NANO2ALL

SOCIETAL ENGAGEMENT ON RESPONSIBLE NANOTECHNOLOGY

D4.1 NANO2ALL ROADMAP

THE NANO2ALL PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME, UNDER THE GRANT AGREEMENT NUMBER 685931.
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Changes with respect to the DoA

N/A

Dissemination and uptake

The report is primarily aimed at European Union (EU) and national decision-makers in the EU Member States competent in areas of science and technology with a focus on nanotechnology development (where relevant).

Short Summary of results (<250 words)

Deliverable 4.1 draws on the findings of the NANO2ALL project and outlines recommended trajectories and actions that should be undertaken by EU and national decision-makers in order to foster RRI (and in particular societal engagement) in nanotechnology research and innovation (R&I).

Evidence of accomplishment

Report

Contents

1. Purpose of the document

This report, the NANO2ALL Roadmap, was developed as part of the NANO2ALL (Nanotechnology Mutual Learning Action Plan for Transparent and Responsible Understanding of Science and Technology) project, which has received funding from the European Union (EU) Horizon 2020 programme, under the Grant Agreement number 685931. The NANO2ALL Roadmap represents Deliverable 4.1 of Work Package 4 (WP4) – NANO2ALL Roadmap[1]. WP4 aims to disseminate the outcomes of previous NANO2ALL activities to a wider circle of EU and national nanotech policy arena members. The specific purpose of this dissemination is to enable a systemic commitment of policymakers and relevant communities (researchers, industry and others) at national and EU level towards responsible research and innovation (RRI) in nanotechnology development and create sustainable working groups as Joint Stakeholder Undertakings to progress with RRI in this field of research and innovation (R&I). In line with these goals, the roadmap aims to transfer the results of previous NANO2ALL activities, in particular from the mapping and the various participatory actions (explained further below). The roadmap addresses primarily EU and national decision-makers in the EU Member States competent in areas of science and technology (with a focus on nanotechnology development where such decision-makers exist) and outlines trajectories and actions that should be undertaken by these actors in order to foster RRI (and in particular societal engagement) in nanotechnology R&I (see more explanation on RRI in chapter 4).

The roadmap is structured as follows:

1. **Purpose of the document**: provides information in short about the roadmap and its structure.
2. **Methodology used to develop the roadmap**: explains the methodology used to elaborate the roadmap document, highlighting the origin of its conclusions and recommended trajectories and actions.
3. **Roadmap in short**: briefly summarises the main findings and includes the recommended trajectories and actions in their full extension.
4. **Contextualisation of the roadmap**: presents the context relevant for societal engagement into nanotechnology R&I and includes general findings from the NANO2ALL activities in this regard. In particular, it presents a brief state-of-the-art, existing needs, as well as the conditions necessary to be in place to further increase societal engagement into nanotechnology R&I.
5. **Recommended way forward**: further details the referred conditions and outlines recommended trajectories and actions required for increased societal engagement and the responsiveness of the nanotechnology R&I ecosystem towards societal needs, values and expectations.

[1] The Roadmap is officially referred as NANO2TRUST Roadmap within the grant agreement in line with the former acronym of the NANO2ALL initiative. For the sake of resemblance to the current project acronym, NANO2ALL is used within the name of the roadmap.

2. Methodology used to develop the roadmap

The roadmap presented in this document is based on the outcomes of several previous NANO2ALL activities as presented in Figure 1.

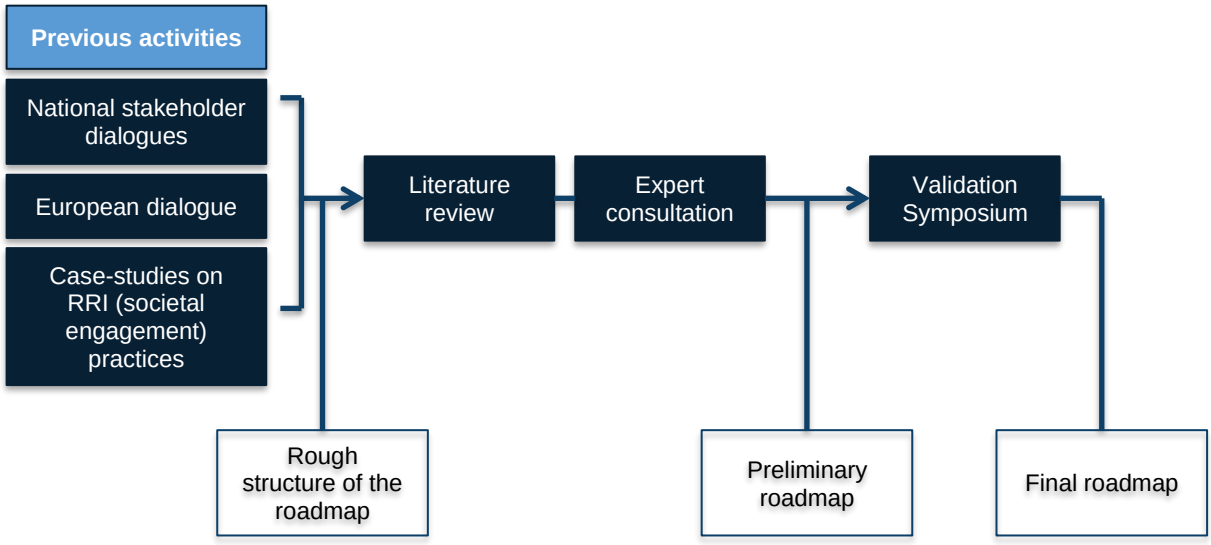

Figure 1 – Methodology used to develop the roadmap

The outcomes of three prior activities in the NANO2ALL project served as the starting point for the roadmap development:

1. **National stakeholder dialogues**: between October (2017) and February (2018), NANO2ALL organized multi-stakeholder dialogues in six countries (France, Israel, Italy, Poland, Spain, Sweden). In these dialogues, participants discussed how societal perspectives can be better identified through interactions between societal actors and integrated in nanotechnology R&I processes. Each dialogue specifically focused on one of the following three nanotechnology application fields: medicine, textile and brain-computer interfaces.
2. **European dialogue:** in April (2018), NANO2ALL organized a multi-stakeholder dialogue at European level in Brussels revolving around the concept of responsiveness. Participants discussed what would be needed to make the nanotechnology R&I ecosystem more responsive to societal perspectives.
3. **Case studies on practices of societal engagement:** throughout the NANO2ALL project, several case studies have been developed on societal engagement practices in nanotechnology development[2]. This resulted in several reports that describe the major learning lessons that can be extracted from these cases.

[2] More information: http://www.nano2all.eu/engaging-society-in-nanotechnology-development-practices/

The outcomes of these three activities were analysed with a particular focus on what was said in relation to *societal engagement* (in contrast to, for instance, remarks on required safety related measures[3]). In the analysis, the data was clustered, which resulted in a rough overall structure for the roadmap. This structure outlined three broad recommendation categories to expedite the uptake of RRI approaches – with a specific focus on societal engagement – in (nanotechnology) research, development and innovation (see chapter 5). To further flesh out the roadmap, relevant literature was reviewed, and several experts were consulted. At a final event (validation symposium) in March 2019, expert feedback was collected and integrated in the final roadmap document.

3. Roadmap in short

Over the past decades, awareness has grown that the impact of technologies is not always predictable, and unintended or unforeseeable consequences might occur. This unpredictability is inherent in the increasing complexity of new and emerging technologies (including nanotechnology) and their development processes. Inclusive approaches implemented under the terms of RRI can enable the identification and integration of inputs from stakeholders and the public into R&I decision-making contributing to the development of socially acceptable and desirable research and products.

Inclusive and other RRI approaches were introduced early on in nanotechnology development in Europe and NANO2ALL as an initiative was promoted within this process. NANO2ALL addressed RRI / societal engagement in responsible nanotechnology development as a topic, and at the same time it applied societal engagement as an approach through its dialogue activities. NANO2ALL´s roadmap integrates findings from its previous activities (especially from dialogues and mapping tasks) and outlines specific actions to better align nanotechnology development with societal values, needs and expectations through increased societal engagement into nanotechnology R&I. The roadmap actions address primarily EU and national decision-makers competent in areas of science and technology with a focus on nanotechnology development (where this exists) but are also relevant for several other groups (researchers, industry, civil society, consumers of nano-enabled technologies and others).

NANO2ALL´s activities (including dialogues and case-studies) verified that there is a deeply-felt need for inclusiveness and integration of societal perspectives in the nanotechnology R&I ecosystem. Inclusive approaches (societal engagement) have been implemented over the past 15 – 20 years in Europe to inform and enrich nanotechnology R&I. However, this has been mainly done at the EU level and in specific EU countries, and thus have not reached a full array of societal actors from different national, regional and local contexts in the EU. Further, these initiatives often did not establish continuous interactions or trust-building between societal actors. There is, therefore, a need to set up

[3] Although safety related measures and regulations are key in accomplishing responsible approaches in nano-related areas of R&I, recommendations on required safety measures move beyond the scope of this project, as they do not allow identifying in what ways societal engagement can be enhanced in nanotechnology R&I.

frameworks for continuous interactions for the EU and Member States (including regional and local levels) levels with mechanisms to ensure that these feed directly into nanotechnology R&I decision-making across value chains. There is also an expressed need to extrapolate lessons learned from the wide range of societal engagement initiatives that have been carried out in previous years to inform such future frameworks (that should preferably build on existing ones) for continuous societal engagement and RRI processes of other new and emerging technologies. The role of independent intermediaries (for instance science centres, professional moderators and science communicators) in the facilitation of interactions regarding responsible nanotechnology development should be reinforced.

NANO2ALL's analysis showed that frameworks for continuous societal engagement alone will not be enough to fully achieve the desired change. A comprehensive change is only possible if other conditions are simultaneously in place. These conditions relate mainly to the participatory culture of our society in science and society matters and the openness of the R&I ecosystem towards societal perspectives. There is a need for stimulating an open and inquisitive attitude among learners of all ages and equip citizens with the state-of-the-art, potential benefits and risks of nano- and other new and emerging technologies to motivate and enable their participation in scientific matters. This requires interventions of different dimensions, starting from changes in the European education systems and the promotion of informal, lifelong learning opportunities, to fostering more impactful science communication initiatives.

On the other hand, the increased openness and responsiveness of the R&I ecosystem is also necessary for bridging the gap between science and society. NANO2ALL found that creating genuine interest and motivation for RRI, rather than enforcement by top-down regulation, especially as regards the private sector, is a preferred way to enable change. While, there is a need for increasing the awareness and capacity of researchers and technologists to engage with society, long-term measures that can incentivise and reward RRI practices, including structural and institutional adjustments, are also required.

The recommended trajectories and actions are included in Table 1. These are grouped under the main conditions (referred above) that have to be in place to enable true change. These are:

1. Frameworks for systematised societal engagement in nanotechnology R&I
2. Lifelong participatory culture in science and society matters
3. Open research and innovation ecosystem towards societal perspectives

For the sake of completeness, instead of a summary, Table 1 fully reflects the recommended trajectories and actions as presented in Chapter 5. This chapter also provides additional information on the rationale of recommended trajectories and actions.

Table 1 – Recommended trajectories and actions

Condition 1: Frameworks for systemised societal engagement in nanotechnology R&I

Trajectory 1. Evaluate past societal engagement activities in research and innovation in nanotechnology
Action 1.1 The European Commission supported by the Member States should commission an evaluation study (including impact assessment) of the societal engagement activities conducted in the past years in Europe and elsewhere at all stages of the nanotechnology R&I cycle - including policy-design, research agenda setting, research steering, R&I processes[4]
Action 1.2 The European Commission and the Member States should use knowledge from such an evaluation to elaborate a plan for the future promotion of societal engagement in nanotechnology development. This should identify and select existing frameworks or create new ones, and conceive mechanisms for implementing inclusive processes and their link / feed-into nanotechnology R&I decision-making at all stages in a systematic way. Knowledge from the evaluation should also inform processes in other emerging technology fields
Trajectory 2. Adapt existing frameworks (or create new ones where not existing) to increase the involvement of all actors, including citizens and their representatives in research and innovation decision-making at all stages
Action 2.1 Decision-makers at EU and Member States levels should mandate and finance selected EU level and national platforms to undertake systematic and continuous discussion and trust-building between societal actors – in a coordinated way between EU and national levels – informing EU and national nanotechnology policies and research and innovation agendas
Action 2.2 Decision-makers at EU and Member States levels should adapt current public consultations for setting R&I priorities (covering nanotechnology and new and emerging technology fields) in a way that can allow the increased participation of citizens, through challenge-led forms of engagement / engagement starting from citizens´ life experiences, and using appropriate methodology to reach and involve citizens
Action 2.3 Decision-makers at EU and Member States levels should adapt existing EU, national and regional research and innovation funding programmes to foster societal engagement in actual nanotechnology R&I processes (and of other new and emerging technologies) where such activities are linked with or build on each other
Action 2.4 Decision-makers at EU and Member States levels should set up advisory services to support the implementation of societal engagement in nanotechnology R&I (and of other new and emerging technologies), including the identification of the most suitable approaches for interactions, considering the aims and available resources, as well as the moderation of such participatory activities

[4] Four levels of the research system where societal engagement is necessary, as recommended by the H2020 Advisory Group for Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing in its publication on the *Outreach to newcomers and societal engagement in industrial technologies*, 2018. Available for download at: https://publications.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/5be04f7f-ff55-11e8-a96d-01aa75ed71a1

Condition 2: Lifelong participatory culture in science and society matters

Trajectory 1. Promote capacity-building and reflections on nano- and other new and emerging technologies via the formal education system
Action 1.1 The European Commission and Ministries of Education in the Member States should implement funding programmes for open nanoscience and nanotechnology (and other new and emerging technology) collaborative projects – bringing schools in contact with universities and other stakeholders (similar to Nan-O-Style[5]). A bottom-up and inter-disciplinary approach should be promoted to allow different perspectives and the maximisation of entry points into the official curricula
Action 1.2 Decision-makers at EU and Member States levels should promote the uptake, translation, adaptation – as well as the maintenance of existing and the development of new (where necessary) nano- and other emerging technology related teaching materials **– b**y European, national and regional platforms offering lifelong learning to teachers and marketplaces of educational materials
Action 1.3 The European Commission, relevant national ministries and regional authorities should ensure that publicly and privately funded R&I platforms equipped to engage with public audiences provide a fast track framework for interaction between teachers and researchers to allow information and knowledge provision. Examples of potential platforms include the EU NanoSafety Cluster and the NANOfutures Working Group on Societal Engagement.
Trajectory 2. Promote scientific culture and critical thinking on nano- and other new and emerging technologies among citizens via lifelong learning and science communication
Action 2.1 The European Commission and relevant national ministries should fund (including through a dedicated strand for science and society matters in Horizon Europe) informal lifelong learning programmes that increase the knowledge, skills, values and attitudes necessary for scientific citizenship, targeting defined audiences (for example considering age, ethnicity and economic disadvantages) in ways that recognise their unique needs. Creating a bi-directional loop of information in the everyday life of citizens and civil society should trigger the willingness and acceptance of people to learn more through inclusiveness, experimental courses and lifelong learning programmes. This could be complemented by interdisciplinary funding schemes supporting citizen-science projects. Lifelong learning programmes and funding schemes should be embedded into a unique standardised procedure to avoid fragmentation and risk of failure.
Action 2.2 The European Commission should develop a clear set of criteria (performance indicators and guidelines) on the quality of science communication activities, which can facilitate scientists and science communicators in designing communication activities and enable research funders to screen proposals and help determine the allocation of funds. EU-level funding frameworks could set the example and provide a blueprint for national policy-makers and research funders. Science communicators or non-academic stakeholders should be involved in peer-reviewing the scientific communication component of research proposals. Newly-created or existing regional, national and EU innovation ecosystems and Science Communication Offices should also use these guidelines to provide tailored advice to researchers.

[5] www.bionanonet.at/news/latest-news/723-project-nano-o-style

Condition 3: Open research and innovation ecosystem towards societal perspectives

Trajectory 1. Foster RRI awareness and competence within the nanotechnology R&I community and incentivise the adoption of RRI by relevant institutions at regional, national and EU levels
Action 1.1 Decision-makers at EU and Member States levels should develop a long-term plan for the promotion of awareness-raising and capacity building to members of the R&I community with regard to RRI principles and practices. Dedicated training programmes should be coupled with structural changes to the education system resulting in the alignment of academic programmes with RRI goals. In addition, innovation ecosystems such as the European Institute of Innovation and Technology, Joint Technology Initiatives and the European Innovation Council should act as multipliers to foster engagement and provide evidence that RRI can be beneficial to industry.
Action 1.2 National and regional authorities should induce structural and institutional changes within research organisations, including the adaptation of the evaluation frameworks of these entities and researchers to RRI goals (such as consideration of public engagement criteria for professional advancement and awards), the involvement of societal engagement specialists in research projects and the institutionalisation of new profiles – such as a Responsible Research and Innovation Manager. This will enable RRI dimensions to become mainstream, and allow research players to recognise them as an important responsibility and value within their work. The elaboration of targets and key performance indicators (KPIs), as well as specific incentives, can facilitate the implementation of this process.
Action 1.3 Decision-makers at EU and Member States levels should develop and continuously update EU and national level measures in order to incentivise the implementation of RRI. This should build as much as possible on existing frameworks (for instance Corporate Social Responsibility in industry) and reward schemes that can be broaden by RRI aspects. A brief “RRI checklist” for companies (particularly start-ups) can encourage them to follow RRI principles. Moreover, the identification of RRI KPIs could facilitate the creation of a certification scheme with an “RRI label” and a ranking system for the most RRI-compliant companies, along with awards, prizes and incentives. This could encourage bottom-up and organic RRI practices while fostering a truly entrepreneurial RRI discovery process.

4. Contextualisation of the roadmap

What is RRI and why is it important?

RRI is a term that has gained considerable ground in the past decade, particularly in the field of EU policy-making. The general idea behind RRI is that R&I should be sensitive to societal needs and values, and require transparent and deliberative processes in which attention is paid to the collective responsibility of societal actors, researchers and innovators in producing (ethically) acceptable and socially desirable research and products (Burget, Pedone & Pedaste, 2017; Owen, Macnaghten, & Stilgoe, 2012)[6] [7].

Over the past decades, there has been an increasing awareness that **the impact of technologies is not always predictable**, and unintended or unforeseeable consequences might occur. This unpredictability is inherent in the increasing complexity of new and emerging technologies (including nanotechnology) and their development processes; most of the time, unforeseen effects do not result from the action of one particular player, but from the intricate interplay of actions amongst a multitude of players (Stilgoe, Owen & Macnaghten, 2013)[8].

RRI aims to foster a sense of collective responsibility among actors and encourages a reflexive attitude. Actors should deliberate on the purpose of technologies and in what way technologies contribute to addressing societal challenges. These deliberations should be inclusive, and open to all sorts of input from stakeholders and public. R&I systems need consistent integration of deliberative processes to increase value-sensitivity and to stimulate thought about the right impacts of technologies. Crucial here is that deliberative practices should be tightly linked to policy and decision-making processes to ensure responsive action and change (Stilgoe, Owen, & Macnaghten, 2013)[9].

Learning from the previous failure of implementing other new technologies, for instance following the transgenic seed breeding and GMO foods development, which was stalled by public distrust in the 1990s (Paarlberg, 2014)[10], **RRI approaches were introduced early on in nanotechnology development in Europe**. Similar to the GM food case, there were several controversies around nanotechnology (promised high benefits vs. potential negative impacts of its use, but with no general consensus on these aspects) that could potentially trigger public resistance and eventually the full refusal of this breakthrough technology. Through RRI and the consideration of societal perspectives

[6] Burget, M., Bardone, E., & Pedaste, M. (2017). Definitions and conceptual dimensions of responsible research and innovation: a literature review. *Science and engineering ethics*, *23*(1), 1-19.
[7] Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. *Science and public policy*, *39*(6), 751-760.
[8] Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. Research Policy, 42(9), 1568-1580.
[9] Idem.
[10] Paarlberg, R. A dubious success: The NGO campaign against GMOs (2014). GM Crops Food. 2014 Jul-Sep; 5(3): 223–228.

within nanotechnology R&I (e.g. the approval of the EC´s code of conduct[11]), the smooth market application of nanotechnology was sought.

The responsible development of nanotechnology became visible in a number of ways, including a proactive and anticipatory EU approach to nanotechnology risk governance, and the involvement of key stakeholders (including civil society representatives) in the risk debate at the EU level and in some Member States. Further, among others, the EU invested in a range of initiatives to explore the uncertainty around nanotechnology development, to raise public awareness of the latest nanotech developments, and engage societal actors in a dialogue (for example DEEPEN[12], Nanodialogue[13], NANOOPINION[14], NANODIODE[15]).

NANO2ALL (www.nano2all.eu) has been funded by the EU within this process with the aim of fostering RRI in the EU policy and governance of nanotechnologies. In particular, NANO2ALL aimed to drive the discussions on the conditions and actions necessary to enhance inclusiveness / societal engagement in nanotechnology R&I. This is a specific dimension of RRI implying interactions between relevant stakeholders, such as companies, research organizations, policy-makers, civil society organizations, consumers, affected citizens and others, with the aim to align research, development and innovation with the values, expectations and needs of society. In order to do so, NANO2ALL explored the current responsible nanotechnology R&I landscape, identified cases of societal engagement in nanotechnology R&I and organised various participatory activities across Europe (listed in chapter 2), hosting a broad range of actors (e.g. researchers, policy-makers, representatives from business, civil society organizations, engagement experts and the general public).

RRI and societal engagement in NANO2ALL is two-fold:

- RRI/Societal engagement as a topic: in many of the NANO2ALL activities (as referred before), RRI/societal engagement itself functioned as the topic of discussion/exploration.
- RRI/Societal engagement as an approach: the NANO2ALL project aspired to bring the RRI-societal engagement approach into practice itself by involving a wide range of actors, including citizens, in the NANO2ALL activities. By ensuring the participation of policy-makers, researchers, industry and other relevant societal communities in dialogues, it aimed to influence the actual decision-making processes and instil responsive action.

[11] European Commission: 'Commission adopts code of conduct for responsible nano research', February, 2008: https://cordis.europa.eu/news/rcn/29114/en

[12] More information is available at: https://cordis.europa.eu/project/rcn/84695/factsheet/en

[13] More information is available at: https://cordis.europa.eu/project/rcn/74979/factsheet/de

[14] More information is available at: https://cordis.europa.eu/project/rcn/103465/factsheet/en

[15] More information is available at: https://cordis.europa.eu/project/rcn/109051/factsheet/en

A final product of NANO2ALL is this roadmap that integrates findings from the project's activities and outlines specific actions that should be undertaken to increase societal engagement across the nanotechnology R&I value chain.

Do we need to foster societal engagement in nanotechnology R&I?

NANO2ALL´s activities (including dialogues and case-studies) verified that there is a deeply-felt need for inclusiveness and integration of societal perspectives in the nanotechnology R&I ecosystem. The NANO2ALL mapping activities and EU dialogue indicated, though, that a wide range of societal engagement initiatives have already been implemented in the past 15 – 20 years in Europe to inform and enrich nanotechnology R&I. NANO2ALL mapping and the general feedback from the NANO2ALL national dialogues, however, suggest that these initiatives mainly took place at the EU level and in specific EU countries, and thus, may have been **unable to reach a wide array of societal actors** from different national, regional and local contexts in the EU.

At the EU dialogue event it was also referred that these activities often **did not establish continuous interactions** or trust-building between societal actors, resulting in limited interlinkages between such initiatives and the repetition of similar issues during the different interactions. Transparently describing how input of societal actors is used after the engagement initiatives was stressed as being a critical factor in ensuring continuity and trust-building in the interaction process.

In line with the above, many of the issues brought up at the EU dialogue (eg. challenges and obstacles) in connection to the alignment of nanotechnology R&I with societal needs continue to be very similar to those brought up 10 to 15 years ago[16]. Conclusively, this reveals that it has been difficult to overcome certain barriers and structurally implement changes **based on lessons learned** from the wide range of societal engagement initiatives that have been carried out in the past years.

When and who do we need to engage and what should we discuss?

Findings from the NANO2ALL dialogues suggest that societal actors (including non-informed citizens and their representatives) should be involved in the various stages of nanotechnology development across the value chains. Some emphasised, however, that interactions on more technical aspects should be left with scientists and innovators, and thus, the inclusion of societal representatives and their views should be enabled only at certain stages of decision-making. There was **no consensus**, though, on the 'best stages' for engagement. The views on how society should be involved in nanotechnology R&I related issues also differed across the dialogues. These included, among others, the public consultation of citizens, the engagement of civil society to represent societal views, training selected

[16] More information on the existing issues can be found in the materials reporting on the NANO2ALL dialogue results on the following page of the NANO2ALL website: http://www.nano2all.eu/resources/nano2all-dialogue-materials-and-results/

citizens as mediators, and the nomination of trustworthy intermediaries. In addition, although it was not a specific focus of the NANO2ALL dialogues, some of the participants recommended that interactions should be established for tackling diverse topics. The mentioned topics ranged from general societal needs (challenges) to allow priority setting for R&I, nanomaterial safety related issues (eg. standards and labelling), broader ethical and societal impacts that nanotechnology developments may have (e.g. data privacy in nano-enabled brain-computer interfaces), as well as user / consumer feedbacks on nano-enabled products.

From the above non-exhaustive list, it can be observed (as highlighted at the NANO2ALL EU dialogue event) that many issues that instil the need for societal engagement approaches do not merely arise from the development of nanotechnology (e.g. nanomaterial safety matters), but from the ongoing intertwinement between nanotechnology and other fields (i.e. application fields of nanotechnology developments). Therefore, some of the aspects that potentially require the inclusion of societal perspectives (e.g. right to privacy, human dignity or others) with regard to nanotechnology development may be of a more general character (i.e. not necessarily “nano-specific”).

What are the pre-conditions to enhancing societal engagement in nanotechnology R&I?

NANO2ALL’s analysis showed that several conditions have to be in place simultaneously in order to truly enhance societal engagement across nanotechnology R&I value chains. These broad conditions are briefly described below.

It is of note that these conditions are broad system-level pre-requisites and, thus, can also be associated with other domains that belong under the same umbrella term as nanotechnology (for instance new and emerging technologies), or even science and technology in general. Therefore, references to other fields, are often explicitly made within the further description of the roadmap. This allows these conditions and the recommended trajectories and actions deriving from them to be applied to other R&I domains.

- Condition 1. Frameworks for systemised societal engagement in nanotechnology R&I

It is important to ensure the availability of dedicated frameworks (e.g. platforms and mechanisms) at EU and national levels (including regional and local, where relevant) that can facilitate systemised continuous interaction on a long-term basis between societal actors and R&I communities. In particular, NANO2ALL dialogue participants mentioned some concrete examples of possible types of frameworks, such as public citizen consultations for nanotechnology R&I agenda setting, as well as government programmes for continuous interactions and trust-building.

- Condition 2. Lifelong participatory culture in science and society matters

Participants of the NANO2ALL dialogues frequently referred to the participatory culture of the members of our society (and of the representatives of their views) in scientific matters as being a key pre-requisite to increasing societal engagement into nanotechnology R&I. Indeed, these views overlapped across the dialogues. The recommendations made by participants have a wide scope and address the need for engendering an open and inquisitive attitude among learners of all ages. Citizens should be able to gain awareness of the potential impacts of nano and other new and emerging technologies and skills for contributing to the democratic governance of these technologies through education and capacity-building about the state-of-the-art, potential benefits and risks that these technologies can bring to European citizens. Citizens and society must be able to express their lifelong values, needs and concerns regarding science and technology from the outset and to participate in the co-design of policies and R&I which affect their lives. This will ensure that societal actors – including citizens – are willing (interested) and able to engage.

- Condition 3. Open research and innovation ecosystem towards societal perspectives

The increased openness and responsiveness of the R&I ecosystem as a pre-condition for societal engagement was also discussed at the NANO2ALL stakeholder events. The recommendations received suggest that the opening up of the system should be promoted by decision-makers through generating a genuine interest and motivation for RRI, rather than enforcement by top-down regulation. This is especially the case for the private sector. In addition, considering the costs, effort and time necessary to enable change, long-term measures should be considered first and foremost over short-term ones.

The following chapter (Chapter 5) deepens the presented views for each of the three conditions in the form of a rationale, and outlines a set of broader and more specific actions (recommended trajectories and actions) to be undertaken by EU and national decision-makers in the EU Member States to contribute to creating the listed conditions.

5. Recommended way forward

Condition 1. Frameworks for systematised societal engagement in research and innovation in nanotechnology

Rationale

Lessons learned from societal engagement in nanotechnology R&I implemented in past decades in Europe can generate valuable knowledge to define when, how, on what topics and with what purpose societal engagement should be promoted in the future development of nanotechnology.

Accumulated experience from the nanotechnology field can also be useful to adopt and shape inclusive approaches for the implementation of other new and emerging technologies in the future. This calls for the **review and extraction of knowledge from past and ongoing practices** undertaken at the EU level and in European national contexts, with an outlook also towards non-European countries (eg. inclusive approaches developed in the U.S. by the Center for Nanotechnology in Society at Arizona State University or others). Societal engagement cases mapped by NANO2ALL can be used a starting point for such an analysis with an emphasis on practices that constitute successfully running platforms for continuous interaction between societal actors (e.g. NanoTrust[17], an ongoing platform dedicated to health and environmental risks of nanotechnology integrated within the Austrian Academy of Sciences; and NanoRESP[18], a multi-actor dialogue forum in France).

Furthermore, such a review can be important for the identification of existing EU and national (including regional and local) frameworks that can potentially have a role in promoting future systemised and continuous interaction on responsible nanotechnology development and trust-building between societal actors (including citizen representatives). Experts consulted in NANO2ALL underlined the importance of **not creating new frameworks but building on existing ones** to the greatest degree possible. Such frameworks can mean that, for example, relevant European technology platforms, EU and national clusters, national academies of sciences, national and regional nanotechnology fora, dedicated government programmes and initiatives, among others, whose roles and competences can be extended to accommodate the need for increased and continuous interactions and trust-building with dedicated mechanisms, contribute to decision-making on responsible nanotechnology development. Financial compensation of the time and efforts of participants in such frameworks appeared in NANO2ALL findings as one option to facilitate engagement.

Both NANO2ALL dialogues and recommendations of some of the collected societal engagement practices suggested that **independent intermediaries are of key importance** in the facilitation of

[17] More information available at: http://www.nano2all.eu/resources/nano2all-collected-practices-of-engaging-society-in-nanotechnology-development/

[18] Idem

interactions on responsible nanotechnology development. These can be science centres, professional moderators, and science communicators, among others, who can provide a neutral interface between actors and provide expertise in moderation.

Recommended trajectories & actions

Trajectory 1. Evaluate past societal engagement activities in research and innovation in nanotechnology

- Action 1.1 The European Commission supported by the Member States should commission an evaluation study (including impact assessment) of the societal engagement activities conducted in the past years in Europe and elsewhere at all stages of the nanotechnology R&I cycle - including policy-design, research agenda setting, research steering, R&I processes[19]

- Action 1.2 The European Commission and the Member States should use knowledge from such an evaluation to elaborate a plan for the future promotion of societal engagement in nanotechnology development. This should identify and select existing frameworks or create new ones, and conceive mechanisms for implementing inclusive processes and their link / feed-into nanotechnology R&I decision-making at all stages in a systematic way. Knowledge from the evaluation should also inform processes in other emerging technology fields

Trajectory 2. Adapt existing frameworks (or create new ones where not existing) to increase the involvement of all actors, including citizens and their representatives in research and innovation decision-making at all stages

- Action 2.1 Decision-makers at EU and Member States levels should mandate and finance selected EU level and national platforms to undertake systematic and continuous discussion and trust-building between societal actors – in a coordinated way between EU and national levels – informing EU and national nanotechnology policies and research and innovation agendas

- Action 2.2 Decision-makers at EU and Member States levels should adapt current public consultations for setting R&I priorities (covering nanotechnology and new and emerging technology fields) in a way that can allow the increased participation of citizens, through challenge-led forms of engagement / engagement starting from citizens´ life experiences, and using appropriate methodology to reach and involve citizens

- Action 2.3 Decision-makers at EU and Member States levels should adapt existing EU, national and regional research and innovation funding programmes to foster societal engagement in actual

[19] Four levels of the research system where societal engagement is necessary, as recommended by the H2020 Advisory Group for Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing in its publication on the *Outreach to newcomers and societal engagement in industrial technologies*, 2018. Available for download at: https://publications.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/5be04f7f-ff55-11e8-a96d-01aa75ed71a1

nanotechnology R&I processes (and of other new and emerging technologies) where such activities are linked with or build on each other

- Action 2.4 Decision-makers at EU and Member States levels should set up advisory services to support the implementation of societal engagement in nanotechnology R&I (and of other new and emerging technologies), including the identification of the most suitable approaches for interactions, considering the aims and available resources, as well as the moderation of such participatory activities

Condition 2. Lifelong participatory culture in science and society matters

Rationale

A global approach, more awareness and increased visibility of new and emerging technology developments, opportunities and concerns, including those related to nanotechnology, is needed within our society. This will prompt public interest and participation in science and technology matters in these fields. Recommendations from the NANO2ALL dialogues suggest that awareness-raising and the incentivisation of critical thinking should be initiated in the early ages in **formal education environments**. Therefore, the role of schools and educational programmes is critical in promoting this. An analysis performed by NANO2ALL confirms that some national curricula in Europe already embed nanoscience and nanotechnology in secondary education (compulsory or optional activities) (NanoEIS, 2013[20]). There have also been several other approaches to promote science and technology (including nano) in schools. For instance, the ongoing Austrian project Nano-O-Style[21] (funded by the Austrian Federal Ministry of Research) brought together eight schools along with scientists at the University of Salzburg to test the introduction of nanotechnology in schools in a cross-curricular and inter-disciplinary approach. While formal curricula remain the competence of its Member States, the EU carries out actions to support, coordinate or supplement their initiatives at the European level (eg. EU-funded NanoYou[22], NANOChannels[23], NanoEIS[24], or the Scientix platform on Science, Technology, Mathematics and Engineering (STEM)[25] teaching and learning that hosts 26 learning resources on nanotechnology). Further good practices provide teachers with access to researchers to support their acquisition of knowledge about nanotechnology and access to FAIR (Findable, Accessible, Interoperable, Reusable) data (Wilkingson et al, 2016[26]) are further good practices.

The recommendations from the NANO2ALL multi-stakeholder workshops saw a prominent role for science engagement organisations such as science centres and museums (hosts of the dialogues at

[20] NanoEIS, "Report on Secondary school education and its contribution to facilitating transition into university," 2013, http://nanoeis.sbg.ac.at/sites/nanoeis.eu/files/downloads/NanoEIS%20D2%203.pdf.

[21] More information available at: https://www.bionanonet.at/news/latest-news/723-project-nano-o-style

[22] More information available at: https://nanoyou.eu/

[23] More information available at: https://cordis.europa.eu/project/rcn/97562/en

[24] More information available at: https://cordis.europa.eu/project/rcn/105496/brief/en

[25] More information available at: http://www.scientix.eu

[26] Wilkingson, D. M. et al (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Nature*. 15 March 2016 edition.

the national level) in **informal public lifelong learning**, as they hold valuable expertise in engaging broad publics of all ages. Science engagement organisations, together with science journalists, have significant expertise on this matter and could be ideally placed to implement relevant initiatives. Whenever possible, a range of methods of participation should be considered for greater inclusiveness such as scientists´ co-participation into education (i.e; bringing scientists into schools), public engagement and science communication tools such as radio and TV.

Expert interviews conducted to enrich the dialogue findings revealed the **lack of a clear strategy to assess the impact when deciding the allocation of funds for science communication** within R&I programmes, including those on nanotechnology, of which public engagement forms a significant component**.** This results in the wasting of funds and the prioritisation of the means of science communication over their actual impact. Such issues have perpetuated for a while, in part because there is no structure in place to learn from mistakes and prevent or rectify them.

Some steps in the desired direction can nevertheless be noted: the OECD's Working Party on Nanotechnology (in a workshop co-sponsored by the Netherlands Ministry for Education, Culture and Science, the Rathenau Institute, and the OECD), for instance, produced a common definition of public engagement and eight key points for policy-makers to consider as organisers, commissioners or funders of public engagement activities in nanotechnology (OECD 2012[27]). The Netherlands' Rathenau Institute created an 'Assessment Tool for Science Communication'[28] that can be used a standard to assess the quality of science communication activities and projects (with an additional focus on the importance of the dialogic character of science communication activities as opposed to one-way dissemination). For example, Research Councils UK considers economic and societal 'Pathways to Impact'[29] as a mandatory aspect of the secondary assessment criteria for research. Peer-reviewers for this section might be non-academic (e.g. potential users and beneficiaries). In addition, projects should be evaluated more rigorously on the quality of science communication activities. These and other open-access resources can be a good starting point for developing assessment criteria, and commitment on the part of Ministries in charge of research and research funders to their use will be essential.

Recommended trajectories & actions

Trajectory 1. Promote capacity-building and reflections on nano- and other new and emerging technologies via the formal education system

- Action 1.1 The European Commission and Ministries of Education in the Member States should implement funding programmes for open nanoscience and nanotechnology (and other new and emerging technology) collaborative projects – bringing schools in contact with universities and other stakeholders

[27] OECD. "Planning Guide for Public Engagement and Outreach in Nanotechnology." 2012. Available for download from: http://www.oecd.org/sti/emerging-tech/49961768.pdf

[28] More information available at: https://www.rathenau.nl/nl/kennisgedreven-democratie/beoordelingsinstrument-wetenschapscommunicatie

[29] More information available at: https://www.ukri.org/innovation/excellence-with-impact/pathways-to-impact/

(similar to Nan-O-Style[30]). A bottom-up and inter-disciplinary approach should be promoted to allow different perspectives and the maximisation of entry points into the official curricula

- Action 1.2 Decision-makers at EU and Member States levels should promote the uptake, translation, adaptation – as well as the maintenance of existing and the development of new (where necessary) nano- and other emerging technology related teaching materials – by European, national and regional platforms offering lifelong learning to teachers and marketplaces of educational materials
- Action 1.3 The European Commission, relevant national ministries and regional authorities should ensure that publicly and privately funded R&I platforms equipped to engage with public audiences provide a fast track framework for interaction between teachers and researchers to allow information and knowledge provision. Examples of potential platforms include the EU NanoSafety Cluster and the NANOfutures Working Group on Societal Engagement.

Trajectory 2. Promote scientific culture and critical thinking on nano- and other new and emerging technologies among citizens via lifelong learning and science communication

- Action 2.1 The European Commission and relevant national ministries should fund (including through a dedicated strand for science and society matters in Horizon Europe) informal lifelong learning programmes that increase the knowledge, skills, values and attitudes necessary for scientific citizenship, targeting defined audiences (for example considering age, ethnicity and economic disadvantages) in ways that recognise their unique needs. Creating a bi-directional loop of information in the everyday life of citizens and civil society should trigger the willingness and acceptance of people to learn more through inclusiveness, experimental courses and lifelong learning programmes. This could be complemented by interdisciplinary funding schemes supporting citizen-science projects. Lifelong learning programmes and funding schemes should be embedded into a unique standardised procedure to avoid fragmentation and risk of failure.
- Action 2.2 The European Commission should develop a clear set of criteria (performance indicators and guidelines) on the quality of science communication activities, which can facilitate scientists and science communicators in designing communication activities and enable research funders to screen proposals and help determine the allocation of funds. EU-level funding frameworks could set the example and provide a blueprint for national policy-makers and research funders. Science communicators or non-academic stakeholders should be involved in peer-reviewing the scientific communication component of research proposals. Newly-created or existing regional, national and EU innovation ecosystems and Science Communication Offices should also use these guidelines to provide tailored advice to researchers.

[30] www.bionanonet.at/news/latest-news/723-project-nano-o-style

Condition 3. Open research and innovation ecosystem towards societal perspectives

Rationale

Enhancing the R&I community´s willingness and competence to adopt RRI has been part of the EU debate for years (e.g. RRI conference in Rome November 2014 at the EC leading to Rome Declaration[31]). A lack of awareness and knowledge on RRI by the members of the nanotechnology R&I community was also mentioned in the NANO2ALL stakeholder events. **Awareness raising and capacity-building**, therefore, were recommended to broaden perspectives and competence on RRI principles and approaches, including science communication. The concrete benefits of RRI for researchers and companies, such as avoiding a backlash against new technologies, are not currently obvious and should be emphasised so as to create a genuine and lasting interest in the field.

Related to this and as mentioned beforehand, measures that can foster interest and motivation for RRI in the long-term should be preferred to a top-down enforcement type of strategy and instrumentation. These can take the form of different **reward schemes and incentives** applied both to public research providers and industry. Throughout the various NANO2ALL participatory activities and interviews, it was also verified that many research organisation and industry representatives already commit to at least some of the EC RRI policy keys, although they usually do not frame this commitment explicitly under the banner of RRI. For example, many research organisations have long established practices for promoting open access, ethical standards, gender equality, and corporate social responsibility (CSR) items that could now be classified under the umbrella of RRI. A realistic discussion on possible implementation strategies and assessment processes therefore has to investigate and understand not only the RRI keys, as defined by the EC, but also the organisations' own framing of responsibility in R&I (what might be described as 'de facto RRI'), as well as the context of implementation, including cultural, political and institutional dimensions. Therefore, **existing frameworks, as well as existing EU and national measures should be used and broadened by RRI aspects**.

Further steps are also needed to recognise the importance of RRI, including societal engagement, so to move from being a neglected add-on to scientific research projects to a fundamental aspect that is **structurally embedded** in the work of researchers.

[31]Rome Declaration on Responsible Research and Innovation in Europe (2014) Retrieved from https://ec.europa.eu/research/swafs/pdf/rome_declaration_RRI_final_21_November.pdf

Recommended trajectories & actions

Trajectory 1. Foster RRI awareness and competence within the nanotechnology R&I community and incentivise the adoption of RRI by relevant institutions at regional, national and EU levels

- Action 1.1 Decision-makers at EU and Member States levels should develop a long-term plan for the promotion of awareness-raising and capacity building to members of the R&I community with regard to RRI principles and practices. Dedicated training programmes should be coupled with structural changes to the education system resulting in the alignment of academic programmes with RRI goals. In addition, innovation ecosystems such as the European Institute of Innovation and Technology, Joint Technology Initiatives and the European Innovation Council should act as multipliers to foster engagement and provide evidence that RRI can be beneficial to industry.
- Action 1.2 National and regional authorities should induce structural and institutional changes within research organisations, including the adaptation of the evaluation frameworks of these entities and researchers to RRI goals (such as consideration of public engagement criteria for professional advancement and awards), the involvement of societal engagement specialists in research projects and the institutionalisation of new profiles – such as a Responsible Research and Innovation Manager. This will enable RRI dimensions to become mainstream, and allow research players to recognise them as an important responsibility and value within their work. The elaboration of targets and key performance indicators (KPIs), as well as specific incentives, can facilitate the implementation of this process.
- Action 1.3 Decision-makers at EU and Member States levels should develop and continuously update EU and national level measures in order to incentivise the implementation of RRI. This should build as much as possible on existing frameworks (for instance Corporate Social Responsibility in industry) and reward schemes that can be broaden by RRI aspects. A brief “RRI checklist” for companies (particularly start-ups) can encourage them to follow RRI principles. Moreover, the identification of RRI KPIs could facilitate the creation of a certification scheme with an “RRI label” and a ranking system for the most RRI-compliant companies, along with awards, prizes and incentives. This could encourage bottom-up and organic RRI practices while fostering a truly entrepreneurial RRI discovery process.



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