the context of performance-based science education, since assessments in this field are commonly summative and at the end of the process (Odegaard 2003). The assessment as learning approach implies that monitoring and evaluation are also understood as self-reflexive, iterative research processes aiming to contribute to the improvement of the PERSEIAs proposed. Such contributions will take place both during the PERSEIAS development and their pilot testing. This will be possible thanks to the collection of data at different stages of the participatory educational process (prior to, during and after); but also, to the inclusion of self-diagnostic assessment methods that will allow students and researchers to collectively reflect on PERSEIAs learning outcomes and processes. Such iterative process will also allow us to critically reflect on the methodological implementation of the assessment and to adapt it and improve it if needed according to gathered evidence and feedback received. Furthermore, the development of PERSEIAs in selected schools in two different stages along two consecutive school years will facilitate such approach. Through the assessment of the participatory educational processes carried out during the first year in selected schools, we will identify and address potential shortcomings in the methodology that will be reviewed and improved for the second year." (Heras et al., 2016:58)
16	"In order to learn about how ongoing processes can be improved and to share such a learning among consortium members and beyond, the EnRRICH project provides for peer evaluation of pilot activities and mutual learning to identify best practices and main bottlenecks in RRI curriculum embedment practices and further develop the relevant student competencies and learning outcomes." (Vargiu, 2018:16) "The EnRRICH project seeks to building learning and understanding by embedding evaluation in the heart of the project. A specific set of the project's tasks provided for formative evaluation through peer-to-peer activities, sharing learning and building horizontal links across different work packages and with the stakeholder group in order to accomplish a learning function (Scriven 1967; MEANS 1999). The formative evaluation is approached by examining methods to evaluate RRI embedding in HEIs curricula." (Vargiu, 2018:16)
19	"Based on insights from the discourses on responsible innovation and organizational learning (Fortis et al. 2018), this chapter introduces a self- assessment tool tailored to evoke organizational learning for responsible innovation in a corporate setting. The COMPASS self-check tool takes a diagnostic approach and aims to enable learning by translating the concept of responsible innovation into concrete corporate practices and policies, ascribing them to specific business functions. This facilitates the assimilation of information about specific responsible innovation practices as well as the refection about company strengths and weaknesses in terms of the responsible innovation approach." (Tharani et al., 2020:199)
20	"Besides defining the joint targets and shared values for the innovation activity, the goal of the process is also that the participating organizations and people change their own behaviour so that the joint targets are possible to achieve." (Nieminen and Ikonen, 2020:257)

	"Following from this, we have suggested an evaluation model that incorporates future orientation, a systemic view and multi-actor approach. The model emphasizes continuous development instead of outcomes. Ideally, the evaluation should be aimed at developing operations and processes from the very beginning, not afterwards. In other words, assessing the acceptability and desirability of an innovation or development takes place in a dialogic process of anticipating the impacts and outcomes of the innovation from the very beginning of the process. In the model, RRI intertwines in a step- wise process with successive innovation and organizational actions. A focal character of the model is co-creation, which helps to define values and operational goals for the innovation activity and supports the assessment of the success of operations. At its best, the process is a loop of continuous learning in which participating organizations and individuals learn from each other during the evaluation process and reflexively develop their activity. The desirability and acceptability of the innovation are supported by creating shared visions for the innovation activity." (Nieminen and Ikonen, 2020:266)
23	"To emphasize: we refer to these questions as inviting questions to highlight their intended status as points of departure for various forms of refection and deliberation, rather than as an instrument of accounting." (Klaassen et al., 2020:227) "In this chapter, we further focus on one specific reflexive approach that has proliferated in various domains and explore its value for RRI projects: RMA. RMA is an interactive, action-oriented monitoring and evaluation method, originally developed to support projects with ambitions to make system innovations and which require major institutional and social change (Van Mierlo et al. 2010). As for most reflexive approaches, RMA is intended to increase a project's reflexivity – its ability to affect and interact with the context within which it operates – by encouraging its participants' collective learning processes, through which institutional and societal barriers to system innovation are identified and overcome." (Klaassen et al., 2020:231)
25	"The SR Thinking Tool was designed and deployed for online use (http://thinkingto ol.eu/). Our primary initial target group was academics, whose research and innovation trajectories often start with an idea seeking funding. Increasingly, funders expect applicants to address a diverse set of issues such as ethics, gender, and open science. These expectations of applicants are what we leveraged to create "entry points" to the SR tool. By "entry points" we mean instigating reasons motivating a user to seek out SR tool. Answering SR tool questions is intended stimulate thought and subsequent decisions about research and innovation practices. Researchers may use responses to these questions when preparing a particular proposal, crafting protocols, drafting intermediary and final reports for funders, or any number of other moments in project life." (Bernstein et al., 2022:19)

Table 42 *Finding c: Proof quotes for the primary purpose of "Trust and cooperation" of the M&E mechanisms of RRI*

Code	Proof quote
9	"While a number of explicit proposals for responsible research and innovation have already been developed, these cannot be the definite final manifestation for all the different contexts at different political and organisational levels across Europe, as the very essence

	of what is responsible in research and innovation is contested and will need constant re-negotiation and deliberation. This fluid and contested nature of responsible research and innovation is the starting point of Res-AGorA. Rather than constructing yet another framework to specify the normative content of what responsible research and innovation should be, Res-AGorA developed a framework to guide the process of governing towards higher levels of responsibility in research and innovation, where the normative content is negotiated by the actors themselves as part of a continuous process of reflexive, anticipative and responsive adaptation of research and innovation to changing societal challenges. The aim of Res-AGorA was to develop a framework of principles intended to harness the self-governing capacities and capabilities of actors within Europe. This orienting framework will help actors to understand their responsibility challenges and to design, negotiate and implement their own context- specific understanding of responsibility in research and innovation." (Lindner et al., 2016:4)

Table 43 *Finding d: Proof quotes for actor's participation as criteria providers in translation 2*

Code	Proof quote
1	"An essential element of the model is that the normative framework employed for judging the innovation outcomes is based on the values and perceptions of the community itself. As we argued earlier in the chapter, imposing an external - western - normative framework is not viable, since the perceptions and evaluations of environmental and social outcomes are subjective, context specific and subject to constructivism and multiple realities." (Voeten et al., 2014:172)
2	"The quality criteria and indicators for RRI that we propose were derived through a series of events and activities over several months. These events and activities were aimed at elucidating through conversation and deliberation with a range of stakeholders what criteria might be used to understand, explain, judge and approach 'RRI' in the context of the development and use of nanoparticles for environmental remediation (nanoremediation)." (Wickson & Carew, 2014:257)
4	"The formulation of the criteria was an extensive, iterative process in which many contributed." (Kupper et al., 2015:16) "Considering these high demanding issues, the construction of the questions required a multiple approach of desk research on respective literature, similar tools and co-design phases with experts, consortium partners, stakeholders and end-users." (Schrammel et al., 2016:6)
7	"These questions became the focal points in a joint workshop among the project partners in Brussels in May 2015. […] The joint deliberations of the Brussels workshop resulted in a common understanding of the framework for the final indicator design, including the subsequent procedural steps. Against the backdrop of this meeting, and in view of a number of EC recommendations, the partners agreed upon the following main criteria to guide the identification and construction of the final set of indicators:[…]" (Ravn et al., 2015:23)

	"[…] 19 research and innovation (R&I) actors from 15 European countries representing the core R & I actor groups (academia, research and technology organisations, policy and industry), and five colleagues from different units of the European Commission participated in the visioning workshop (September 21 to 22, 2015). The vision was developed through a visioning process starting from individual visions of the participants that were then synthesised in ever-larger group compositions until finally an agreement on five key elements was reached. (Mejlgaard et al., 2018:10)
8	"In order to help derive our organizational and RRI indicators for companies, companies identified relevant indicators within their projects from 49 organizational and 43 RRI indicators. Companies might show a variation in their selection of relevant indicators under organizational indicators and RRI counterparts. These variations probably reflect differences in the stage of implementation of RRI within companies. Considering that not all our identified statements are relevant for each company, we developed a method to identify and select elements that play a role in the individual pilot projects. Table 4 provides an overview of how we envision this to work in practice." (van de Poel et al., 2017:14) "In our workshop we first asked industry representatives to identify, from the stack of 92 indicators, which indicators they considered 'relevant', 'irrelevant' or 'maybe relevant' for their organizations. Out of 92 indicators, 89 functioned as a 'relevant' for companies in one or more situation. Of these, 11 indicators emerged as 'relevant' for all companies, while 7 indicators function as 'relevant' for 5 companies and marked as 'maybe' for the last company." (Flipse and Yaghmaei, 2018:5)
9	"Second, an intensive co-construction process with high-level stakeholders from science, industry, civil society and policy-making was to be conducted with the aim of testing, further developing and refining the building components for a governance framework for RRI." (Lindner et al., 2016:12)
11	"Based on the participatory approach of the PERFORM project, we paid special attention to the inclusion of students' views and opinions about science learning and engagement in the evaluation process by conducting exploratory workshops with students in selected schools in each case study (France, Spain, and the UK). This had a twofold objective: to actively involve the students in the assessment process since the beginning, and to contextualise the PERFORM impact assessment methodology in each educational setting. As a result, we identified both criteria and indicators that students consider important when assessing the impact of science-related activities they experience both inside and outside school." (Heras et al., 2016:26)
13	"For this, an interpretive research approach, conducting qualitative techniques and a single case study were applied. The work needed to be broken into relevant components, first specifying RRI indicators and then determining the levels of implementation of RRI within the research and innovation design process. Qualitative research was used to build the RRI key performance indicator list, with 30 interviews conducted in 11 countries with ICT thought leaders. A single case study was also conducted after the analysis of interviews in a company to identify the levels of responsible innovation. The case study corroborates knowledge gained from the interviews, helps us design an integrative model for managing RRI principles in industry and permits iteration and triangulation during the study." (Yaghmaei, 2018:7)

	"The levels of maturity in any maturity model need to be relevant to that given situation and are thus decided upon by those who develop the model. Additionally, the development of maturity does not conform to a particular number of stages; there is no set number of levels. Boundaries between levels tend to be continuous rather than discrete. One key quality of good maturity models is the selection of intuitively clear and convincing levels. Once established, it is vital that these levels are shown to be empirically relevant. Following consultation with industry representatives, we decided upon use of the widespread approach of five levels of maturity for the RRI model. " (Stahl et al., 2017:7)
14	"The experts met in October 2017 in a participatory workshop. They proposed a list of nine relevant aspects and a set of indicators to monitor each of them (52 indicators in total). The questions addressed were: which gender issues might be more relevant in a specific Spanish RRI context, and how could these aspects be measured. They were encouraged to use both existing indicators and/or create new ones. No further information was provided and the aim was not to produce a specific typology of indicators (e.g., aimed at organizations or policies, results, or perceptions). Our interest was in observing the preferences in the Spanish case, given the differences already observed at the European level." (Otero-Hermida & García-Melón, 2018:8)
16	"This implied that relevant resources have been dedicated to the development of a shared evaluation framework for assessment criteria and method. The methodological process aimed at working out a common understanding of evaluation objectives and procedures that would orient peer evaluation can be summarized in the following steps: 1. First definition of self-evaluation criteria. 2. Criteria refinement and clustering. 3. Definition of a common set of peer evaluation procedures and instruments. All steps were conceived, designed and implemented in order to ensure highest levels of participation by all concerned actors. Early stage involvement in the evaluation exercise was actively sought. Notably, participation in the definition of evaluation criteria can be considered a crucial issue as it can be regarded as the core of evaluation which—unlike other forms of research—is explicitly value driven (see discussion, below). Based on such premises, in the following pages, steps 1 and 2 will be briefly presented as they are at the very heart of the RRI approach to evaluation within the EnRRICH project." (Vargiu, 2018:16)
17	"While RRI offers relevant principles to address health policy challenges, there are no tools to assess whether an innovation qualifies as a Responsible Innovation in Health (RIH). The purpose of this article is to share the results of a modified Delphi study, which aimed at critically evaluating, improving and reaching consensus on a RIH Tool. International experts were asked to examine: (1) the inclusion and exclusion criteria that should be used to identify whether an innovation may potentially qualify as a RIH (screening); (2) the responsibility dimensions and attributes that should be measured in more detail (assessment); and (3) the scoring system that should be applied (rating)." (Silva et al., 2018b:389)
23	"To arrive at a comprehensive model of RRI and its criteria, we engaged in a process of iterative conceptual modelling (Figure 9.1, and see Klaassen et al. 2017 for a more

	extensive description). Central to this methodology for concept development are different and disparate forms of expertise, confronted in a series of iterative steps which, in this case, sought to answer our question 'What is RRI?'." (Klaassen et al., 2020:225)
25	"Conceptual development of the SR Tool consisted of a comprehensive literature survey of peer-reviewed scholarly papers using Web of Science, Scopus, and CORDIS (supplement 2.1, Table S1, Figure S1). A total of 1,026 titles and abstracts yielded 171 relevant articles, the contents of which were organized into RRI conditions and keys across research design, data collection, analysis, and dissemination phases and further refined through co-creation sessions with 25 RRI experts from the NewHoRRIzon project. Subsequently, in a two-day Design Sprint (Knapp et al., 2016), the team developed the architecture and web-design concept for the tool." (Bernstein et al., 2022:6)

Table 44 *Finding e: Proof quotes for actor's participation as criteria providers in translation 3*

Code	Proof quote
2	"In the case and process we were working within, we arrived at the elements listed below as important components for consideration under each of the criteria. It is entirely possible, however, that alternative elements for each criterion could (and arguably should) be developed in specific relation to different contextual situations and by different actors, and ideally through deliberative processes involving a range of relevant stakeholders to the identified problem and context." (Wickson & Carew, 2014:262) "We specifically see scope for different research groups, innovation organizations, funding bodies and interested stakeholders to engage in analytic-deliberative processes to create their own criteria, and/or indicators for the quality criteria we present, and to articulate these statements across an evaluative scale." (Wickson & Carew, 2014:270)
6	"These stakeholders should jointly decide what indicators best represent the kind of R & I that takes place in their particular network." (Strand et al., 2015:6) "We believe that RRI indicators can be relevant to a number of policy levels and contexts. […] This means that we see the framework as a toolbox more than a tick box. Users should use this framework to pick and choose those indicators that fit their activities and those of their R & I network the best. What counts is that they show their RRI performance in a way that makes sense in their context. That is why they should do this together, in a process that will arguably also raise the commitment among stakeholders for RRI. The choices they make in this process are not inconsequential, because the set of indicators they choose form a specific framework of accountability." (Strand et al., 2015:16) "These stakeholders should jointly decide what indicators best represent the kind of R & I that takes place in their particular network." (Strand et al., 2015:6) "Finally, the Directorate-General for Research and Innovation should make its discretional choice in the identification of this smaller set, as it is the directorate-general and not the expert group that owns its policy priorities. Based upon our knowledge of the current policy context and the mandate for the expert group, the group makes a proposal for such a smaller set. This is given in the table at the end of this report." (Strand et al., 2015:8) "Ultimately, DG Research and Innovation should make its discretional choice in the identification of this smaller set, as it this the DG and not the expert group that owns its policy priorities. Based upon our knowledge of the current policy context and the mandate

	for the expert group, we have felt entitled, however, to make our proposal for such a smaller set." (Strand et al., 2015:41)
8	"After innovation-process relevant KPIs are identified, a model is developed that helps innovators operationalize these KPIs in their daily practices and link them to RRI. This can only work if the innovators using the model communicate with one another about RRI concepts in relation to project success. This model is the basis of a tool for decision support for industrial innovation practices aimed at stimulating RRI, through active communication between stakeholders about RRI-relevant aspects." (Flipse et al., 2015:137) "The KPI we use below are based on earlier studies, in which these KPIs are identified, analysed and validated (Flipse et al., 2013a,b). Their relevance to RRI needed to be discussed in collaboration with the organization in which the KPIs are identified; yet mostly these KPIs can be framed in terms of RRI-relevant aspects, i.e. inclusion, anticipation, reflexivity and responsiveness. Namely, the KPIs only become relevant when people talk about these in relation to their work, thereby actively considering also the socio-ethical and socio-economic aspects of their work (reflexivity, anticipation) and translating these considerations into concrete actions (inclusion and responsiveness). Of course, these aspects partially overlap, but still we consider reflection and anticipation only to be operationalized through discussions (with colleagues and outsiders), and we consider responsiveness and inclusion only to be possible through explicit innovation actions (decisions in innovation practice)." (Flipse et al., 2015:138)
9	"A small team within the Res-AGorA consortium developed a workshop design that aims at facilitating and encouraging reflective processes between diverse and often opposing stakeholder groups. It is centered on the conceptualization and implementation of Responsible Research and Innovation (RRI) in organisations and elsewhere. The workshop design offers a unique process for organisations which want to steer research-related decision-making processes towards more responsible research and innovation. It provides an open space for refection without normatively predefining what "responsibility" is. Rather, it is designed to "walk the talk", making it possible for stakeholders to gain firsthand experience on how to possibly promote RRI in organisations and elsewhere." (Lindner et al., 2016:55)
10	"These areas of analysis and influence to operationalise RPM are the starting questions for each of the projects and the customised variables are left open as they are defined for each project in consideration such as research projects and mega projects, industrial, infrastructure and complex projects. Customised variables could be analysed and defined by using indicators as proposed by several authors depending on the stakeholders' views, interest and responsibilities of a specific project (see examples in Table 1). These indicators are included in Table 3, that is, the framework informs the analysis of the customised variables. Moreover, the elaboration of the customised variables, as indicated in the Framework would also be informed by a project categorisation and typology, which can highlight some aspects such as the extent of the geographical impact of the project - from local, to regional, to national, to international, to global." (Tinoco et al., 2016:90)
11	"A third methodological implication derived from the review findings is the opportunity for broadening and enriching data collection sources by including more actors beyond students in the PERFORM assessment. […] The involvement of these actors in the PERFORM

	assessment will be key not only to enrich the collection of data but also to ensure that it can be formatively integrated into the learning process. The guiding role of teachers and early career researchers during the process will provide a constant conceptual support and assessment of contents. Furthermore, their involvement in the performance-based participatory process will be a key element to address and assess the public engagement required for RRI." (Heras et al., 2016)
14	"The quick and mainstreamed irruption of the concept RRI in the European scientific agenda caused a reaction from the scientific community, which reflects on how it might be articulated and put in practice, how to measure efforts in this context, and how to integrate the efforts made in other areas of knowledge. The purpose of this article is to present an exploratory study on how the multicriteria analysis technique Analytical Hierarchical Process (AHP) [5] could be used to weight and select by relevant actors the indicators proposed so far [6] to measure the processes, results, and outcomes of the RRI policies and initiatives in specific contexts." (Monsonís-Payá et al., 2017:1) "Therefore, our aim with this study was not to offer a definitive prioritized list of indicators of RRI for the Spanish research and innovation ecosystem, but to explore the potential of the methodology to advance towards that broader objective by involving relevant actors in the process of selection of indicators." (Monsonís-Payá et al., 2017:15) "Last but not least, concerning the development of the AHP participatory methodology used as a tool for prioritization, we want to state that there has been considerable agreement among the experts, and that the first meeting for defining and agreeing the indicators was fruitful. All the stakeholders felt that the AHP procedure allowed them to deal with prioritization in an organized and systematic way. They all agreed that the procedure enhanced participation and transparency and it was a necessary source of information and support for defining indicators based on consensus. Concerning the utility and applicability of this tool and findings in similar cases, the procedure is easily adaptable to other RRI areas, as is the case for Public Engagement or Open Science. For that, facilitators must bear in mind three key rules: first, to arrange a panel of stakeholders fully representative and motivated; second, to provide an appropriate means of communication among them; and third, to take AHP as a whole procedure and to devote the necessary time. As such, the AHP procedure becomes not only interesting in terms of reaching a final prioritization of indicators, but mainly in terms of enabling debates and reflections." (Otero-Hermida & García-Melón, 2018:18)
15	"Our indicators were preliminary in nature, but they were designed to reflect specific attributes associated with smart dairying, such as the influence of private companies, changes to farmer practice, and community concerns over animal welfare and the environment. In contexts with fragmented application of RRI to smart farming, research providers, funders, and policymakers can use this framework for greater guidance of the comprehensive functional application of RRI. However, as exhibited by Wickson and Carew (2014), further effort is required to refine the indicators interactively and adapt them to specific contexts." (Eastwood et al., 2017:20)
18	The second stage consists of determining the weights of the index components (E1, E2, G1, G2, Gov1, Gov2, O1, O2, P1, S1, S2). Weights could be determined arbitrarily by a researcher or policy maker or they may be determined collectively by the enterprises participating in the survey." (Nazarko, 2020:362)
20	"Thus, there are critical questions that need to be kept in mind and solved when the model is applied. […] Fourthly, the evaluation should pay careful attention to the identification and

	engagement of stakeholders to ensure, not only fair and wide, but also effective participation. And finally, the far from simple challenge of functional indicators and their measurement needs to be addressed to provide appropriate follow-up indicators and incentives for RRI. (Nieminen and Ikonen, 2020:265) "However, implementing the model is not without its challenges. For instance, in a complex and systemic environment, the line between an organization and its environment may become blurred and the concept of stakeholder may turn out to be more or less obsolete in describing symbiotic relationships in innovation ecosystems or in global interaction. Neither is balancing between different values and avoidance of value relativism or dominance easy. In addition, not all actors may be motivated to participate in RRI activities. Motivation to participate can, however, be increased by ensuring trust among the participating actors. As stakeholder and/or citizen participation is the "cornerstone" of our evaluation approach – and of any RRI approach – a specific critical factor for further development of the model is theoretical and practical enquiry into the stakeholder concept. Further studies are needed to clarify its theoretical relevance as well as practical usefulness in implementation situations. Correspondingly, the model as a whole needs to be tested in diverse social contexts and organizations in order to secure sufficient empirical feedback on its elements." (Nieminen and Ikonen, 2020:266)

Table 45 *Finding e: Proof quotes for participation of experts and independent assessors in translation 3*

Code	Proof quote
8	"An important component of our conceptual model is the assessment of RRI outcomes through the definition of a number of RRI key performance indicators (KPIs). We are aware that assessing or even measuring RRI outcomes raises a number of issues that are beyond the scope of this paper. One issue is who is to do the assessment. Although it is good if companies apply tools for self-assessment, from a societal point of view, some form of independent assessment is required. This can be implemented in several ways, including external auditing, independent certification, or government oversight, each of which may have its advantages and drawbacks." (van de Poel et al., 2017:15)
17	"Finally, the RIH Tool is an evidence-informed tool and it must be applied by individuals who possess research skills and are able to retrieve and critically read scientific literature. In this regard, requirements for an appropriate application of the Tool include holding formal training in an applied discipline with a focus in health and social care as well as experience working within an interdisciplinary research team, and having access to relevant bibliographic databases and search engines for retrieving scientific peer-reviewed journals. After having retrieved and compiled the relevant sources of information, consensus over each criterion and attribute should be sought through deliberation." (Silva et al., 2021:183) "While the Tool is meant to be applied by researchers, its results are meant to be used by various health innovation stakeholders (eg, research funding agencies technology transfer

	offices [TTOs], innovators, investors, etc). Since the latter do not typically hold research skills, they will have to rely on scholars who can apply the Tool." (Silva et al., 2021:183)

E. Capítulo 4. Full list of indicators

Table 46 *Full list of indicators*

Dimension/Sub-Dimension	Category	Code	Indicator
Governance	Process	GO1_PR1	Identification of formal and informal networks that promote RRI, at both the national and EU level
		GO1_PR2	Activities (number) of funders to promote RRI
	Outcome	GO2_OU1	For each of these networks (PR1.) number of RRI debates
		GO2_OU2	For each of these networks (PR1.) number of RRI protocols
		GO2_OU3	For each of these networks (PR1.) number of RRI policies
		GO2_OU4	For each of these networks (PR1.) of RRI agreements
		GO2_OU5	Number of funding mechanisms to support RRI activities
		GO2_OU6	Number of euros invested in RRI projects
	Perception	GO3_PE1	Involvement of the wider public in RRI debates, measured for example through social media
		GO3_PE2	Involvement of the wider public in RRI policy, the development of policy, protocols, agreements
		GO3_PE3	Number of references in applications to RRI
		GO3_PE4	Number of collaborative RRI projects
Public engagement/Policies, regulations, and frameworks	Process	PE_PRF1_PR1	Formal commitment
	Outcome	PE_PRF2_OU1	Public engagement funding percentage from R&I
		PE_PRF2_OU2	Public influence on research agendas
		PE_PRF2_OU3	Share of public engagement in R & I projects based on consultation, deliberation or collaboration
	Perception	PE_PRF3_PE1	Public expectations of involvement
		PE_PRF3_PE2	Researcher's openness to pursue PE
		PE_PRF3_PE3	Interest of publics

Public engagement—Event and initiative making; attention creation	Process	PE_EV1_PR1	Science events and cycles
		PE_EV1_PR2	Referenda and Danish-model activities. Organised debates
		PE_EV1_PR3	Museums/Science centers informal settings
		PE_EV1_PR4	Citizen science initiatives
		PE_EV1_PR5	Crowd funded science and technology development
	Outcome	PE_EV2_OU1	Media coverage
		PE_EV2_OU2	Social media/web 2.0 attention
		PE_EV2_OU3	Museum visits and impacts (on visitors, stakeholders, local communities)
		PE_EV2_OU4	Civil society organization activities and impacts
	Perception	PE_EV3_PE1	Engagement activities (ladder)
		PE_EV3_PE2	Interest in science
		PE_EV3_PE3	Issue discrimination
		PE_EV3_PE4	Image of an atmosphere of science culture
Public engagement/Competence building	Process	PE_CB1_PR1	Training of communicators
		PE_CB1_PR2	Training of scientists/engineers
		PE_CB1_PR3	Mediators
		PE_CB1_PR4	Grass roots
	Outcome	PE_CB2_OU1	PR staffing
		PE_CB2_OU2	Social Scientists collaboration
		PE_CB2_OU3	In house/outsourced consultancies
		PE_CB2_OU4	The state of science journalism
	Perception	PE_CB3_PE1	Knowledge beliefs
		PE_CB3_PE2	Trust, confidence
		PE_CB3_PE3	Attitudes (utilitarian expectations, fundamental orientations)
Gender equality	Process	GE1_PR1	% of Member State funding programmes explicitly including gender requirements
		GE1_PR2	% of research institutions (including universities) that (a) have gender equality plans and (b) provide documentation of their implementation

		GE1_PR2.1	% of research institutions that document specific actions that minimize/reduce barriers in work environment that disadvantage one sex (e.g., flexibility of working hours)
		GE1_PR2.2	% of research institutions that document specific actions aiming to change aspects of their organizational culture that reinforce gender bias
		GE1_PR3	% of research institutions that provide training/support for researchers in regard to the inclusion of gender dimensions in the content of research
		GE1_PR4	% of schools (primary and secondary) that have programmes promoting gender equality issues in regard to career choices
	Outcome	GE2_OU1	% of women in advisory committees
		GE2_OU2	% of women in expert groups
		GE2_OU3	% of women in proposal evaluation panels
		GE2_OU4	% of women in projects throughout the whole life cycle (in full-time equivalent)
		GE2_OU5	% of women that are principal investigators on a project
		GE2_OU6	% of women that are first authors on research papers
		GE2_OU7	% of research projects including gender analysis/gender dimensions in the content of the research
		GE2_OU8	% of women taking part in research mobility programmes
	Perception	GE3_PE1	Perception of gender roles in science amongst young people and their parents, e.g., percentage of young people who believe that science careers are equally suitable for both women and men; percentage of parents who believe their children (daughters) will have equal opportunities to pursue a career in STEM
		GE3_PE2	Perception of people working in the area of R&I in regard to gender equality, e.g., percentage of women in R & I, who believe they have equal opportunities to pursue their careers in R & D in comparison to men
Science education	Process	SE1_PR1	The inclusion of an initiative or requirement for RRI-related training in a research strategy/call/work programme, etc.) (yes/no; %)
		SE1_PR2	Capacity building for RRI-related training (existence; % of funds allocated)
	Outcome	SE2_OU1	Presence of RRI descriptors in the qualification frameworks for lower and higher education (EU and national level)
		SE2_OU2	Presence of RRI education/training (education institution/research disciplines)
		SE2_OU3	Presence of encouragement of RRI education/training by R & D projects (e.g., in an integrated ELSA model)
		SE2_OU4	Percentage of research projects with at least one educational resource delivered

		SE2_OU5	Percentage of research projects involving STEM teachers or students
		SE2_OU6	Number of projects registered in the Scientix collaboration
Open access/Open science	Process	OSA1_PR1	Documentation of open science policies
		OSA1_PR2	Documentation of institutional mechanisms for promoting open science
		OSA1_PR3	Documentation of mechanisms for learning from open science experience
		OSA1_PR4	Inclusion of open science measures in research policies and calls for proposals
	Outcome	OSA2_OU1	Percentage of research projects with a virtual environment that is updated and actively used with a threshold frequency (to be defined)
		OSA2_OU2	Percentage of data repositories that include explanation and commentary to facilitate use
		OSA2_OU3	Percentage of research projects with daily laboratory notebooks online
		OSA2_OU4	Percentage of research projects that report real added value by an open science mechanism (for themselves and/or other actors)
	Perception	OSA3_PE1	The extent to which members of the public have visited such environments and found them useful
Ethics	Process	ETH1_PR1	Mechanisms for multi-stakeholder/transdisciplinary processes of appraisal of ethical acceptability (best practices)
		ETH1_PR2	Documented ELSI/ELSA project component for ethical acceptability (best practices)
		ETH1_PR3	Documentation regarding normative tensions related to research integrity policies and actions
		ETH1_PR4	Formal and actual scope of ethics review/IRB clearance
	Outcome	ETH2_OU1	Documented change in R & I priorities attributable to appraisal of ethical acceptability
		ETH2_OU2	Percentage of research proposals for which ethics review/IRB clearance process requires substantive changes in grant application or second ethics assessment

F. Capítulo 4. Normalized Geometric Means and reduced set of indicators per areas

This annex presents the complete list of indicators ordered by the weights obtained. It also includes the reduced sets of indicators for each area resulting from the application of the criteria presented in Section 3: "Best in class", "50% NGM", "50% indicators", and "NGM higher than the difference between the highest and the lowest NGM". The final table in this annex shows the total number of indicators that would be selected after the applying the before-mentioned criteria.

Table 47 *Normalized Geometric Mean and reduced sets of indicators in the area "Governance"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "NGM Higher Than the Difference between the Highest and the Lowest NGM"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						26.79
GO1_PR1	63.40	X	X	X	X	
GO1_PR2	36.60					
Category: Outcome						15.93
GO2_OU3	25.95	X	X	X	X	
GO2_OU6	18.89		X	X	X	
GO2_OU5	17.58		X	X	X	
GO2_OU2	15.83					
GO2_OU4	11.74					
GO2_OU1	10.02					
Category: Perception						10.15
GO3_PE4	30.12	X	X	X	X	
GO3_PE2	29.25		X	X	X	
GO3_PE3	20.66				X	
GO3_PE1	19.97					
Total indicators selected in the reduced sets in the area		**3**	**6**	**6**	**7**	

Table 48 *Normalized Geometric Mean and reduced sets of indicators in the area "Public Engagement", sub-area "Policy, Regulations, and Framework"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						
PE_PRF1_PR1		X	X	X	X	
Category: Outcome						
PE_PRF2_OU2	59.44	X	X	X	X	41.01
PE_PRF2_OU1	22.13			X	X	
PE_PRF2_OU3	18.43					
Category: Perception						
PE_PRF3_PE2	66.22	X	X	X	X	51.58
PE_PRF3_PE3	19.14			X	X	
PE_PRF3_PE1	14.64					
Total indicators selected in the reduced sets in the area		3	3	5	5	

Table 49 *Normalized Geometric Mean and reduced sets of indicators in the area "Public Engagement", sub-area "Event and initiative making/attention"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						40.59
PE_EV1_PR2	46.35	X	X	X	X	
PE_EV1_PR4	25.90		X	X		
PE_EV1_PR3	15.21			X		
PE_EV1_PR1	6.76					
PE_EV1_PR5	5.76					
Category: Outcome						21.47
PE_EV2_OU1	34.54	X	X	X	X	
PE_EV2_OU3	31.27		X	X	X	
PE_EV2_OU4	21.13					
PE_EV2_OU2	13.07					
Category: Perception						26.22
PE_EV3_PE1	36.70	X	X	X	X	
PE_EV3_PE4	28.26		X	X	X	
PE_EV3_PE2	24.57					
PE_EV3_PE3	10.47					
Total indicators selected in the reduced sets in the area		3	6	7	5	

Table 50 *Normalized Geometric Mean and reduced sets of indicators in the area "Public engagement", sub-area "Capacity building"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						23.37
PE_CB1_PR1	38.11	X	X	X	X	
PE_CB1_PR2	23.58		X	X	X	
PE_CB1_PR4	23.58				X	
PE_CB1_PR3	14.74					
Category: Outcome						27.29
PE_CB2_OU2	38.31	X	X	X	X	
PE_CB2_OU3	27.18		X	X		
PE_CB2_OU4	23.50					
PE_CB2_OU1	11.01					
Category: Perception						56.44
PE_CB3_PE3	67.72	X	X	X	X	
PE_CB3_PE2	21.00			X		
PE_CB3_PE1	11.28					
Total indicators selected in the reduced sets in the area		3	5	6	5	

Table 51 *Normalized Geometric Mean and reduced sets of indicators in the area "Gender"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process (first hierarchical level)						34.84
GE1_PR2	39.48	X	X	X	X	
GE1_PR1	33.56		X	X		
GE1_PR3	22.32					
GE1_PR4	4.64					
Category: Process (second hierarchical level)						
GE1_PR2.2	75.00	X	X	X	X	
GE1_PR2.1	25.00	X	X	X	X	
Category: Outcome						17.34
GE2_OU6	23.11	X	X	X	X	
GE2_OU5	21.56		X	X	X	
GE2_OU7	15.04		X	X		
GE2_OU2	11.06			X		
GE2_OU3	9.06					
GE2_OU1	7.81					
GE2_OU8	6.59					
GE2_OU4	5.77					
Category: Perception						64.17
GE3_PE2	82.09	X	X	X	X	
GE3_PE1	17.91					
Total indicators selected in the reduced sets in the area		5	8	9	6	

Table 52 *Normalized Geometric Mean and reduced sets of indicators in the area "Science education"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						58.96
SE1_PR2	79.48	X	X	X	X	
SE1_PR1	20.52					
Category: Outcome						20.66
SE2_OU5	25.77	X	X	X	X	
SE2_OU2	20.84		X	X	X	
SE2_OU3	19.79		X	X		
SE2_OU4	19.97					
SE2_OU1	8.52					
SE2_OU6	5.11					
Total indicators selected in the reduced sets in the area		2	4	4	3	

Table 53 *Normalized Geometric Mean and reduced sets of indicators in the area "Open Science/Open access"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						52.95
OSA1_PR4	59.25	X	X	X	X	
OSA1_PR3	20.93			X		
OSA1_PR2	13.51					
OSA1_PR1	6.31					
Category: Outcome						
OSA2_OU4	67.29	X	X	X	X	61.79
OSA2_OU2	20.14			X		
OSA2_OU3	7.08					
OSA2_OU1	5.50					
Category: Perception						
OSA3_PE1		X	X	X	X	
Total indicators selected in the reduced sets in the area		3	3	5	3	

Table 54 *Normalized Geometric Mean and reduced sets of indicators in the area "Ethics"*

Code of the Indicator	Normalized Geometric Mean	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"	Difference between the Highest and Lowest Normalized Geometric Mean
Category: Process						34.61
ETH1_PR1	40.62	X	X	X	X	
ETH1_PR2	36.91		X	X	X	
ETH1_PR3	16.46					
ETH1_PR	6.01					
Category: Outcome						58.96
ETH2_OU1	79.48	X	X	X	X	
ETH2_OU2	20.52					
Total indicators selected in the reduced sets in the area		2	3	3	3	

Table 55 *Total indicators selected for all the areas in the reduced sets*

	Reduced Set of Indicators "Best in Class"	Reduced Set of Indicators "50% NGM"	Reduced Set of Indicators "50% Indicators"	Reduced Set of Indicators "Higher Than the Difference between the Highest and the Lowest Normalized Geometric Mean"
Total indicators selected in the reduced sets for all the areas	24	38	45	37

G. Capítulo 5. Indicators of the GRI Environmental Standards G4–300 series

Table 56 *Indicators of the GRI Environmental Standards G4–300 series*

Environmental Topic	Indicators
GRI 301: Materials	301-1 Materials used by weight or volume 301-2 Recycled input materials used 301-3 Reclaimed products and their packaging materials
GRI 302: Energy	302-1 Energy consumption within the organization 302-2 Energy consumption outside of the organization 302-3 Energy intensity 302-4 Reduction of energy consumption 302-5 Reductions in energy requirements of products and services
GRI 303: Water and Effluents	303-1 Interactions with water as a shared resource 303-2 Management of water discharge-related impacts 303-3 Water withdrawal 303-4 Water discharge 303-5 Water consumption
GRI 304: Biodiversity	304-1 Operational sites owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas 304-2 Significant impacts of activities, products, and services on biodiversity 304-3 Habitats protected or restored 304-4 IUCN Red List species and national conservation list species with habitats in areas affected by operations
GRI 305: Emissions	305-1 Direct (Scope 1) GHG emissions 305-2 Energy indirect (Scope 2) GHG emissions 305-3 Other indirect (Scope 3) GHG emissions 305-4 GHG emissions intensity 305-5 Reduction of GHG emissions 305-6 Emissions of ozone-depleting substances (ODS) 305-7 Nitrogen oxides (NOX), sulfur oxides (SOX), and other significant air emissions
GRI 306: Effluents and Waste	306-1 Water discharge by quality and destination 306-2 Waste by type and disposal method 306-3 Significant spills 306-4 Transport of hazardous waste 306-5 Water bodies affected by water discharges and/or runoff
GRI 307: Environmental Compliance	307-1 Non-compliance with environmental laws and regulations
GRI 308: Supplier Environmental Assessment	308-1 New suppliers that were screened using environmental criteria 308-2 Negative environmental impacts in the supply chain and actions taken

H. Capítulo 5. Description of the elements by levels

Table 57 *Description of the elements of the first level*

Elements of First Level and Code	Description
Flows from the biosphere (E1)	This element includes the elements related to the extraction of existing resources in the biosphere: raw materials, energy, and water mainly. These extracted resources alter the composition of the biosphere and its ecosystem equilibria and limit their availability for future generations.
Flows to the biosphere (E2)	This element groups the substances that are released into the biosphere, altering their composition and their eco-systemic equilibria.
Environmental management (E3)	This element groups the elements of reflexivity on what the research team can do in relation to the protection of the environment.
Biodiversity (E4)	This element addresses those elements related to reflexivity on how the research, or the product of it, can directly impact the species in danger of extinction, or their habitats.

Table 58 *Description of the elements of the second level*

Element of First Level	Element of Second Level	Description
Flows from the biosphere (E1) [1]	Materials (E1.1)	This element groups everything related to the different materials that will be consumed, renewable, non-renewable, etc.
	Water (E1.2)	This element includes both the extraction of the different types of water throughout the R & D & I project and the life cycle of the products derived from the research, as well as the consequences that these extractions have on water sources.
	Energy (E1.3)	This element addresses the extraction of energy resources, that is, the consumption of primary energy by sources, for the entire project and the life cycle of the research products
Flows to the biosphere (E2) [2]	Emissions (E2.1)	This element groups everything related to the different gaseous emissions of substances that will be produced during the R & D & I project and during the life cycle of the product resulting from the investigation.
	Wastewater (E2.2)	This element groups the liquid discharges with polluting load that will be carried out during the project and during the life of the product of the investigation.
	Solid waste (E2.3)	This element groups the solid waste with environmental impact for the entire project and the life cycle of the research products.
Environmental management (E3) [3]	Certification (E3.1)	This element addresses all the activities that the research team can carry out aimed at verifying and, where appropriate, certifying that the actions, the suppliers of goods and services, the facilities and equipment, the products of the research, etc. comply with environmental requirements. Requirements that are normally more demanding than legislation, although not always
	Training (E3.2)	This element addresses the team's activities aimed at improving awareness and competence in the protection of the environment during the project and during the life of the product developed. It refers to the awareness and competence of researchers and directly related stakeholders: research partners, suppliers, beneficiaries, funders, etc.

Eco-design (E3.3)	This element addresses the activities aimed at changing the design of research and research products so that environmental impacts are reduced throughout their life cycle.

[1] The experts who selected the elements of reflexivity specified that the research or innovation team should assume the possible responsibility for these energy consumptions with a perspective of the life cycle of the project and its possible product. Also, direct and indirect consumption should be considered. That relative consumption should be estimated, by a functional unit of the project and the product, in contrast with an absolute estimate of total numbers. "Functional unit", according to the definition of the UNE-EN ISO 14040: 2006 standard, refers to the "Quantified performance of the product system for use as a reference unit" and "Product", according to the same norm, refers to tangible objects, but also to research services in an R&I project.

[2] It has been decided to separate the waste that is generated in a waste discharge that is generated in solid state. Although all should be managed properly, in reality there are leaks and bad practices, and it has been considered that it is not the same when this happens with a solid or semi-solid waste, compared to a totally liquid one. Regardless of the origin of the waste and in what medium that residue ends.

[3] These three elements have strong connections with each other but should be considered as isolated. It is a forced independence, but not impossible. We want to evaluate what is considered to be the most influential in the environmental responsibility of the research team, for ICT projects. In addition, the experts agreed that the research teams should study how some actions or others contribute to their environmental responsibility from the point of view of the direct impact on the research and its product, but without taking into account indirect effects.

Table 59 *Description of the elements of the third level*

Elements of Second Level	Elements of Third Level	Description
Materials (E1.1) [1]	Renewable materials (E1.1.1)	This element refers to all the materials that the biosphere renews on a time scale compared to the human scale. Basically, they are the primary organic materials (not cultivated) such as wood, fish, guano and other natural fertilizers, etc. that would be used during the research project and during the life cycle of the research product
	Non-renewable and scarce materials (E1.1.2)	This element refers to the consumption of different scarce materials that the biosphere may never renew or will employ a time scale much greater than the human scale. Minerals such as Coltan, Titanium, etc. are included. But fossil fuels are not included, they go in the element E1.3.
	Rest of non-renewable materials (E1.1.3)	This element refers to the consumption of different materials that, like Silicon, Lithium, Iron or others, are very abundant at present, but as they are not renewable, their availability decreases, apart from the impact that their extraction has on habitats
Water (E1.2)	Extraction of water from sources (E1.2.1)	This element addresses all the water extractions that are carried out during the project and the life of the product. Likewise, the experts who selected the elements of reflexivity specified that the team should assume the possible responsibility for this water consumption with a perspective of the life cycle of the project and its possible product. Also, that direct and indirect consumption should be included, and that relative consumption should be estimated, by the functional unit of the project and the product, in contrast to an absolute estimate of total numbers.
	Affected sources of water (E1.2.2)	This element addresses all water sources that have reduced their contribution, or worsened their quality, or suffered any other environmental impact. The experts who selected this element specified that the team reflected on the number of directly affected sources, and the intensity of the effect, per functional unit, with a life cycle perspective of the project and its possible outcome.
Emissions (E2.1)	Green-house gases–GHG (E2.1.1)	This element addresses all the greenhouse gas emissions that are made during the project and the life of the product. For example, methane, carbon dioxide, dinitrogen monoxide, etc. The experts indicated that the team should assume the possible responsibility for these direct and indirect emissions, with a perspective of the life cycle and functional unit of project and product of the project.
	Ozone-depleting substances–ODS (E2.1.2)	This element addresses all gaseous emissions of substances that attack stratospheric ozone: CFCs, HCFCs, etc. They already occur directly or indirectly, by the functional unit, and with a perspective of the life cycle of the project and its possible product.
	Other emissions (E2.1.3)	This element addresses the gaseous emissions of other polluting substances that are directly, but not indirectly, emitted per functional unit during the life cycle of the project and its possible product. They include, for example, solid particles in suspension, volatile organic compounds, sulfur oxides, etc.
Wastewater (E2.2)	Hazardous liquid waste (E2.2.1)	This element includes all those that can be given in the liquid form and which, due to their composition and origin, are classified as hazardous according to the European Waste List. The experts indicated that the team should assume the possible responsibility for these direct and indirect discharges, with a perspective of the life cycle and functional unit of project and product of the investigation.
	Non-hazardous liquid waste (E2.2.2)	This element includes all those not included in the European List, which occur directly, but not indirectly, by the functional unit, and with a perspective of the life cycle of the project and its possible product.

Solid waste (E2.3)	Hazardous solid waste (E2.3.1)	This element includes all those that may occur in solid or semi-solid state and that, due to their composition and origin, are classified as hazardous according to the European Waste List. The experts indicated that the team should assume the possible responsibility for these direct residues, but not indirect ones, with a perspective of the life cycle and functional unit of project and product of the investigation.
	Non-hazardous solid waste (E2.3.2)	This element includes all those not included in the European List, which occur directly, but not indirectly, by the functional unit, and with a perspective of the life cycle of the project and its possible product.

[1] The element E1.1. "Materials" can be divided into three elements of the third level. It is important to highlight that the experts who selected the elements of reflexivity specified that the team should assume the possible responsibility for these material consumptions with a perspective of the life cycle of the project and its possible product. Also that direct and indirect consumption should be included, and that relative consumption should be estimated, by functional unit of the project and the product, in contrast to an absolute estimate of total numbers.

I. Capítulo 6. Cuestionario para la priorización de indicadores de ética de Investigación e Innovación Responsable

CUESTIONARIO PARA LA PRIORIZACIÓN DE INDICADORES DE ÉTICA DE INVESTIGACIÓN E INNOVACIÓN RESPONSABLE

Proyecto INPERRI: propuesta de indicadores para impulsar el diseño de una política orientada al desarrollo de investigación e innovación responsable en España (CSO2016-76828-R)

INTRODUCCIÓN

El objetivo de este cuestionario es la **obtención de un peso o importancia** para cada indicador relacionado con la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

Estos indicadores son el resultado del análisis de las propuestas trabajadas conjuntamente en la sesión participativa presencial celebrada el 11 de abril de 2019 en el Instituto INGENIO CSIC-UPV.

HOJA DE INSTRUCCIONES

Lea detenidamente estas instrucciones antes de completar el cuestionario.

En primera sección se incluye en primer lugar el listado de indicadores resultantes del análisis de las propuestas de la sesión participativa del 11 de abril de 2019 así como una estructura jerárquica de los mismos.

En la segunda sección, se incluye el cuestionario para la priorización de los grupos de indicadores e indicadores de la jerarquía incluida en la primera sección.

Siguiendo el método de las jerarquías analíticas, AHP, en el cual los elementos a comparar se representan mediante un árbol jerárquico, se han de realizar comparaciones pareadas entre indicadores y grupos de indicadores teniendo en cuenta su nivel de contribución al nivel superior al cual están ligado. Este proceso de comparación conduce a una escala de medida relativa de prioridades o pesos de los elementos cuya suma total es la unidad.

Los elementos han de ir comparándose dos a dos preguntándose cómo de importante es el indicador I_A frente al indicador I_B, utilizando la siguiente escala, donde R_{AB} es la respuesta dada por Ud a la pregunta.

	EX	MF	F	MO	=	MO	F	MF	EX	
Indicador I_A	9	7	5	3	1	3	5	7	9	Indicador I_B

- R_{AB} = 1: se considera **igualmente importante** el indicador A que el indicador B (=)
- R_{AB}= 3: se considera **moderadamente más importante** el indicador A que el indicador B (**MO**)
- R_{AB} = 5: se considera **bastante más importante** el indicador A que el indicador B (**F. Fuerte**)
- R_{AB} = 7: se considera **mucho más importante** (o demostrablemente más importante) el indicador A que el indicador B (**MF. Muy Fuerte**)
- R_{AB} = 9: se considera **absolutamente más importante** el criterio A que el criterio B (**EX. Extremo**)

Si por ejemplo se le pregunta:

Desde su punto de vista, qué GRUPO DE INDICADORES es más importante y en qué grado para **MONITORIZAR Y VALORAR LA RELEVANCIA SOCIAL Y ACEPTABILIDAD ÉTICA DE LOS RESULTADOS DE LA CIENCIA E INNOVACIÓN** en España

Y Ud. responde:

	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	X	1	3	5	7	9	Participación de grupos de interés

Para Ud. esto significa que el grupo de indicadores sobre la colaboración entre áreas de conocimiento es moderadamente más importante que el grupo de indicadores sobre la participación de grupos de interés.

En el caso de que un elemento o indicador presente sub-indicadores se le preguntará asimismo sobre la importancia de dichos SUB-INDICADORES en relación con el indicador al cual estén ligados.

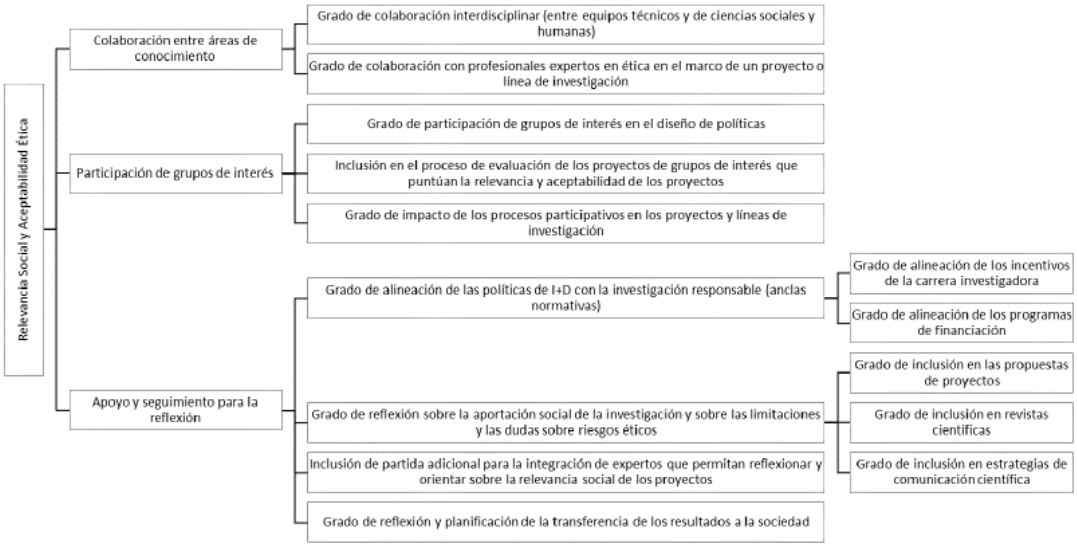
Se estima un tiempo para contestar el cuestionario de unos 30 minutos. El cuestionario puede rellenarlo:

- ✓ a mano indicando con una X sus respuestas y devolverlo luego escaneado
- ✓ en el propio documento Word marcando igualmente la respuesta elegida como Ud. prefiera

Muchas gracias por su tiempo y dedicación.

Sección 1: Listado de indicadores y modelo jerárquico

Categoría	Código y nombre del Indicador	Nota sobre el indicador
Colaboración entre áreas de conocimiento	Grado de colaboración interdisciplinar (entre equipos técnicos y de ciencias sociales y humanas)	
	Grado de colaboración con profesionales expertos en ética en el marco de un proyecto o línea de investigación	
Participación de los grupos de interés	Grado de participación de grupos de interés en el diseño de políticas	Este indicador se refiere al diseño de las agendas de investigación.
	Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúen la relevancia y aceptabilidad de los proyectos	Este indicador se refiere a la fase de evaluación de proyectos. Estos grupos de interés, que podrían ser no académicos, puntuarían la relevancia y aceptabilidad del proyecto.
	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación	Este indicador se refiere a las fases de ejecución de desarrollo de proyectos y líneas de investigación y analiza los ajustes y modificaciones llevadas a cabo como consecuencia de los procesos participativos realizados.
Seguimiento y apoyo para la reflexión sobre la relevancia social y aceptabilidad ética	Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	Se entienden por anclas normativas los objetivos políticos y acuerdos internacionales tales como los ODS, declaraciones de DDHH, Estrategias supranacionales sobre justicia social y sostenibilidad medioambiental, etc.
	Grado de alineación de los incentivos de la carrera investigadora con las anclas normativas	
	Grado de alineación de los programas de financiación con las anclas normativas	
	Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos (aceptabilidad ética)	
	Grado de inclusión en las propuestas de proyectos	
	Grado de inclusión en revistas científicas	
	Grado de inclusión en estrategias de comunicación científica	Este indicador indicaría la amplitud, calidad y diversidad de estrategias de comunicación utilizadas por la unidad de medida para difundir responsablemente los resultados de la investigación.
	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	
	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad	Este indicador incluiría elementos sobre la reflexión sobre la relevancia social y aceptabilidad ética en los procedimientos y procesos de transferencia y las estrategias para la reducción de tiempo de aplicación de los resultados de la investigación.



1	Igual (=)
3	Moderado (MO)
5	Fuerte (F)
7	Muy fuerte (MF)
9	Extremo (EX)

Sección 2: Cuestionario

2.1. Cuestionario de priorización de conjunto de indicadores (1er nivel)

Desde su punto de vista, qué GRUPO DE INDICADORES es más importante y en qué grado para **MONITORIZAR Y VALORAR LA RELEVANCIA SOCIAL Y ACEPTABILIDAD ÉTICA DE LOS RESULTADOS DE LA CIENCIA E INNOVACIÓN** en España.

	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	5	7	9	Participación de grupos de interés
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	5	7	9	Apoyo y seguimiento para la reflexión
Participación de grupos de interés	9	7	5	3	1	3	5	7	9	Apoyo y seguimiento para la reflexión

2.2. Cuestionarios de priorización de indicadores (2º nivel)

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar el grado de **COLABORACIÓN ENTRE ÁREAS DE CONOCIMIENTO** para contribuir a incrementar la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de colaboración interdisciplinar (entre equipos técnicos y de ciencias sociales y humanas	9	7	5	3	1	3	5	7	9	Grado de colaboración con profesionales expertos en ética en el marco de un proyecto o línea de investigación

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar la **PARTICIPACIÓN DE LOS GRUPOS DE INTERÉS** para contribuir a incrementar de la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	3	1	3	5	7	9	Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	3	1	3	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	9	7	5	3	1	3	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación

1	Igual (=)
3	Moderado (MO)
5	Fuerte (F)
7	Muy fuerte (MF)
9	Extremo (EX)

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar el **APOYO Y SEGUIMIENTO PARA LA REFLEXIÓN SOBRE LA RELEVANCIA Y ACEPTABILIDAD** para contribuir a incrementar la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	3	1	3	5	7	9	Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	3	1	3	5	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	3	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	3	5	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	9	7	5	3	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad

2.3. Cuestionarios de priorización de indicadores (3er nivel)

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar el **GRADO DE ALINEACIÓN DE LAS POLTÍCIAS DE CIENCIA E INNOVACIÓN CON LA INNOVACIÓN RESPONSABLE (ANCLAS NORMATIVAS)** en España.

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de alineación de los incentivos de la carrera investigadora	9	7	5	3	1	3	5	7	9	Grado de alineación de los programas de financiación

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar el **GRADO DE REFLEXIÓN SOBRE LA APORTACIÓN SOCILA DE LA INVESTIGACIÓN Y SOBRE LAS LIMITACIONES Y LAS DUDAS SOBRE RIESGOS ÉTICOS.**

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de inclusión en las propuestas de proyectos	9	7	5	3	1	3	5	7	9	Grado de inclusión en revistas científicas
Grado de inclusión en las propuestas de proyectos	9	7	5	3	1	3	5	7	9	Grado de inclusión en estrategias de comunicación científica
Grado de inclusión en revistas científica	9	7	5	3	1	3	5	7	9	Grado de inclusión en estrategias de comunicación científica

J. Capítulo 6. Informe de revisión de inconsistencias sobre el cuestionario para la priorización de indicadores de ética de investigación e innovación responsable

REVISIÓN DE INCONSISTENCIAS SOBRE EL CUESTIONARIO PARA LA PRIORIZACIÓN DE INDICADORES DE ÉTICA DE INVESTIGACIÓN E INNOVACIÓN RESPONSABLE

Proyecto INPERRI: propuesta de indicadores para impulsar el diseño de una política orientada al desarrollo de investigación e innovación responsable en España (CSO2016-76828-R)

¿Qué es una inconsistencia en la técnica AHP? Un ejemplo

La ratio inconsistencia mide el nivel de inconsistencia que se considera aceptable en la comparación de un cierto número de elementos cuando se aplica la metodología AHP. Esta ratio, mide que haya suficiente consistencia como para mantener la cohesión entre los objetos que comparamos, sin ser necesario que la consistencia sea perfecta.

Pongamos por ejemplo la comparación de la intensidad de color de tres círculos. Ante la pregunta ***"Desde su punto de vista, ¿qué círculo tiene un color más intenso en qué grado?"***, veamos ejemplos de respuestas "aceptables" por el método AHP por no superar la ratio de inconsistencia y un ejemplo de respuesta ***"***no aceptable" por superar la ratio de inconsistencia utilizada en la técnica y que, por tanto, debe ser revisada.

<u>Respuestas aceptables</u> por tener una ratio de inconsistencia reducido (ordenadas de más consistentes a menos)

	EX	MF	F	MO	=	MO	F	MF	EX	
A	9	7	5	**3**	1	3	5	7	9	B
A	9	**7**	5	3	1	3	5	7	9	C
B	9	7	5	**3**	1	3	5	7	9	C

	EX	MF	F	MO	=	MO	F	MF	EX	
A	9	7	**5**	3	1	3	5	7	9	B
A	**9**	7	5	3	1	3	5	7	9	C
B	9	7	5	**3**	1	3	5	7	9	C

<u>Respuesta no aceptable</u> por tener una ratio de inconsistencia alto

	EX	MF	F	MO	=	MO	F	MF	EX	
A	9	**7**	5	3	1	3	5	7	9	B
A	9	7	**5**	3	1	3	5	7	9	C
B	9	7	**5**	3	1	3	5	7	9	C

La respuesta B es inconsistente porque habiendose valorado la intensidad del círculo A respecto a B de “Muy fuertemente” y del círculo A respecto al C de “Fuertemente” intensa, el grado de intensidad esperado de B respecto a C debaría ser practicamente igual. De hecho, la respuesta menos inconsistente sería darle una puntuación de 1 o un punto intermedio entre el 1 y el 3 rojo.

Habiendo visto este ejemplo, incluimos a continuación una reflexión sobre los grupos de preguntas que usted contestó y que tienen un grado de inconsistencia superior al permitido por la técnica AHP. El objetivo es comprobar si usted quiere mantener el juicio que realizó (en cuyo caso le pediremos que trate de justificarlo) o si identifica que hay alguna alternativa de las que le presentamos que refleja mejor su opinión (en cuyo caso le pediremos que nos indique cual es).

Inconsistencias en el cuestionario y posibles alternativas

Tras el análisis de las inconsistencias en el cuestionario sobre indicadores de ética, hemos identificado algunos grupos de preguntas inconsistentes y por ello queremos pedirle que revise su respuesta. Así para cada grupo le presentamos:

1. La pregunta que se le hizo, la respuesta que nos dio y el porcentaje de importancia resultante de la comparación.
2. Las posibles alternativas para que identifique si alguna refleja mejor su opinión junto con el porcentaje de importancia resultante de cada opción.

Primer grupo de comparaciones

Pregunta y respuesta inicial

Desde su punto de vista, qué GRUPO DE INDICADORES es más importante y en qué grado para **MONITORIZAR Y VALORAR LA RELEVANCIA SOCIAL Y ACEPTABILIDAD ÉTICA DE LOS RESULTADOS DE LA CIENCIA E INNOVACIÓN** en España.

Respuesta inicial	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	**X**	7	9	Participación de grupos de interés
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	5	**X**	9	Apoyo y seguimiento para la reflexión
Participación de grupos de interés	9	7	5	3	1	**X**	5	7	9	Apoyo y seguimiento para la reflexión

Indicador	% de importancia
Colaboración entre áreas de conocimiento	7,2%
Participación de grupos de interés	27,9%
Apoyo y seguimiento para la reflexión	64,9%

A continuación, se presentan varias opciones que resolverían la inconsistencia (cambios marcados en amarillo):

Opción A:

	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	3	1	**4**	5	7	9	Participación de grupos de interés
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	5	**X**	9	Apoyo y seguimiento para la reflexión
Participación de grupos de interés	9	7	5	3	1	**X**	5	7	9	Apoyo y seguimiento para la reflexión

Indicador	% de importancia
Colaboración entre áreas de conocimiento	7,8%
Participación de grupos de interés	26,3%
Apoyo y seguimiento para la reflexión	65,9%

Opción B:

	EX	MF	F	MO	=	MO	F	MF	EX	
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	**X**	7	9	Participación de grupos de interés
Colaboración entre áreas de conocimiento	9	7	5	3	1	3	5	**X**	9	Apoyo y seguimiento para la reflexión
Participación de grupos de interés	9	7	5	3	1	**2**	5	7	9	Apoyo y seguimiento para la reflexión

Indicador	% de importancia
Colaboración entre áreas de conocimiento	7,5%
Participación de grupos de interés	33,3%
Apoyo y seguimiento para la reflexión	59,2%

Por favor, revise la explicación de la inconsistencia y confirme si quiere cambiar su juicio a alguna de las alternativas propuestas o si desea mantener su juicio inconsistente, en cuyo caso, justifique el motivo. Marque la opción preferida:

☐ **Opción A**
☐ **Opción B**
☐ **Querría que me presentaseis más opciones de posibilidades consistentes**
☐ **Respuesta inicial. Por favor, justifique por qué quiere mantener la respuesta inicial**

Segundo grupo de comparaciones

Pregunta y respuesta inicial

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar la **PARTICIPACIÓN DE LOS GRUPOS DE INTERÉS** para contribuir a incrementar de la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

Respuesta inicial (inconsistente)

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	**X**	1	**3**	5	7	9	Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos
Grado de participación de grupos de interés en el diseño de políticas	9	7	**X**	3	1	**3**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	9	7	5	3	1	**X**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación

Indicador	% de importancia
Grado de participación de grupos de interés en el diseño de políticas	65%
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	12,7%
Grado de impacto de los procesos participativos en los proyectos y líneas de investigación	22,3%

A continuación, se presentan varias opciones que resolverían la inconsistencia (cambios marcados en amarillo):

Opción A: mantener las comparaciones de "Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos"

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	**X**	1	**3**	5	7	9	Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	3	**X**	**3**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	9	7	5	3	1	**X**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación

Indicador	% de importancia
Grado de participación de grupos de interés en el diseño de políticas	43%
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	14%
Grado de impacto de los procesos participativos en los proyectos y líneas de investigación	43%

Opción B: mantener las comparaciones de "Grado de participación de grupos de interés en el diseño de políticas"

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de participación de grupos de interés en el diseño de políticas	9	7	5	**X**	1	**3**	5	7	9	Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos
Grado de participación de grupos de interés en el diseño de políticas	9	7	**X**	3	1	**3**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	9	7	5	3	**X**	**3**	5	7	9	Grado de impacto de los procesos participativos en los proyectos y líneas de investigación

Indicador	% de importancia
Grado de participación de grupos de interés en el diseño de políticas	65,9%
Inclusión en el proceso de evaluación de los proyectos de grupos de interés que puntúan la relevancia y aceptabilidad de los proyectos	18,5%
Grado de impacto de los procesos participativos en los proyectos y líneas de investigación	15,6%

Por favor, revise la explicación de la inconsistencia y confirme si quiere cambiar su juicio a alguna de las alternativas propuestas o si desea mantener su juicio inconsistente, en cuyo caso, justifique el motivo. Marque la opción preferida:

☐ **Opción A**

☐ **Opción B**

☐ **Querría que me presentaseis más opciones de posibilidades consistentes**

☐ **Respuesta inicial. Por favor, justifique por qué quiere mantener la respuesta inicial**

Tercer grupo de comparaciones

Pregunta y respuesta inicial

Desde su punto de vista, qué INDICADOR es más importante y en qué grado para monitorizar y valorar el **APOYO Y SEGUIMIENTO PARA LA REFLEXIÓN SOBRE LA RELEVANCIA Y ACEPTABILIDAD** para contribuir a incrementar la relevancia social y aceptabilidad ética de los resultados de la ciencia e innovación en España.

Respuesta inicial (inconsistente)

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	**X**	1	3	5	7	9	Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	**X**	3	1	3	5	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	**X**	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	3	**X**	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	**X**	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	9	7	5	**X**	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad

Indicador	% de importancia
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	53,3%
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	7,7%
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	25,2%
Grado de reflexión y planificación de la transferencia de los resultados a la sociedad	13,8%

Opción A:

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	X	1	3	5	7	9	Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	3	X	3	5	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	X	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	3	X	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	X	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	9	7	5	X	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad

Porcentaje de importancia resultante - Indicador	% de importancia
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	36%
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	8%
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	40%
Grado de reflexión y planificación de la transferencia de los resultados a la sociedad	16%

Opción B:

	EX	MF	F	MO	=	MO	F	MF	EX	
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	X	3	1	3	5	7	9	Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	X	1	3	5	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	9	7	5	X	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	3	X	7	9	Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	9	7	5	3	1	X	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	9	7	5	X	1	3	5	7	9	Grado de reflexión y planificación de la transferencia de los resultados a la sociedad

Porcentaje de importancia resultante - Indicador	% de importancia
Grado de alineación de las políticas de I+D con la investigación responsable (anclas normativas)	50,5%
Grado de reflexión sobre la aportación social de la investigación y sobre las limitaciones y las dudas sobre riesgos éticos	6,4%
Inclusión de partida adicional para la integración de expertos que permitan reflexionar y orientar sobre la relevancia social de los proyectos	28,7%
Grado de reflexión y planificación de la transferencia de los resultados a la sociedad	14,4%

Por favor, revise la explicación de la inconsistencia y confirme si quiere cambiar su juicio a alguna de las alternativas propuestas o si desea mantener su juicio inconsistente, en cuyo caso, justifique el motivo. Marque la opción preferida:

☐ **Opción A**

☐ **Opción B**

☐ **Querría que me presentaseis más opciones de posibilidades consistentes**

☐ **Respuesta inicial. Por favor, justifique por qué quiere mantener la respuesta inicial**

Una reflexión final

En caso de que quieras comentar alguna percepción sobre la metodología utilizada o compartir las dificultades que has encontrado al completar los cuestionarios, te agradeceríamos que la incluyeses aquí para poder analizarla como parte del trabajo de investigación.

¡Muchas gracias por tu colaboración!

K. Capítulo 6. Aspectos relevantes identificados para las categorías "integridad de la investigación y buenas prácticas" and "ética de la investigación para la protección del objeto de investigación"

Integridad de la investigación y buenas prácticas

1. Objetivo de la investigación y su aportación. Únicamente satisface una curiosidad personal o aporta algo.
2. Necesidad de una evaluación por pares más transparente y global
    a. ANECA: quien te ha evaluado y de qué en el grupo
    b. Tesis doctorales: el tribunal se podría incluir en la portada.
3. Replanteamiento del anonimato en la evaluación por pares
4. Opacidad sobre qué es prioritario y por qué
5. Conflicto de intereses:
    a. Declaración
    b. Gestión del conflicto. Damos por sentado los económicos pero los ideológicos y sentimentales
    c. Sistemas de incentivos no alienados.
6. Plagio y replicabilidad.
7. Las gafas de la inclusión en el investigador: tratar de garantizar desde el principio aspectos inclusivos.
8. Códigos de conducta para ser más transparentes en diferentes fases de la carrera investigadora (tesis, acceso a plazas)
9. Publicaciones y cómo se fabrican datos que no fueron exactamente como se cuenta pero permiten confirmar la hipótesis → alta presión por publicar, su futuro y vida profesional depende de dichas publicaciones → gran competitividad y estrés. → inclusión de autores en artículos porque, aunque no hayan contribuido.
10. Burocratización en los procesos: asignación de proyectos, justificación.
11. Cuidado de los investigadores. No desconexión y respuesta a la alta competencia mediante la dedicación excesiva fuera de horario laboral.
12. Alineación de objetivos entre cómo se valora a los investigadores (docencia e investigación) y la investigación responsable.
13. Uso de indicadores: riesgo fomentar vs medir.
14. Indicadores cuantitativos y cualitativos. En ANECA: los cualitativos incluyen seguridad, su desventaja: la injusticia de no poder considerar todos los supuestos. Para abordarlo, se establecieron también indicadores cualitativos.
15. Sexenio de transferencia de conocimiento: modo de integrar conocimientos
16. Indicadores (RSC y experiencia con sus indicadores): procedimentar a través de indicadores vs principios. RSC sobre regulada con un exceso de indicadores.
17. Mayor presencia en el debate sobre malas prácticas
18. Evaluación de la ejecución del gasto en las partidas
19. Formación de investigadores: inclusión de buenas prácticas. // Precaución con el riesgo de formar y que posteriormente la institución no responda
20. Conciencia institucional que se refleje en códigos y que cambie la cultura organizacional → Formación en etapas tempranas de la carrera investigadora (ej. Estudiantes de master que desconocen cómo se cita, qué es plagio, etc.).
21. Impunidad de las malas prácticas, hay un rechazo social mínimo → necesidad de mayor concienciación social sobre el método científico.
22. Periodismo científico y de calidad.

Ética de la investigación para la protección al objeto de investigación	
Aspectos relacionados con el consentimiento y la protección al objeto	1. Importancia del consentimiento informado especialmente con grupos que requieren especial sensibilidad. Proceso para asegurarse de que el consentimiento es realmente informado. 2. Protección de información sensible y revisar qué se entiende por sensible. 3. Extender la cultura sobre la protección, considerando: a. La molestia generada b. Qué metodologías están legitimadas c. Qué pasa cuando discrepamos éticamente cuando en un comité se discrepa sobre la adecuación de una metodología. Se exige un sí o no pero no una justificación/reflexión sobre ella. 4. Falta de cultura en los equipos de investigación (salvo en ciertas áreas como medicina) sobre esta protección del objeto de investigación. 5. Seguimiento de la legislación existente y definir qué flexos existen. a. Sensibilización real (especialmente de CCSS y Humanidades). Posibles vías como exigencia por parte de las revistas. b. Se cubre el requerimiento, pero no sabemos si se ha hecho bien. Comprensión de riesgos, beneficios, etc. para asegurar la autonomía. Preguntar también a los que presentan las hojas de consentimiento, cómo será el proceso para asegurar la comprensión. c. Criterios para reducción de daños, etc. (experimentación animal) d. Sensibilidad sobre los consentimientos. Anonimización. 6. Burocratización. Establecer mecanismos para agilizar. 7. Medidas correctoras cuando hay casos detectados de falta de ética. 8. Necesidad de formación 9. Auditorías sobre el impacto social y no exclusivamente económica.
Aspectos relacionados con los Comités de ética	1. Cómo se eligen / conflicto de intereses. 2. Qué experiencia tienen y si es la mejor. A veces su experiencia impide que sean plenamente conscientes de lo que está en juego. 3. No deberían ser simplemente reactivos sino realizar también acciones proactivas. Necesitarían incrementar su capacidad para poder hacerlo. 4. Falta de orientación y recomendación, deliberar. 5. Seguimiento y feed-back. No hay trazabilidad sobre lo que pasa después. 6. La exigencia jurídica puede haber burocratizado su funcionamiento. 7. Integración del comité en la cultura. Sólo cubre la parte de investigación, dejando la docencia, vida universitaria, agente del cambio, etc. Cuelgan del vacío. 8. Se aprueban los procedimientos, pero no se revisa quien y que capacidades tienes quienes ejecutan el proceso.

L. Capítulo 6. Hierarchy structure of indicators for the categories “research integrity and good research practice”, “research ethics of the protection of the objects of research”, and “ethics’ training”

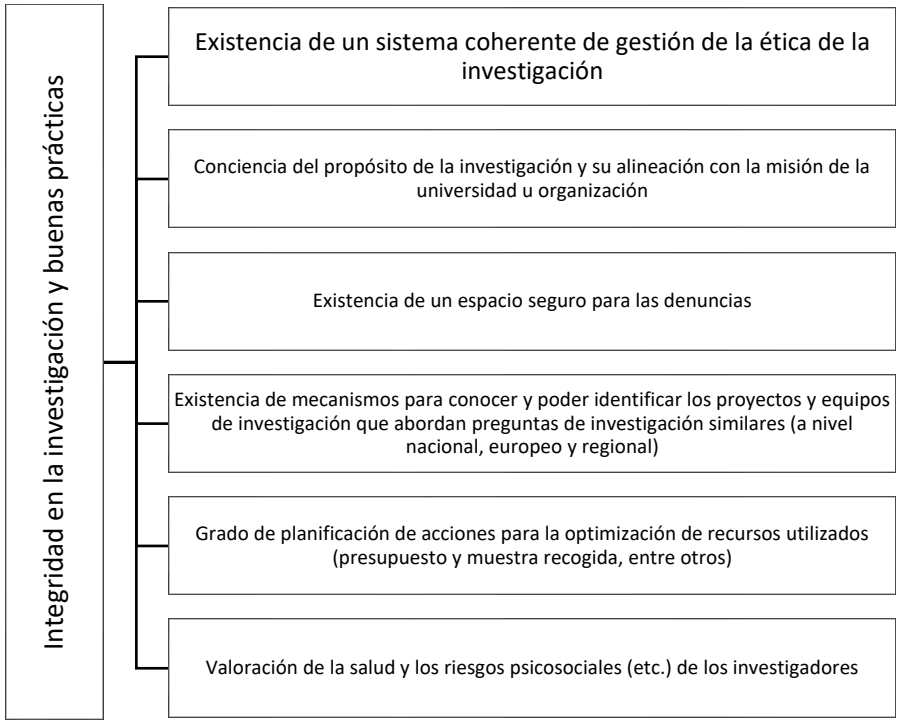


Figura 27 *Estructura jerárquica para la categoría “integridad en la investigación y buenas prácticas”*

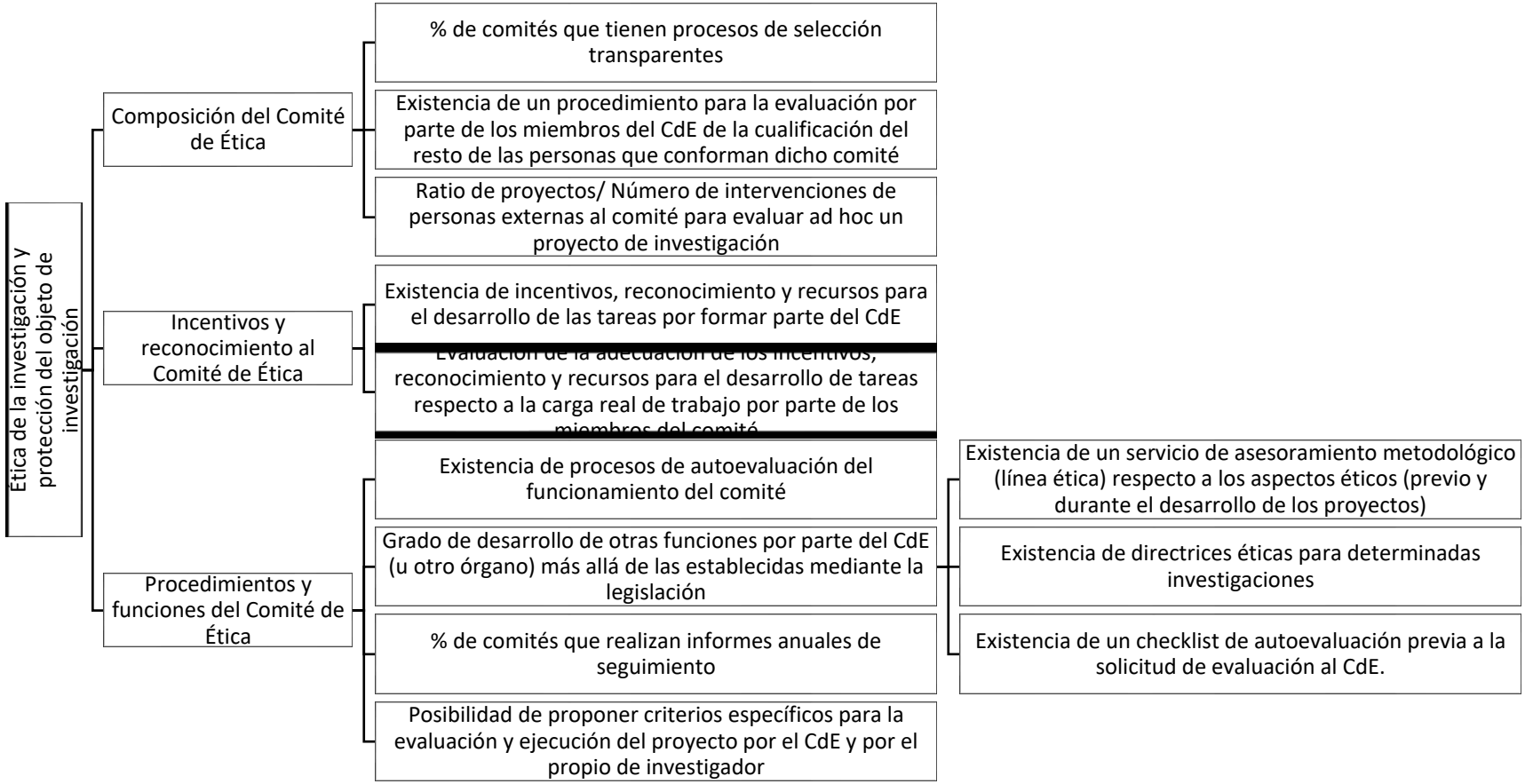


Figura 28 *Estructura jerárquica para la categoría "ética de la investigación y protección del objeto de investigación"*

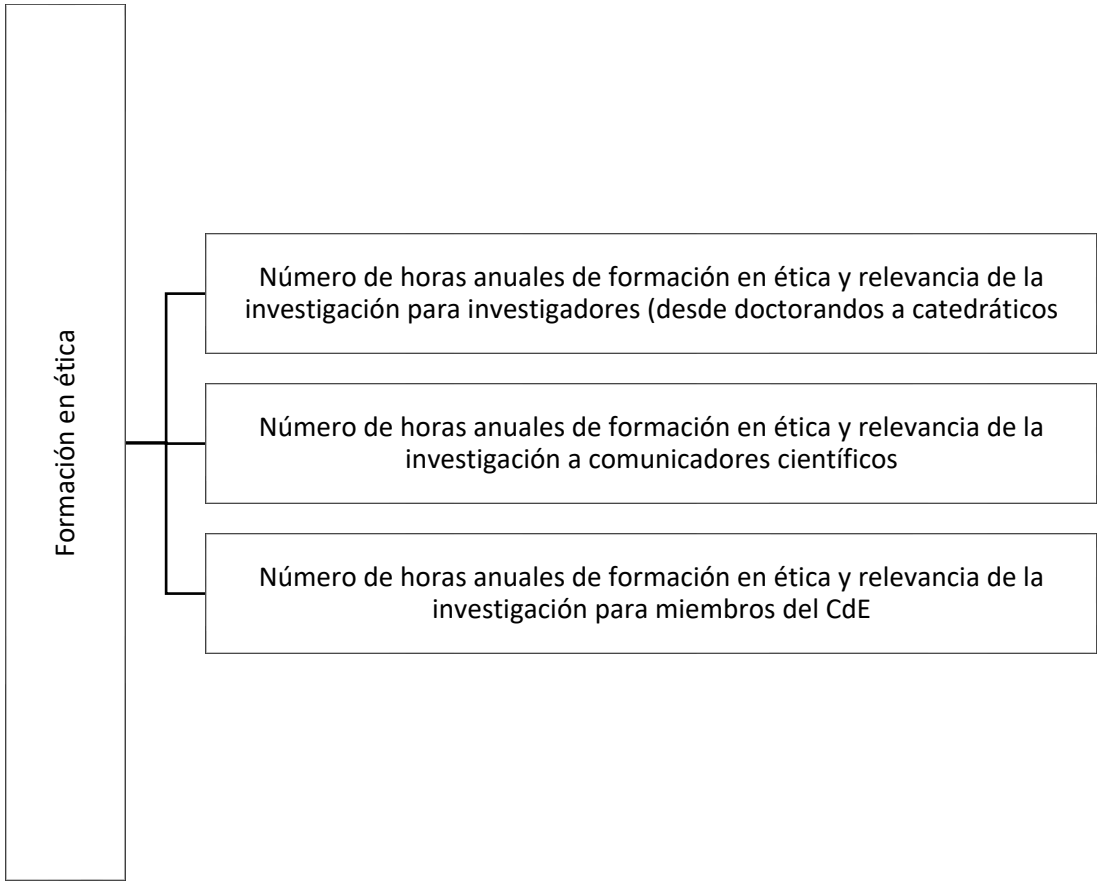


Figura 29 *Estructura jerárquica para la categoría "formación en ética"*

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