

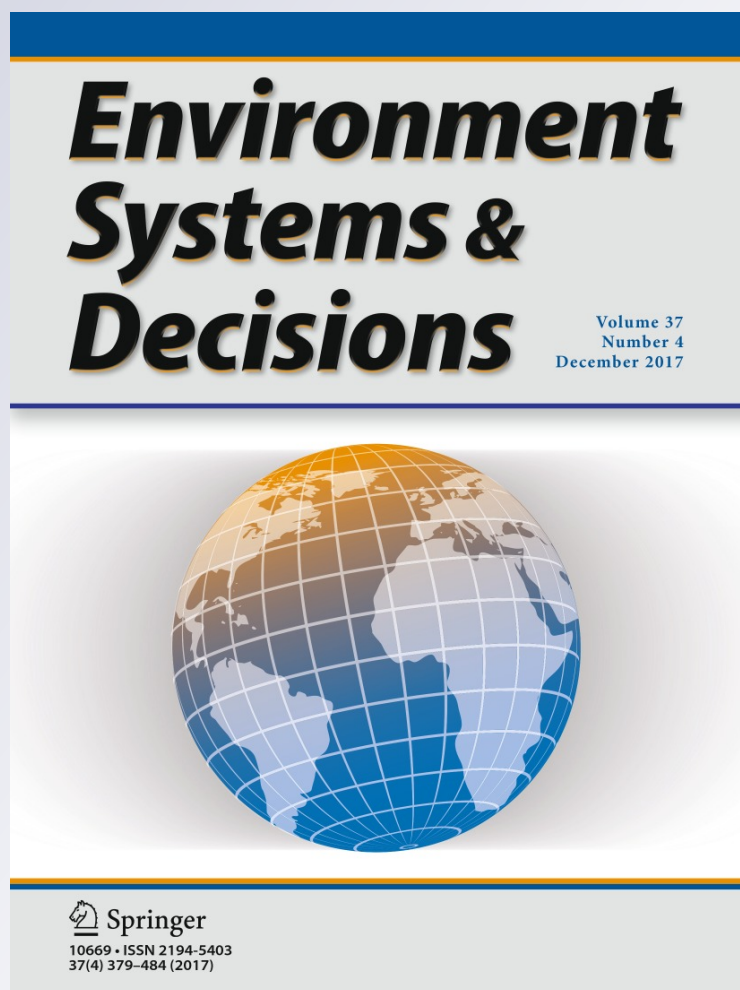
# *Comparing mental models of prospective users of the sustainable nanotechnology decision support system*

**Ineke Malsch, Vrishali Subramanian, Elena Semenzin, Alex Zabeo, Danail Hristozov, Martin Mullins, Finbarr Murphy, Igor Linkov, et al.**

**Environment Systems and Decisions**  
Formerly The Environmentalist

ISSN 2194-5403  
Volume 37  
Number 4

Environ Syst Decis (2017) 37:465-483  
DOI 10.1007/s10669-017-9648-3



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# Comparing mental models of prospective users of the sustainable nanotechnology decision support system

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Published online: 17 June 2017  
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**Abstract** Mental modelling analysis can be a valuable tool in understanding and bridging cognitive values in multi-stakeholders' communities. It is especially true in situation of emerging risks where significant uncertainty and competing objectives could result in significant difference in stakeholder perspective on the use of new materials and technologies. This paper presents a mental modelling study performed among prospective users of an innovative decision support system for safe and sustainable development of nano-enabled products. These users included representatives of industry and regulators, as well as several insurance specialists and researchers. We present methodology and tools for comparing stakeholder views and objectives in the context of developing a decision support system.

**Keywords** Nanomaterials · Decision support · Mental model · Industry · Regulators

## 1 Introduction

The development of nano-enabled products is complicated due to the uncertainty associated with risk estimates and the differences in risk perception along the product value chain. Moreover, trade-offs between potential risks and benefits of a product varies widely across different stakeholder communities. To better understand how different stakeholders perceive risks and benefits, cognitive scientists have developed mental models to study how individuals contribute to a larger distributed cognition, which is particularly valuable in identifying the effects of risk communication (e.g. Morgan et al. 2002; Hollan et al. 2000; Hutchins, 1995). A mental model can represent an issue in the mind of an individual, and these representations are influenced by his or her education and experience. Additionally, mental models are used to study learning processes (e.g. Nersessian et al. 2003), among other applications (Wood et al. 2017). Professionals in a specific field typically share similar mental models of their field. The mental model does not reveal the world as it is (i.e. ontologically) but as it is known (i.e. epistemologically). We propose that mental modelling can help resolve the problems surrounding nanomaterials by generating a deeper understanding of how different stakeholder groups perceive nanomaterials and their associated risks and benefits. We assume that each stakeholder group holds a unique perception of the potential risks and benefits of nanomaterials. For instance, industrialists are expected to perceive nanomaterials differently from regulators, insurance experts or risk assessment specialists. By studying the mental models of representatives of each group, we aim to discover whether it is possible to identify notable differences between group-specific perceptions of nanomaterials.

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Mental models can be presented as influence diagrams, which are often discussed in the context of specific decisions (cf. Wood et al. 2012, 2017). Influence diagrams are visualisations that illustrate the users' understanding of interrelated scientific and societal aspects of a field or product—in this case, of early stage nanomaterial and nanoprodukt development. Wood et al. (2012) prescribe the compilation of a multidisciplinary expert model or influence diagram, which focuses on the influence of factor X on factor Y. The probability or magnitude of this influence can be investigated; moreover, expert knowledge represented through the model is then compared to lay person knowledge. To compile an original expert model, possible methods for data collection include: group modelling sessions or literature reviews. The researcher should solicit lay beliefs through semi-structured interviews, map these onto the expert model, and then analyse lay beliefs compared to expert elicitations. Finally, a formal survey assesses the frequency of occurrence of certain scientific and societal considerations unveiled by the lay people in the target population. Three metrics are used to analyse lay beliefs: completeness, similarity, and specificity. Such a mental modelling study should result in an expert influence diagram, characterisation of lay mental models, and a comparison between the two groups (Wood et al. 2012).

In our study, the expert influence diagram is the design of the SUNDS decision support tool. This SUNDS decision framework has a modular design that allows users to pick criteria relevant to the decision they need to make. At the highest level, the tool consists of two tiers: a screening-level, semi-quantitative Tier 1 and an advanced, data-intensive Tier 2. Tier 1 is based on the LICARA NanoScan (van Harmelen et al. 2016) and includes six criteria: environmental benefits, economic benefits, societal benefits, public health and environmental risks, occupational health risks, and consumer health risks. The user inserts as much data as available, complemented with best guesses that compare the performance of a nano-enabled product to a product with similar functionality without nanomaterials. In addition, the user can also estimate the level of uncertainty. The output includes recommendations as to whether to proceed with nano-enabled product development, terminate development, or collect more information on specific risks and benefits.

Tier 2 assesses environmental risk assessment, public human health risk assessment, occupational and consumer human health risk assessment, life cycle assessment, economic assessment and social impact assessment (Subramanian et al. 2016). For the risk assessment modules, following a decision tree, the user is expected to insert test results from in-house tests and literature or to run exposure and hazard models connected to the SUNDS tool. From distributions of exposure and hazard, it is possible to derive

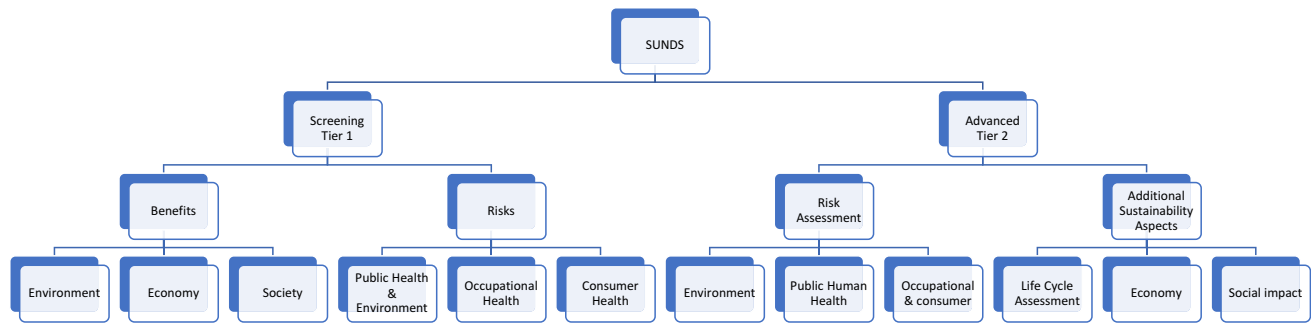
a probabilistic assessment. The deterministic or probabilistic assessment is the basis for selecting appropriate risk management measures. For life cycle assessment, the tool accepts midpoints calculated as per explicitly specified LCIA methodology (e.g. ReCIPe, CML, etc.), while for economic and social impact assessment, it implements specific life cycle costing (LCC) and social-LCA methodologies. The SUNDS tool is designed for an organisation's internal use in the context of a sustainability assessment and risk management approach that is compatible with preexisting regulation (reported in Malsch et al. 2015a, b, c). A schematic overview of the SUNDS design as influence diagram is depicted in Fig. 1.

The current paper describes the next step in a study of the specifications of the SUNDS tool through a survey investigating whether there are significant differences in weighing the distinct modules in the screening-level Tier 1 and advanced Tier 2 of the SUNDS tool. Both tiers facilitate multi-criteria decision analysis, allowing the user to consider all relevant aspects in decision making on nanomaterials and nano-enabled products. One might expect that industrial users attach different weights to each criterion than regulatory or other users, but this hypothesis must be tested.

This paper aims to analyse and understand how different stakeholders would weigh a set of sub-modules in Tiers 1 and 2. In Tiers 1 and 2 of the final SUNDS system, we have not included the possibility of attaching a weighting to different sub-modules. For Tier 1, a weighing scheme was developed and included in LICARA NanoSCAN, but the developers decided to remove it from its final version (van Harmelen et al. 2016). In the mental modelling study presented in this paper, weights are not collected for inclusion in the assessment methodology, rather to understand preferences of users. This understanding is critical because it indicates the relative importance of different potential risks and benefits of nanomaterial decision making respective to industrialists, regulators, and other stakeholders. One might expect that industry deems economic assessment data highly important, while regulators attach more weight to risk assessment data. Likewise, a regulator responsible for environmental protection may have more use for the environmental risk assessment modules, while a policy maker from the department of employment prefers the occupational health and safety modules. This study seeks to detect such differences in user preferences through collecting qualitative information.

## 2 Participants and design

This study compared the mental models of prospective users of the SUNDS decision support tool, a tool designed to promote safe and sustainable manufacturing of



**Fig. 1** Overview of the SUNDS design, which serves as the influence diagram of the mental model under study

nanomaterials and nanoproducts. These prospective users were predominantly in the industrial and regulatory fields. Industrial participants in the study included managers and professionals working for large and small companies in the nanomaterials value chains, as well as representatives of industrial associations. Regulators included policy makers and professionals authorising and overseeing nanomaterial and nanoproduct development. Other participants included risk assessment specialists and insurance experts.

The design of this mental modelling study was adapted from Wood et al.'s (2012) abovementioned comparison of lay mental models with an expert model or influence diagram. The SUNDS tool is the expert model in question, and the metrics for comparison are completeness and similarity. Rather than comparing lay mental models with the expert model, we assessed the completeness of different stakeholders' mental models compared with the SUNDS expert model. We also assessed similarity of the stakeholders' mental models with each other. The expert model was not independent, but based on the stakeholders' stated needs for decision support.

### 3 Procedure

We investigated the mental models in four rounds. To find information on desirable specifications of the SUNDS decision support tool, our mental modelling study includes a survey among participants in the SUN kick-off meeting (Round 1), a series of semi-structured telephone interviews (Round 2), a stakeholder workshop in Utrecht in October 2014 (Round 3), and a survey soliciting comparative weights of the different modules in the SUNDS decision support tool (Round 4).

## 4 Results: soliciting the weights in SUNDS

### 4.1 First survey and questionnaire results

Based on responses from 13 survey participants attending the SUN project kick-off meeting, 27 telephone interviews, and 24 participants in a workshop, the ranking of modules

in the SUNDS system across different stakeholders was determined. In Round 4 reported in the section "Determining SUNDS Weights of Industry and Regulators", we distributed a survey to assess the frequencies of stated priorities ranked across the different industry and regulation stakeholders. We compared the results of this survey to survey results collected in earlier rounds to assess the evidence provided for our mental models.

The first survey distributed during the kick-off meeting in 2013 resulted in a long list of possible criteria to include in the SUNDS tool (Malsch et al. 2015c). The interviewees in Round 2 (Spring 2014) were then asked to rank criteria by priority through allocating a score between 1 and 10 (Malsch et al. 2015b). As only four regulators and thirteen industry representatives completed the ranking, the outcomes of this interview round are merely indicative. Table 1 summarises the rank of priorities. It is worth noting that one of the industry representatives was uncertain about the importance of several criteria. In principle, knowledge on the criterion would be very relevant to the work of this person, but the participant cast doubts about the feasibility to collect the data through a decision support tool. Therefore, we list two sets of average scores for industrial respondents, one including this person's high scores and one including the low scores.

The results suggest that regulators may place the most priority on risk assessment data and the least on economic implications, while industry may place the most priority on environmental or economic data and the least on social implications. In Round 4, a survey of representative samples of regulators and industry representatives was carried out between June 2016 and March 2017 to support our earlier findings and assumption that differences in value preferences is representative of wider communities. Further, we aimed to understand whether stakeholders would weigh differently the similar modules found in different tiers of analysis.

### 4.2 SUNDS user preferences

Taking another angle in Round 3, Subramanian et al. (2016) have analysed the preferences of different types of participants in the first SUN Stakeholder workshop in



**Table 1** Ranking different priorities in safe and sustainable nanomaterials management

Feature	4 regulators	13 industry +	13 industry -
<b>Output of risk assessment</b>			
Read across approaches to quantitative data on alternatives for research materials with uncertainties and data gaps before investments in scale up	7,8	7,4	6,4
Banding approaches to quantitative data on alternatives for research materials with uncertainties and data gaps before investments in scale up	6,0	7,3	7,3
Grouping approaches to quantitative data on alternatives for research materials with uncertainties and data gaps before investments in scale up	8,3	7,0	7,0
Quantitative consideration of toxic effects	10,0	8,0	7,3
Quantitative consideration of release rates to human space	10,0	8,1	7,4
Quantitative consideration of release rates to environment	9,5	8,2	7,5
Overall score risk assessment environmental indicators	<b>8,6</b>	7,7	7,1
Environmental risk management	5,8	8,2	7,4
Open LCA software with specific data and ecoinvent data	4,8	7,5	6,8
Overall score environmental indicators	5,3	<b>7,8</b>	7,1
<b>Economic indicators</b>			
Quantitative consideration of use amounts	4,3	7,8	7,8
Large overview of patents and scientific literature	4,0	6,7	6,7
Overall score economic indicators	<i>4,1</i>	7,3	<b>7,3</b>
<b>Societal indicators</b>			
Social perceptions of risk	5,8	7,5	7,5
Factors influencing political decisions	5,8	6,5	6,5
Large overview of normative frames	5,3	6,3	6,3
Overall score societal indicators	5,6	6,8	6,8
Support experimental activity with computational tools	8,8	5,9	5,9
How hazard data can feed into this process and influence output	9,3	6,5	6,5
Easy to use	8,0	7,2	7,2
Online	8,3	6,3	6,3
Sharable with others	9,0	6,3	6,3

The numbers in italics indicate the lowest ranked overall category (risk assessment, environment, economy, society); the bold numbers indicate the highest ranked overall category. One industrial respondent gave either a 10 or a 1 ranking for some risk assessment and environmental features, which is reflected in the differences between '13 industry +' and '13 industry -'

October 2014 in Utrecht. The following modules represent preferences and are examined: environmental (screening and advanced risk assessment and life cycle assessment), economic (benefit cost and insurance cost assessments), social impact assessment and alternatives assessment (risk management measure efficiency, and risk management measure cost). The classification is based on thematic analysis of the workshop transcript. These participants were not asked to rank the different modules. The results of this analysis suggested that participants from large industry had a high preference for almost all modules, except screening-level risk assessment and screening-level life cycle assessment, for which they had a medium preference. Participants from SMEs had a high preference for economic and social modules, and for screening-level risk

assessment and life cycle assessment modules. They had a medium preference for alternatives assessment modules and no preference for advanced risk assessment and life cycle assessment modules. Participating regulators only had a high preference for the advanced risk assessment module and medium preferences for the other environmental modules, social impact assessment, benefit cost assessment and risk management measure efficiency. They had no preference for insurance cost assessment and risk management measure cost. In contrast, participants from insurance companies only had a high preference for insurance cost assessment, and medium preferences for benefit cost assessment, social impact assessment, alternatives assessment and advanced risk assessment and life cycle assessment. Those working in insurance sector had

no preference for screening-level risk assessment and life cycle assessment (see Subramanian et al. 2016).

Table 2 compares the modules in SUN with the categories used in these two analyses. The risk assessment module is further subdivided in the SUNDS tool compared to the survey and interviews, and the analysis of the workshop.

The design of the SUNDS tool was inspired by the outcomes of the survey, interviews, and the stakeholder workshop in Utrecht, though it also considers other expertise and the availability of data. Therefore, the three categories are not independent.

### 4.3 Determining SUNDS weights of industry and regulators

In Round 4, we made a comparison between mental models of regulators and industry—the two largest groups of potential users of the SUNDS tool. In a survey held between June 2016 and March 2017, stakeholders were asked to weigh the different modules highlighted in Table 2 by scoring them on a 5-point Likert scale. The resulting responses were normalised to 100%. Participants included 36 individuals on our mailing list who completed an online questionnaire that lasted 10–15 min in duration. The questionnaire was designed to help identify the respondent and the group he or she belonged to, and it included three questions to determine the weights of the

modules within Tiers 1 and 2, as well as the relative importance of each (see Annex 1).

In total, 36 respondents completed the survey, including 19 industrialists, 10 regulators, and 7 others. The industrialists included nine respondents from large industry, seven from SMEs, two from industrial associations, and one from an unspecified size company. The regulators included seven policy makers and three authorities. The others included two insurance experts, three researchers, and two consultants. One large industry respondent did not indicate preferences in any question, and therefore, his or her answers will be excluded from the analysis.

The remaining 35 respondents were from 10 EU member states, three other countries, and one international organisation: Germany (7), Italy (7), The Netherlands (5), the UK (3), Belgium (2), Finland (2), the USA (2), Canada, Denmark, Greece, International, Luxemburg, Sweden and Switzerland (1 each).

Among the remaining 18 industrial respondents, two were exclusively active in R&D, three in nanomaterials, three in chemicals, one in end products, two worked for associations, and the other seven were active in different combinations of R&D plus one or more stages in the value chain (e.g. R&D plus marketing; R&D plus nanomaterials; R&D plus chemicals (2); R&D plus end products; R&D, nanomaterials, chemicals, intermediaries, end products, marketing; R&D, nanomaterials, chemicals, intermediaries, marketing).

**Table 2** Comparison of the categories used so far in SUN studies of mental models and user preferences for the SUNDS tool

Sub-module	SUNDS Tier 1 (LICARA)	SUNDS Tier 2	Survey + interviews	Workshop 1
Environmental risk assessment	Module 4: public health and environmental risks of nano	Ecological risk assessment	Risk assessment	Environmental assessment: screening-level risk assessment (Tier 1) and advanced risk assessment (Tier 2)
Public human health risks		Public human health risk assessment		
Occupational human health risks	Module 5: occupational health risks of nano	Occupational and consumer human health risk assessment		
Consumer human health risks	Module 6: consumer health risks of nano			
Life Cycle assessment	Module 1: environmental benefits	Life cycle impact assessment (costs and benefits)	Ecology-LCA	Environmental assessment: screening life cycle assessment (Tier 1) and advanced life cycle assessment (Tier 2)
Economic assessment	Module 2: economic benefits	Economic assessment (cost)	Economic indicators	Economic assessment: benefit cost assessment and insurance cost assessment
Social impact assessment	Module 3: societal benefits	Social impact assessment (costs and benefits)	Societal indicators	Social assessment: social impact assessment

Among the 10 regulators, two focused exclusively on chemicals, two on consumers, one on occupational health and safety (OHS), one on funding, two focused on consumers and chemicals, one on chemicals, consumers and OHS, and one on chemicals, consumers, OHS and environment.

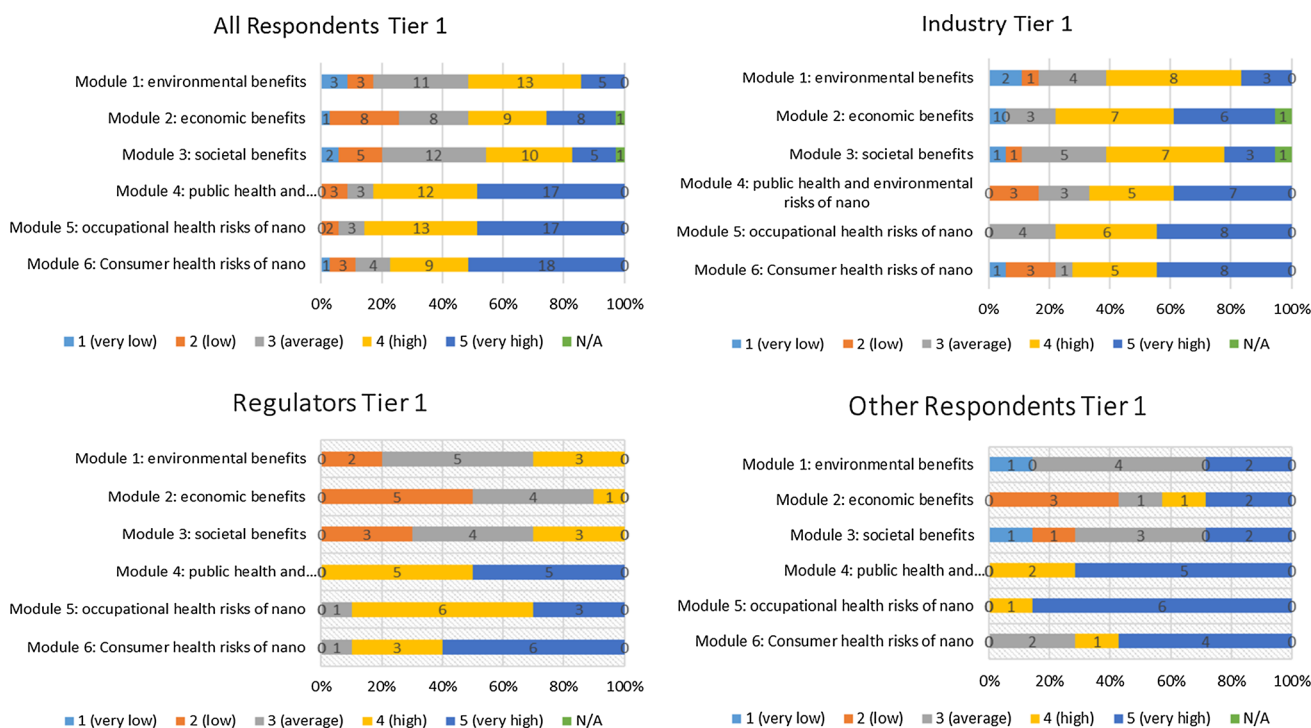
Among the other respondents, two worked in insurance companies. The three researchers were active in unspecified R&D, risk assessment of chemicals and consumer health, and occupational health and safety. One consultant engaged in regulatory assessments of nanomaterials and the other in policy advice.

Because of the low numbers of respondents, the outcomes cannot be extrapolated to draw general conclusions about the population of prospective users of decision support systems for nanomaterials. The low number of respondents is related to the earlier finding that decision makers on the safe and sustainable development of nanomaterials and nano-enabled products are not familiar with decision support tools (Malsch et al. 2015a, b, c). The community of prospective users (industry, regulators, and insurance experts) of the SUNDS decision support tool, who were informed to some extent about the tool design, was rather small (under 100 persons, predominantly from industry). The focus of the questionnaire on the complex modular design of the SUNDS tool was difficult for

prospective users, who had not been otherwise introduced to the tool, to understand. Two people who had been invited to complete the survey responded that they could not answer the questions because of this lack of information. Most respondents in the final survey reported here, had either been interviewed or participated in at least one of the three workshops we organised, where the SUNDS functionality had been explained and discussed. Since the original survey and the final survey allowed for anonymous response, we are not sure how many new respondents participated.

#### 4.4 Tier 1: LICARA NanoScan

Among all respondents, the risk assessment modules in Tier 1 (LICARA NanoScan) received higher interest than the benefit assessment modules (see Fig. 2). Around half of all respondents indicated very high importance for the output of risk assessment modules in Tier 1 for decisions they take in their work. In addition to the 51% of respondents who reported very high importance to Module 6 on consumer health risks of nanotechnology, 26% considered its importance high, while 12% considered its importance low to very low. Additionally, 49% of participants reported very high importance to modules 4 (public health and environment) and 5 (occupational health risks), 34% and



**Fig. 2** Comparing relative importance of the outcomes of the modules in Tier 1 (LICARA NanoScan) for all, industrial, regulatory and other respondents



37% considered their importance high, while only 9% and 6%, respectively, considered their importance low.

While considerably fewer respondents considered the social, economic and environmental benefit modules to be of very high importance for their work, approximately half of the participants still considered these important to some extent. Module 1 (environmental benefits) was deemed very important by 14% of respondents and important by 37%, while 18% of participants did not consider it important. Module 2 (economic benefits) was considered of very high importance by 23% of participants and of high importance by 26%, while 26% did not consider it important. Module 3 (social benefits) was considered very important by 14% of participants and important by 29%, but not important by 20% of participants.

#### 4.4.1 Industry respondents

The eighteen industry respondents were less enthusiastic about the risk assessment modules in Tier 1 (LICARA NanoScan) than the average respondent, yet more than half of them considered all modules important to some extent. Module 6 (consumer health risks) was deemed important by 72% and not important by 23% of respondents. Module 5 (occupational health risks) received the highest interest: 77% of respondents considered it important, and no respondent deemed it unimportant. Module 4 (public health and environmental risks) was reported as important by 67% of respondents and unimportant by 17%. Module 3 (societal benefits) was considered important by 56% of respondents and not important by 12%. Module 2 (economic benefits) was considered important by 72% of respondents and unimportant by 6%. Module 1 (environmental benefits) was deemed important by 61% and not important by 17% of industrialists (see Fig. 2).

During the interviews and workshop, we found that SMEs and large industrial companies have different needs for decision support. Among the valid responses to this survey, seven SMEs and eight large industries were represented. Among the three risk assessment modules, more SME respondents than large industry respondents were interested in and placed importance on consumer health risk assessment. In contrast, the interest among large industry respondents was stronger in public health and environment and in occupational health risk assessment. SMEs were consistently more concerned with economic benefits assessment, while their interest in societal benefits Assessment was more diverse than for the large industry respondents. Additionally, on average, SME respondents were more interested in environmental benefit assessment than the large industry respondents (see Fig. 4).

#### 4.4.2 Regulators and others

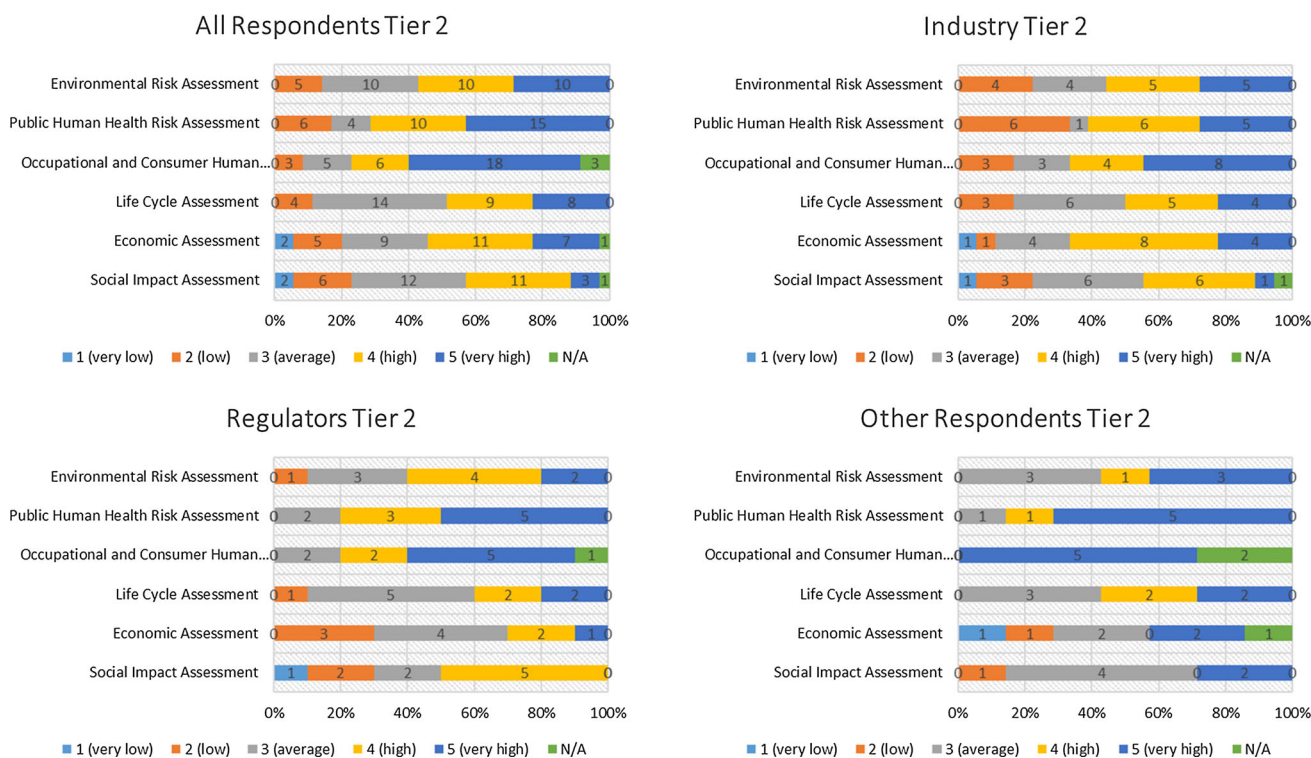
The ten participating regulators were more interested in the risk assessment modules than in the benefit modules. At least, 90% of respondents considered Modules 4, 5 and 6 of high to very high importance to their work, and none of them reported these modules as unimportant. Conversely, 50% of regulators considered Module 2 on economic benefits of low importance to their work. The modules on environmental and societal benefits received mixed responses, with a fairly even spread of responses ranging from low to high importance. The seven 'other' participants were more interested in the risk assessment modules and reported a bit more interest in the benefits modules than did the regulators (see Fig. 2).

### 4.5 SUNDS Tier 2

Among all respondents, the three risk assessment modules of Tier 2 were reported to be more important than the other three modules, in this case covering the three pillars of sustainability: life cycle impact assessment, economic assessment and social impact assessment. The life cycle impact assessment and social impact assessment are cost-benefit assessments, and therefore, these assessments are not directly comparable to the corresponding benefits modules in Tier 1 (LICARA NanoScan). The occupational and human health risk assessment module was very highly relevant to the work of half of the total respondents and highly relevant to another 16%. This was followed by the public human health risk assessment module with 42% very high and 28% high importance, and the environmental risk assessment module with 28% very high and 28% high importance. Life cycle assessment was reported as being somewhat less important, as 22% of respondents considered it very high and 25% high importance. These four modules were considered of low relevance by 16% or less of respondents, and nobody considered their relevance very low. Economic assessment was deemed very highly relevant by 19% of respondents and highly relevant by 31%, while 19% of respondents did not consider it relevant. Social impact assessment received the least interest, with 39% considering it highly or very highly relevant and 22% considering it of low or very low relevance (See Fig. 3).

#### 4.5.1 Industry Tier 2

The occupational and consumer health risk assessment module was the module of highest interest to the 18 industry respondents, though they were somewhat less interested than the average respondent (42% very high and 21% high). Their interest in the environmental risk assessment and public human health risk assessment



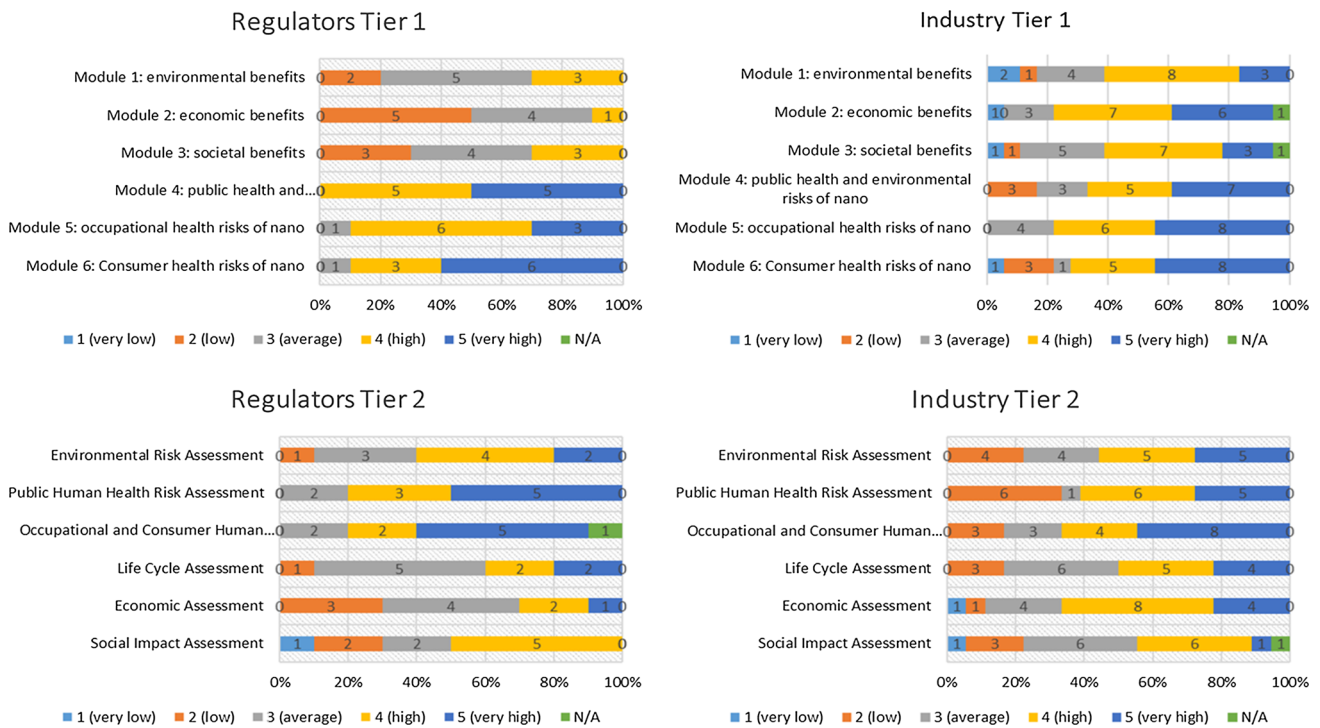
**Fig. 3** Comparing relative importance of the outcomes of the modules in SUNDS Tier 2 for all, industrial, regulatory and other respondents



**Fig. 4** Comparing relative importance of the outcomes of the modules in SUNDS Tier 1 and Tier 2 for SME and large industry respondents

modules was also very high (26% for both assessments) to high (26 and 32%, respectively). Their interest in the economic assessment module was high (42%) to very

high (21%), whereas their high to very high interest in LCA and societal impact assessment was below 50% (see Fig. 3).



**Fig. 5** Comparing relevance of all modules for regulators and industry respondents

Figure 4 indicates that the interest among large industry respondents in occupational and consumer, public human health risk assessment, and (to a lesser extent) environmental risk assessment was larger than among SMEs. These value preferences may be related to the larger need for data input in Tier 2 than in the screening-level Tier 1. In contrast, the average SME respondent was more interested in economic and life cycle assessment than large industry respondents. Regarding social impact assessment, the spread in SME responses was again larger than for industry respondents.

#### 4.5.2 Regulators and others Tier 2

The 10 regulatory respondents shared the common preference for the risk assessment modules, but considered occupational and consumer (70% high to very high importance) and public human health risk assessment (80% high to very high) more relevant than environmental risk assessment (60% high to very high). This trend may be related to the institutional contexts of the respondents. The three sustainability modules were considered less relevant by these respondents. Most of the seven other respondents are again interested in public, and in occupational and consumer human health risk assessment, followed by environmental risk assessment and LCA. Most regulators

and other respondents do not regard economic and societal impact assessments with importance (see Fig. 3).

#### 4.6 Contextualising the users

While most users showed high to very high interest in most of the modules, in some cases there was a large spread over the Likert scale from very low to very high interest. In this section, we present a closer analysis comparing the background of respondents with very high and very low interest in the modules addressing similar risks or benefits. Such an analysis should provide more insight into how the SUNDS tool may be used in practice. The scores are summarised in Table 3.

Three (out of 35) respondents considered all twelve modules of very high interest to their work, including a researcher and a policy consultant who also deemed the advanced Tier 2 of very high interest, and an SME in R&D and nanomaterials who deemed the screening-level Tier 1 of very high interest. These leaders were followed by another group of three respondents—two employed by large chemical companies and a policy maker—who were very interested in seven modules. All three respondents were very interested in the three screening-level risk assessment modules and in the advanced public health and occupational and consumer health risk assessment

**Table 3** Overview of 35 valid responses to the survey on a Likert scale from 1 (very low) to 5 (very high) interest in the different modules of the SUNDS decision support tool

No.	type org.	T1-1	T1-2	T1-3	T1-4	T1-5	T1-6	T2-1	T2-2	T2-3	T2-4	T2-5	T2-6
1	SME-R&D	4	4	3	4	4	4	4	4	4	<b>5</b>	4	3
2	Large industry consumer	<i>1</i>	3	3	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	4	<b>5</b>	4	3	3
3	Large industry R&D car	4	3	3	4	4	2	3	3	3	3	4	4
4	Research org.	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>
5	SME R&D, nanomaterials	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>
6	Large ind-chemicals	4	<i>1</i>	4	<b>5</b>	<b>5</b>	3	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<i>1</i>	3
7	Research org.	3	2	3	<b>5</b>	4	<b>5</b>	4	<b>5</b>	no	4	all	3
8	SME medical device	2	4	no	3	<b>5</b>	<b>5</b>	2	2	4	3	4	<i>1</i>
9	Authority consumers, chemicals	3	2	4	<b>5</b>	4	<b>5</b>	4	<b>5</b>	3	3	2	2
10	Industrial association	3	4	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	3	4	4	2	4	2
11	Research org. OHS	3	2	3	<b>5</b>	<b>5</b>	3	3	3	<b>5</b>	3	2	3
12	Large industry chemicals	4	<b>5</b>	4	<b>5</b>	<b>5</b>	<b>5</b>	4	<b>5</b>	<b>5</b>	4	<b>5</b>	4
13	Policy maker chemicals	3	3	3	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	4	4
14	Authority consumers	2	2	2	4	3	<b>5</b>	2	4	4	4	2	2
15	Consultant regulation	<i>1</i>	2	<i>1</i>	<b>5</b>	<b>5</b>	3	<b>5</b>	<b>5</b>	no	3	<i>1</i>	2
16	SME nanomaterials	3	4	2	<b>5</b>	3	<b>5</b>	4	<b>5</b>	<b>5</b>	3	4	2
17	Large industry ceramics	4	<b>5</b>	4	4	4	4	3	4	<b>5</b>	3	3	4
18	Authority consumers, chemicals	4	3	3	<b>5</b>	4	<b>5</b>	3	<b>5</b>	<b>5</b>	<b>5</b>	3	3
19	Policy maker OHS	3	3	4	4	<b>5</b>	4	3	3	<b>5</b>	3	3	4
20	Industrial association	4	3	4	2	4	2	4	2	3	4	3	4
21	Insurance	3	4	2	4	<b>5</b>	4	3	4	<b>5</b>	3	3	3
22	Consultant policy	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>
23	Policy maker chemicals, consumers, OHS	4	2	3	<b>5</b>	4	<b>5</b>	4	<b>5</b>	<b>5</b>	3	2	4
24	SME R&D	4	4	4	4	<b>5</b>	<b>5</b>	4	4	<b>5</b>	4	4	4
25	Policy maker consumer	4	2	3	4	4	4	4	4	4	2	3	3
26	Company Chemicals	<i>1</i>	<b>5</b>	<i>1</i>	3	4	4	2	2	3	2	<b>5</b>	3
27	Large industry chemicals	<b>5</b>	4	3	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	4	4	3
28	Policy maker chemicals, consumers, OHS, environment	2	2	2	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>5</b>	3	4	4
29	Large industry chemicals	3	4	3	4	4	4	3	4	4	3	4	3
30	SME nanomaterials	4	<b>5</b>	<b>5</b>	2	2	2	2	2	2	2	2	2
31	Insurance	3	3	3	4	<b>5</b>	<b>5</b>	3	<b>5</b>	<b>5</b>	4	3	3
32	Large industry chemicals	3	all	no	2	2	<i>1</i>	2	2	2	3	4	no
34	SME R&D, marketing	<b>5</b>	<b>5</b>	4	3	3	4	<b>5</b>	2	2	<b>5</b>	<b>5</b>	4
35	Policy maker chemicals	4	4	2	4	4	4	3	3	3	3	<b>5</b>	<i>1</i>
36	Policy maker funding	4	3	4	4	4	<b>3</b>	4	4	no	4	3	4

The lowest interest is underscored, and the highest highlighted in bold. Some respondents gave no answer to some questions (no), or indicated all options (all). The codes indicating the modules are explained in Table 4 below

modules. The policy maker and one industrialist were very interested in the advanced environmental risk assessment module. The policy maker combined this with very high interest in the advanced life cycle assessment module, while the industrialist preferred the environmental benefits screening. The other industrialist preferred the screening-level and advanced economic assessment modules. Two respondents expressed very high interest in six modules. A policy maker was very interested in all screening-level and

advanced risk assessment modules, while a large chemical industrialist was very interested in all advanced risk assessment modules, the advanced LCA module and the screening-level modules on public health and environmental risks and occupational health and safety. Three other respondents had very high interest in five modules, five respondents preferred four modules, four preferred three modules, six were very interested in two modules, and three in one module.

**Table 4** Explaining the meaning of the module codes

Code	Module
T1-1	Screening Tier 1—module 1: environmental benefits
T1-2	Screening Tier 1—module 2: economic benefits
T1-3	Screening Tier 1—module 3: societal benefits
T1-4	Screening Tier 1—module 4: public health and environmental risks
T1-5	Screening Tier 1—module 5: occupational health risks
T1-6	Screening Tier 1—module 6: consumer health risks
T2-1	Advanced Tier 2—module 1: environmental risk assessment
T2-2	Advanced Tier 2—module 2: public human health risk assessment
T2-3	Advanced Tier 2—module 3: occupational and consumer human health risk assessment
T2-4	Advanced Tier 2—module 4: life cycle assessment
T2-5	Advanced Tier 2—module 5: economic assessment
T2-6	Advanced Tier 2—module 6: social impact assessment

Most of the respondents who considered one or more modules of very low interest to their work simultaneously expressed very high interest in other modules. This pattern provided insight into their context-dependent needs for decision support. One industrialist with very high interest in six risk assessment and LCA modules had very low interest in both economic assessment modules. Likewise, one consultant on nanoregulation had very low interest in three modules: the screening-level modules on environmental and societal benefits and the advanced economic assessment module. The same respondent was simultaneously very interested in four risk assessment modules. Likewise, a large ceramics manufacturer had very low interest in the environmental and societal benefits screening modules, while expressing very high interest in both economic assessment modules. A chemicals producer had very low interest in assessment of environmental benefits, combined with very high interest in five of the risk assessment modules. One SME producing medical devices had very low interest in advanced social impact assessment, and very high interest in screening-level occupational and consumer health risk assessment. One policy maker had very low interest in advanced social impact assessment and very high interest in advanced economic assessment. Finally, one large chemicals manufacturer had very low interest in screening-level consumer health risk assessment, and not very high interest in any other modules.

#### 4.6.1 Occupational health and safety and consumer risks

Among eighteen respondents with very high interest in advanced occupational and consumer health risk assessment, four worked in large chemicals companies, three in SMEs developing or manufacturing nanomaterials, and one in a large consumer goods manufacturer. Four policy makers and an authority were responsible for different risks

of nanomaterials. Two researchers, a policy consultant and two insurance specialists were also very interested in this module.

Seventeen respondents had very high interest in screening-level Module 5 on occupational health and safety. The eight industrial respondents came from three large chemicals companies, a large consumer goods manufacturer, three SMEs in R&D, nanomaterials and medical devices, and an industrial association. The three interested policy makers were responsible for chemicals, occupational health and safety, and all risks associated with nanomaterials. One researcher was active in R&D, while the other was laboratory safety manager. The two consultants were active in regulatory assessment and policy advice. Interestingly, the two insurance experts also expressed very high interest in this module. Nobody had very low interest.

Among eighteen respondents with very high interest in screening-level Module 6 on consumer health risks, four were from SMEs, including two in R&D—one a producer of nanomaterials and the other of medical devices. Two large chemical manufacturers, one consumer goods manufacturer, and a representative of an industrial association were also very interested in screening-level consumer health risks. While all three interested policy makers were responsible for chemical oversight, one was additionally responsible for consumers and workers, and the other covered all risks of nanomaterials. Two authorities covered chemicals and consumers, while the third was responsible for consumers. Two researchers, a policy consultant, and an insurance expert were also highly interested. In contrast, one large chemical manufacturer had very low interest in this module.

Overall, 24 of the 35 respondents considered at least one occupational or consumer health risk-related module very highly important to their work. Ten respondents considered all three these modules to be of very high importance, four occupational health risk assessment, three seemed to prefer



consumer risk assessment, and six preferred one or both screening-level modules and one only the advanced module.

#### 4.6.2 Public health and environmental risks

Among the seventeen respondents with very high interest in the screening-level module 4 on public health and environmental risks, three worked in large chemical companies, two in SMEs developing or producing nanomaterials, one in a large consumer goods producer, and one in an industrial association. All three policy makers dealt with chemicals; however, two of them additionally covered consumers and occupational health and safety and one of them additionally covered environmental aspects. The two authorities covered chemicals and consumers. Three consultants offered regulatory assessments, R&D services, and policy advice, respectively. Two researchers covered chemicals and consumers, or occupational health and safety. As no respondent expressed very low interest in this module, public health and environmental risk assessments appear to address the needs for decision support of a wide range of industrial and regulatory users quite well.

The fifteen respondents with very high interest in the advanced level Tier 2 on public human health risk assessment included three large chemicals industries, two SMEs producing nanomaterials, three policy makers (all governed chemicals, one also consumers and OHS and one all risks), two authorities covering chemicals and consumers, two researchers, two consultants in regulation and policy advice, and one insurance specialist.

Among the ten respondents who expressed very high interest in the advanced level Tier 2 level on environmental risk assessment, two respondents were employed by large chemical companies and one by a large consumer product manufacturer. The two SMEs were in R&D and nanomaterials and in R&D and marketing. One policy maker governed chemicals, while the other covered all risks associated with nanomaterials. Two consultants advised on regulation and on policy, while the researcher worked in R&D.

In total, nineteen out of 35 respondents (54%) were very interested in at least one module related to public health or environmental risk assessment. Eight respondents were very interested in all three related modules, including large chemicals companies, an SME, policy makers, researchers and consultants. Six authorities, policy makers, and large and small companies were very interested in the screening and advanced public health-related modules, while one large consumer manufacturer was very interested in screening and advanced environmental risk assessment. A representative of an industrial association and a research laboratory manager were only very interested in the screening-level module, while one insurance expert was

very interested in advanced public health risk assessment, and one SME in R&D and marketing was very interested in advanced environmental risk assessment.

#### 4.6.3 Environmental impact

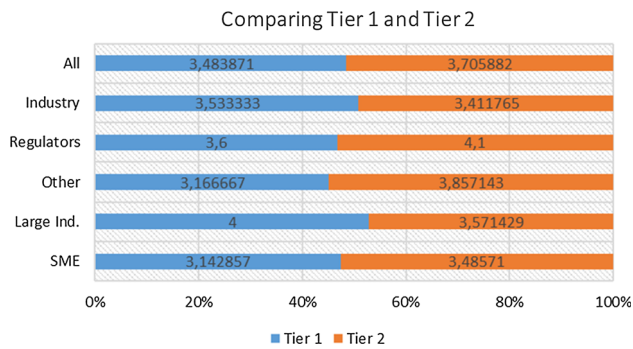
Among five respondents, two SMEs active in R&D, a large chemical industry, a researcher, and a policy consultant expressed very high interest in the screening-level module 1 on environmental benefits. In contrast, a large producer of consumer goods, an unspecified ceramics manufacturer and a consultant specialising in regulatory assessments of nanomaterials expressed very low interest in this module. None of the regulators expressed very high or very low interest in this module. Interest in the advanced life cycle assessment module was very high among eight respondents, including three SMEs active in R&D, a large chemical company, a policy maker, and authority, a researcher and a consultant. This slightly higher interest in LCA may be because it covers risks as well as benefits, or because it is more data-intensive. Four respondents expressed very high interest in both modules, four only in LCA and one in environmental benefits assessment.

#### 4.6.4 Economy

Economic assessment modules within both tiers received similar interest. Three SMEs active in nanomaterials or R&D and marketing, two large chemicals industries, a ceramics company, a researcher, and a policy consultant expressed very high interest in the screening-level Module 2 on economic benefits, while one large chemical industry found it of very low interest. Again, the interest of regulators was less outspoken. Two SMEs active in R&D—one in a large chemical company and the other a ceramics manufacturer, a policy maker, a researcher, and a consultant were very interested in the advanced economic assessment module. However, respondents from the same large company and a consultant considered it of very low interest. Six respondents considered both economic modules of high interest, while two preferred the screening-level modules and one the advanced Tier 2 module.

#### 4.6.5 Society

Two SMEs active in nanomaterials, an industrial association, a researcher and a policy consultant expressed very high interest in the screening-level module 3 on societal benefits, while a ceramics producer and a consultant expressed very low interest. Regulators had neither very low nor very high interest. The SME, researcher, and policy consultant who expressed very high interest in the advanced social impact assessment module were very



**Fig. 6** Comparing the relative importance of Tier 1 and Tier 2

interested in all 12 modules. A policy maker and an SME had very low interest in this module.

#### 4.7 Comparing Tier 1 and Tier 2

Comparing the relative scores for the more in-depth analytical tool SUNDS Tier 2 than in the screening-level Tier 1 LICARA NanoScan, the average respondent was slightly more interested in Tier 2, but the difference remained well within the standard deviation. While the average preferences of industrial, regulatory, and other respondents varied a bit, no significant differences emerge from the survey held in the period June 2016 to March 2017. The earlier finding that SMEs were more interested in the screening-level Tier 1 and large industry more in the advanced Tier 2 was not confirmed, and further research should investigate this (see Fig. 6).

## 5 Discussion

The reported survey is the final step in the mental modelling study as explained in the introduction. This study envisages the construction of an expert model and compares the mental models of the user groups within this expert model. The metrics used to analyse these user groups' beliefs are completeness and similarity (based on Wood et al. 2012<sup>1</sup>). Taking the design of the SUNDS decision support system as the expert model, it is possible to assess completeness of the mental models of the average prospective user of the tool. In addition, we can assess similarity among the mental models of industrial and regulatory user groups.

Compared to the expert model, the mental models of most respondents are not complete. Rather, these mental models place greater importance on risk assessment. More

<sup>1</sup> The third prescribed metric, specificity cannot be assessed, as we only asked respondents to rank the different modules, and did not ask them more in depth questions about their understanding of each criterion.

respondents considered the risk assessment modules as important or relevant to their work than the socio-economic assessment modules. Even within the broader category of risk assessment, mental models of most respondents were incomplete. At the screening-level Tier 1 (LICARA NanoScan), the three modules received fairly equal scores. At the more advanced level Tier 2, more diversity in completeness appeared. The diversity in completeness was evident in that environmental risk assessment received the lower scores in relation to both the occupational and consumer module and (to a lesser extent) the public human health risk assessment module. While respondents report less importance for the benefits modules in Tier 1 and the socio-economic assessment modules in Tier 2, they do not clearly prioritise these sustainability-related aspects.

Combining a socio-economic assessment with a more traditional risk assessment in one decision support system could induce a change in the mental models of its users. The socio-economic assessment is based on a cost-benefit classification matrix, which could potentially balance this focus and lead to a more comprehensive and productive picture on development of safe and sustainable nano-enabled products. Assessing the economic factors and implications of nanomaterials is not straightforward. For instance, the current lack of price transparency in the nanomaterial market may complicate one's mental model of nanomaterials.

The most pronounced dissimilarity between industrial and regulatory users lies in the consideration of environmental, economic and societal benefits at screening-level Tier 1 (LICARA NanoScan). Overall, industrial respondents expressed higher levels of interest in these modules, particularly in economic benefit assessment. While industrialists are also slightly more interested in the socio-economic assessment of Tier 2, their responses are more similar to those of regulators. Among the screening-level risk assessment modules, interest among regulators differs from industrialists in that regulators perceive consumer health risks assessment and public health and environmental risks assessment as more important than occupational health risk assessment. At the advanced level Tier 2, regulatory respondents demonstrate more interest in public human health risk assessment than industrialists. Both groups are similar in their preference for occupational and human health risk assessment compared to environmental risk assessment.

While the questions asked both in the interviews and during the workshop held in 2014 were slightly different than those in the final survey, it is possible to compare the highest and lowest interest among the four main categories: risk assessment, environmental, economic, and social pillars of sustainability. There appears to be some consistency across the subsequent steps in stakeholder engagement.

**Table 5** Comparing the highest and lowest priorities of regulators and industry participants in the interviews, workshop and final survey

Regulators	Interviews	Workshop	Final survey	
Highest	Risk assessment	Advanced risk assessment	LICARA consumer human health risks and LICARA public health and environmental risks	
Lowest	Economic	Insurance and risk management costs	LICARA Economic Benefits	
All Industry	Interviews	Workshop	Final survey	
Highest	Environment and economic	Large industry: advanced RA & LCA, economic, social, risk management	SME: economic, social, screening RA & LCA	LICARA occupational human health risks
Lowest	Social	Large industry: screening RA & LCA	SME: advanced RA & LCA	Tier 2 social impact assessment

Responding regulators maintained a higher interest in risk assessment and a lower interest in economic aspects. Most industrial respondents appeared to have a somewhat lower interest in social impacts, but a single highest priority was not apparent. Industrialists' main interests seem to include risk assessment, environmental and economic aspects (see Table 5).

## 6 Conclusion

This paper presents a case study of the mental modelling method applied to inform the design of a sustainable nanotechnologies decision support systems (SUNDS). The use of mental modelling in decision context calls for some adaptations to the decision analysis-based mental modelling approach. We did not compare expert and lay mental models; rather, we compared the mental models of experts in different disciplines contributing to the design of the SUNDS tool and of decision makers in industry, regulatory bodies, and insurance companies engaged in risk management and sustainable development of nanomaterials and nanoproducts. We anticipated that these decision makers would attribute different weights to different types of criteria when assessing the risks and three pillars of sustainable development (economic, environmental and social). These decision makers are not lay persons, but each group has different (yet overlapping and complementary) relevant expertise. The final expert model generated here is a SUNDS decision framework rather than a drawn influence diagram.

To conclude, the modular design of the SUNDS tool appears to be effective and informative, given the limited level of similarity among the mental models of different prospective user groups, and the variability within each group. The results of the survey reported here corroborate earlier findings suggesting that there may be a greater interest in risk assessment decision support than in a sustainability assessment which broadened the scope with environmental, economic and societal (risk-) benefit assessments. That said, perhaps counter-intuitively, the emerging interest in sustainability assessment seems to be greater in industry than among regulators.

**Acknowledgements** We gratefully acknowledge the contributions of the participants during the stakeholder engagement activities reported here, and the constructive comments of two anonymous reviewers. The research leading to these results has received funding from the European Union Seventh Framework Programme [FP7/2007–2013] under EC-GA No. 604305 'SUN'. This publication reflects the views only of the authors, and the European Commission cannot be held responsible for any use, which may be made of the information contained therein.

### Compliance with ethical standards

**Human and animals rights** We have not performed any experiments on humans and/or animals for which prior approval of an ethics board or similar body is required.

**Informed consent** Informed consent was obtained from all individual participants included in the study. All respondents have been offered the option to respond anonymously. All published results are presented in anonymised form.

## Annex 1: The questionnaire

### Introductory e-mail:

Dear XXX

We would like to ask your cooperation in filling out a short online questionnaire soliciting your views on the relative importance of different aspects of risk assessment and sustainable development of nanomaterials based products. This should take about 10-15 minutes. The aspects include occupational and consumer health risks, impacts on public health and environment, life cycle assessment, environmental, economic and social benefits and risks.

Your contribution would be a great help in establishing relative weights of these aspects among industrial, regulatory and insurance sector professionals interested in safe and sustainable governance of nanomaterials. We are soliciting this information as part of the EU funded project SUN (Sustainable Nanotechnologies, grant agreement nr. 604305, [www.sun-fp7.eu](http://www.sun-fp7.eu)).

Your answers will be treated confidentially in accordance with relevant EU legislation and ethical guidelines including The Charter of Fundamental Rights and Directive 95/46/EC of the European Parliament and of the Council of 24 October 1995 on the protection of individuals with regard to the processing of personal data and on the free movement of such data. Results of the survey will only be published in aggregate form.

Could you please complete the questionnaire at your earliest convenience, preferably before XXX? Please contact Ineke Malsch at [postbus@malsch.demon.nl](mailto:postbus@malsch.demon.nl) if you have any questions or comments.

Kind regards,

The SUN WP8 team (Ca'Foscari University, Venice, University of Limerick, Malsch TechnoValuation)

### Questionnaire

#### Section 1: Information on your background.

Please include some information about yourself and the organisation you work for. We will keep this information confidential and not share it with anyone beyond the partners who are involved in the study on mental modelling in the SUN project: Malsch TechnoValuation, Ca'Foscari University Venice and University of Limerick. The reason for questions 1-4 is that we would like to be able to identify you in case we have any additional questions. We will only publish aggregated data, and will handle the data in accordance with the European Data Protection Directive: <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:HTML>. At the end of the questionnaire we include some question soliciting your informed consent.

- 1) Name (optional):
- 2) Organisation:
- 3) Country:
- 4) Contact e-mail for any follow up questions (optional):

**Section 2: Information on the sector you work in**

The following questions aim to identify the type of organisation you work for and in which sector it is active. We need this information to be able to derive average weights for industrial, regulatory and insurance sectors and to be able to compare them.

- 5) Please indicate the type of organisation you work for (tick one box):
  - a. SME <250 employees
  - b. Large industry > 250 employees
  - c. Industrial association
  - d. Policy making body in Government (EU, ministry, etc)
  - e. Public authority responsible for regulatory oversight
  - f. Other (please specify)
- 6) For industrial or insurance sector respondents: Please indicate the sector your organisation is active in and where you handle nanomaterials (tick one or more boxes):
  - a. R&D
  - b. Nanomaterials production
  - c. Chemicals and Materials
  - d. Intermediary products (please specify)
  - e. End products (please specify)
  - f. Marketing and sales (please specify)
  - g. Waste processing
  - h. Instrumentation or services (please specify)
  - i. Insurance sector
- 7) For public respondents: Please indicate the regulatory domain you are responsible for (tick one or more boxes):
  - a. Occupational Health and Safety
  - b. Chemicals and Materials
  - c. Consumer Protection
  - d. Environment and Waste
  - e. Other (please specify)

**Section 3: Your relative weights of different aspects of risk assessment and sustainability**

The following questions aim to solicit your relative preferences for each of the aspects of risk assessment and sustainability that will be incorporated in the SUNDS decision support tool. This tool consists of two Tiers. Tier 1 is a screening level tool, with relatively few data requirements. Tier 2 is an advanced tool with considerable data requirements. We would like to ask you to indicate which aspects are more and which are less important to you in your own work.

Q3.1 Tier 1, LICARA Nanoscan, assesses three types of expected risks and three types of foreseen benefits of nanomaterials during the life cycle of a product incorporating them, at a screening level. These include environmental, economic and societal benefits versus public health and environmental, occupational and consumer health risks. Please indicate the relative importance of the output of each of the modules in Tier 1 for decisions you take in your work by scoring them on a 5-point Likert scale

		1 (very low)	2 (low)	3 (average)	4 (high)	5 (very high)
a)	Module 1: environmental benefits					



b)	Module 2: economic benefits					
c)	Module 3: societal benefits					
d)	Module 4: public health and environmental risks of nano					
e)	Module 5: occupational health risks of nano					
f)	Module 6: Consumer health risks of nano					

Q 3.2 Tier 2, the advanced SUNDS tool, assesses data on six aspects of risk assessment and sustainable development of nanomaterials along the life cycle of products incorporating them. These aspects include environmental risk assessment, public human health risk assessment, occupational and consumer human health risk assessment, life cycle assessment, economic assessment and social impact assessment. Please indicate the relative importance of the output of each of the modules in Tier 2 for decisions you take in your work by scoring them on a Likert scale

		1 (very low)	2 (low)	3 (average)	4 (high)	5 (very high)
a)	Environmental Risk Assessment					
b)	Public Human Health Risk Assessment					
c)	Occupational and Consumer Human Health Risk Assessment					
d)	Life Cycle Assessment					
e)	Economic Assessment					
f)	Social Impact Assessment					

Q 3.3 Some potential users prefer a screening level tool such as Tier 1, while others prefer an advanced tool such as Tier 2. We would like to know if there are significant differences in preferences between sectors. Please indicate the relative importance of Tier 1 and Tier 2 for decisions you take in your work:

		1 (very low)	2 (low)	3 (average)	4 (high)	5 (very high)
a)	Tier 1: LICARA Nanoscan					

b)	Tier 2: advanced SUNDS tool					
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**Informed consent form**

I, the undersigned, confirm that (please tick box as appropriate):

1.	I have read and understood the information about the project, as provided in the Information Sheet	<input type="checkbox"/>
2.	I have been given the opportunity to ask questions about the project and my participation.	<input type="checkbox"/>
3.	I voluntarily agree to participate in the project.	<input type="checkbox"/>
4.	I understand I can withdraw at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.	<input type="checkbox"/>
5.	The procedures regarding confidentiality have been clearly explained to me (e.g. that my personal information will be anonymised and restricted from public access).	<input type="checkbox"/>
6.	No personal information will be published, no activities recorded via sound or video and no data will be shared outside of the project	<input type="checkbox"/>
7.	All data collected during this project will respect the European Union Data Protection Directive: <a href="http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:HTML">http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31995L0046:en:HTML</a>	<input type="checkbox"/>
8.	I understand that other researchers within this project may have access to this anonymised data only if they agree to preserve the confidentiality of the data and if they agree to the terms I have specified in this form. At the end of the project, all collected data will be destroyed.	<input type="checkbox"/>
9.	If I would like to be contacted for follow-up or to receive further information on the project results, I can provide my email address knowing full well that it will be stored in a secured database, apart from my results and with the guarantee that it will not be shared outside of this project	<input type="checkbox"/>
10.	I, along with the Researcher, agree to sign and date this informed consent form.	<input type="checkbox"/>

**Participant:**

\_\_\_\_\_  
Name of Participant (optional)      Signature      Date

**Researcher:**

\_\_\_\_\_

Name of Researcher	Signature	Date
[button] Please submit.		

[After submitting, the respondents should see the following message]

Thank you for contributing to our questionnaire. We may contact you in case we need further information or clarifications. We will continue collecting responses until mid-February 2017 after which we will compile a report on the outcomes. Feel free to contact us if you have any questions or comments.

#### Timing of the study determining weights

The questionnaire soliciting weights has been posted at the website [www.sun-fp7.eu](http://www.sun-fp7.eu) on 6 June 2016, and has been kept open until March 2017 to allow the respondents to fill it in at their convenience. E-mail requests to complete the survey have been sent out in June, September/October, and January/February to regulators, industrialists and other persons who have expressed interest in the SUN project or have been involved in Nanosafety Cluster projects or the DialogForum Nano of BASF meeting in March 2016 in Brussels. In particular, regulatory and industrial participants in events organised in the framework of SUN in 2016 and 2017 have been contacted. These include the annual meeting on 4-5 October 2016 in Edinburgh, the NMSA conference on 6-9 February 2017 in Malaga, and the SRA Policy Forum and SUN-CaLIBRAte stakeholder workshop on 1-3 March 2017 in Venice.

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