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Additional Information

# APPLICATION OF THE ANP TO THE PRIORITIZATION OF PROJECT STAKEHOLDERS IN THE CONTEXT OF RESPONSIBLE RESEARCH AND INNOVATION.

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**Abstract:** This paper presents a methodology to assess the stakeholders' influence in a research project within the context of Responsible Research and Innovation. The methodology is based on a combination of the multicriteria decision making technique Analytic Network Process and the key areas of responsible research. The method allows ranking **and** ordering the project's stakeholders based on their influence **upon** its responsibility. The purpose of such an assessment is to help research teams to more efficiently devote their limited resources to **stakeholder** management.

The procedure is applied to a case study of the Information and Communication Technology business sector. It is an ongoing project at an early phase of development. Influential stakeholders have been identified first, and have been further classified into groups based on their relative importance. The assessment of their influence has been based on up to 16 different criteria, mainly belonging to the framework of Responsible Research and Innovation.

In the case study, the most influential criterion was the Capability to promote public engagement, while Developers were found to be the stakeholders **most** contributing to the research project responsibility. However, as explained, this is a temporary situation, valid for the current project development situation. It may vary over time as criteria vary in weight and stakeholders vary in influence.

**Keywords:** Stakeholders management, Analytic Network Process (ANP), Responsible Research and Innovation (RRI).

## 1 INTRODUCTION

### 1.1 Responsible research and innovation

The European Commission has been promoting a cross-cutting issue named "Responsible Research and Innovation (RRI)". The aim is to **encourage** researchers to take into consideration the potentially unwanted impacts of their research process and of its outcomes, and make responsible decisions about them. The most widely used definition of RRI could be the one given by Von Schomberg (von Schomberg

2011) (p. 9): *'(RRI) is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products'*. Therefore, researchers and Innovators are expected to answer questions from society about the aims and the consequences of any research, or innovation activity (European Commission 2011).

Therefore, the works under the auspices of the European Commission have found that RRI must involve a dialogue with stakeholders during the whole research and innovation process. The aim being to better align with the stakeholders' interests both the research process and its outcomes. Six key areas for that dialogue were first identified: Public Engagement; Gender Equality; Science Education; Open Access; Ethics; and Governance (European Commission 2012). More recently, two more areas have been added, Sustainability (environmental); and Social Justice (Strand et al. 2015).

Furthermore, Burget et al. (2017) added to the RRI definition that: "Responsible Innovation is essentially an attempt to govern research and innovation in order to include all the stakeholders and the public in the early stages of research and development. The inclusion of different actors and the public is, in turn, meant to increase the possibilities **of anticipating and discerning** how research and innovation can or may benefit society as well as **preventing** any negative consequences from happening" (Burget et al. 2016) (p. 15).

According to Koops and Stilgoe et al. (Stilgoe et al. 2013; Koops 2015), RRI can be conceived as an approach and an ideal. The first one involves the available tools and how we can innovate responsibly. The second involves the inclusion and promotion of self-learning via Anticipation, Reflection, Deliberation and Responsiveness of the innovation process (de Jong et al. 2016). Stakeholders are expected to participate **from** the beginning in the Anticipation stage, at which the potential benefits and **harm** of the research and its possible outcomes are envisaged.

A consortium funded by the EU developed the project RRI-TOOLS, (<https://www.rri-tools.eu/>). In it they have considered RRI as: "doing science and innovation with society and for society, including the involvement of relevant **stakeholder** groups **which are** very upstream in the **process of research** and innovation to align its outcomes with **the** values and expectations of society". Under this umbrella, scientist share with society's stakeholders the traditional dynamic of setting agendas and exploring desirable futures to be **reached** with their research. Stakeholders are now more than just beneficiaries, or users of research and innovation (Stahl and Coeckelbergh 2016).

The insertion of relevant stakeholders in research and innovation activities over time **is** complex, but necessary as the context has a significant impact on the utility of RRI

activities (van de Poel et al. 2017). This procedure considers an inclusive deliberation with a broader set of stakeholders related to the aim of research, its processes and, also, a disposition of stakeholders to act according to novel perceptions (Owen et al. 2013).

However, authors have found a wider than expected reluctance to really engage with stakeholders ([Referencia a nuestro paper en Sustainability](#)). Barriers to stakeholder management in research and innovation projects are, among others, i) lack of the skills for managing stakeholders, i.e. difficulties in identifying stakeholders, their interests and powers, who represent or speak on behalf of them, how to engage in a productive collaboration, etc. ii) protecting innovation, avoiding key information getting to the competitors; iii) resources needed for educating stakeholders so that they can really help; or iv) its perception as an obstacle to the agility of the research practices.

One way to facilitate the process and answer those problems is to prioritize the influential stakeholders. This way, the research team can apply the “Pareto principle” and anticipate the majority of issues related to their responsibility, by working with a reduced set of important stakeholders. Providing those teams can really determine who the most influential stakeholders are.

## **1.2 Stakeholder’s influence in research projects**

There is extensive literature on stakeholder management and evaluation (Aragonés-Beltrán et al. 2017). In fact, Corporate Social Responsibility (CSR) and Project Management theories, have already highlighted the relevance of a detailed analysis of stakeholders and their impact (Dahlsrud 2006).

Stakeholder management starts by the identification of stakeholders and the analysis of their interests or expectations, and their impacts on the project (Brugha 2000). There are several other stakeholder analyses like the one which classifies them in terms of Power, Legitimacy and Urgency (Mitchell et al. 1997); the one based on their Assertiveness and Cooperativeness; the analysis of Influence and Interest in the project (Colin and Ackermann 1998; De Lopez 2001); or the one based on a map of Impact for stakeholders vs Impact for the Project promoters.

Nevertheless, none of those analyses are suitable for assessing the influence of stakeholders on the responsibility of a research and innovation project, or of the future exploitation of its outcomes. Features like interests, power, legitimacy, impact for the promoters, etc. are too indirectly related to RRI.

Hence, the research questions this paper seeks to answer are:

i) In which way can a stakeholder contribute to the responsibility of a project in the framework of RRI? and

ii) How to prioritize stakeholders based on their contribution to the responsibility of a research and innovation project?

Thus, this paper proposes a methodology for evaluating the stakeholders of a research project in the framework of RRI. For this goal we apply the Analytical Network Process (ANP).

The rest of the paper is organized as follows. In the next two sections, a detailed description of the methodology with the help of a case study is presented, explaining the procedure and the results of the application. Finally, conclusions and some challenges posed by this work are included.

## **2 METHODOLOGY PROPOSED**

To solve the research questions, a methodology is put forward based on the combination of two realms: the RRI approach as the framework and the Analytic Network Process (ANP) as the tool.

### ***2.1. Analytic Network Process***

ANP is a multicriteria decision making (MCDM) technique that allows the relative measurement of intangible criteria, as proposed by (Saaty 2001). The ANP procedure generalized his original Analytic Hierarchy Process AHP (Saaty 1990). Both theories provide a framework to address decision making or problem assessment. AHP has been accepted as a leading MCDM method due to its ease of use for preferential information elicitation from expert subjects, in order to assign priorities to the criteria or indicators involved in a problem (Sólnes 2003; Ramzan et al. 2008; Šijanec et al. 2009; Akbari et al. 2017). However, AHP does not **allow us to consider** the interdependencies among criteria.

For this reason, the use of the ANP is proposed because it develops a better representation of the complex interactions, interdependencies and feedback relationships among the different components of problems like those of RRI (Saaty and Peniwati 2008; Sipahi and Timor 2010; Botero et al. 2015; De Lotto et al. 2016; Shiau and Chuen-Yu 2016; Wu and Cui 2016). This way, besides, it avoids the compensation problem of other models (Peris et al. 2013). A problem is modelled as a structure or network system composed of different elements (criteria and alternatives), grouped in clusters and connected to each other by influences among them.

The main steps to solve a multicriteria decision-making problem using ANP are the following (Saaty 2001):

1. Identifying the components and elements of the network and their relationships. The problem is then structured as a network.
2. Conducting pairwise comparisons of the elements. Elements are compared using Saaty's 1-to-9 scale. The ANP prioritizes not just elements but also groups or clusters of elements as is often necessary in the real world.
3. Placing the resulting relative importance weights (eigenvectors) in pairwise comparison matrices within the matrix (unweighted matrix).
4. Conducting pairwise comparisons of the clusters.
5. Weighting the blocks of the unweighted matrix, by the corresponding priorities of the clusters, so that it can be column-stochastic (weighted matrix).
6. Raising the weighted matrix to limiting powers until the weights converge and remain stable (limit matrix).
7. **Obtaining the prioritizations of the elements** according to any of the columns of the limit matrix.
8. Once the results are obtained, in case some alternatives achieve very similar results, a sensitivity analysis should be carried out in order to demonstrate the robustness of the ranking obtained.

Mathematical foundations of AHP and ANP can be found in Saaty (Saaty 1990, 1994, 2005, 2008). Several authors introduce the use of ANP in different **areas**; a review of the main developments in the AHP and ANP can be found in Vaidya and Kumar (Vaidya and Kumar 2006), Görener (Görener 2012), and Sipahi (Sipahi and Timor 2010).

Some recent applications of ANP to the field of stakeholder management are found in (Sangle and Babu 2007; Bhupendra and Sangle 2017) and (Rosso et al. 2014). Evidence regarding the use of ANP for assessing or developing **indexes** or indicators related to stakeholders of a complex problem has been found in (Aragonés-Beltrán et al. 2017).

## **2.2. Methodology**

The methodology proposed is organized in three main phases: i) Designing the case study, ii) Modelling the influence assessment with an ANP model and ii) Assessing **stakeholder** influence for RRI by means of ANP. Fig. 1 shows an outline of the methodology.

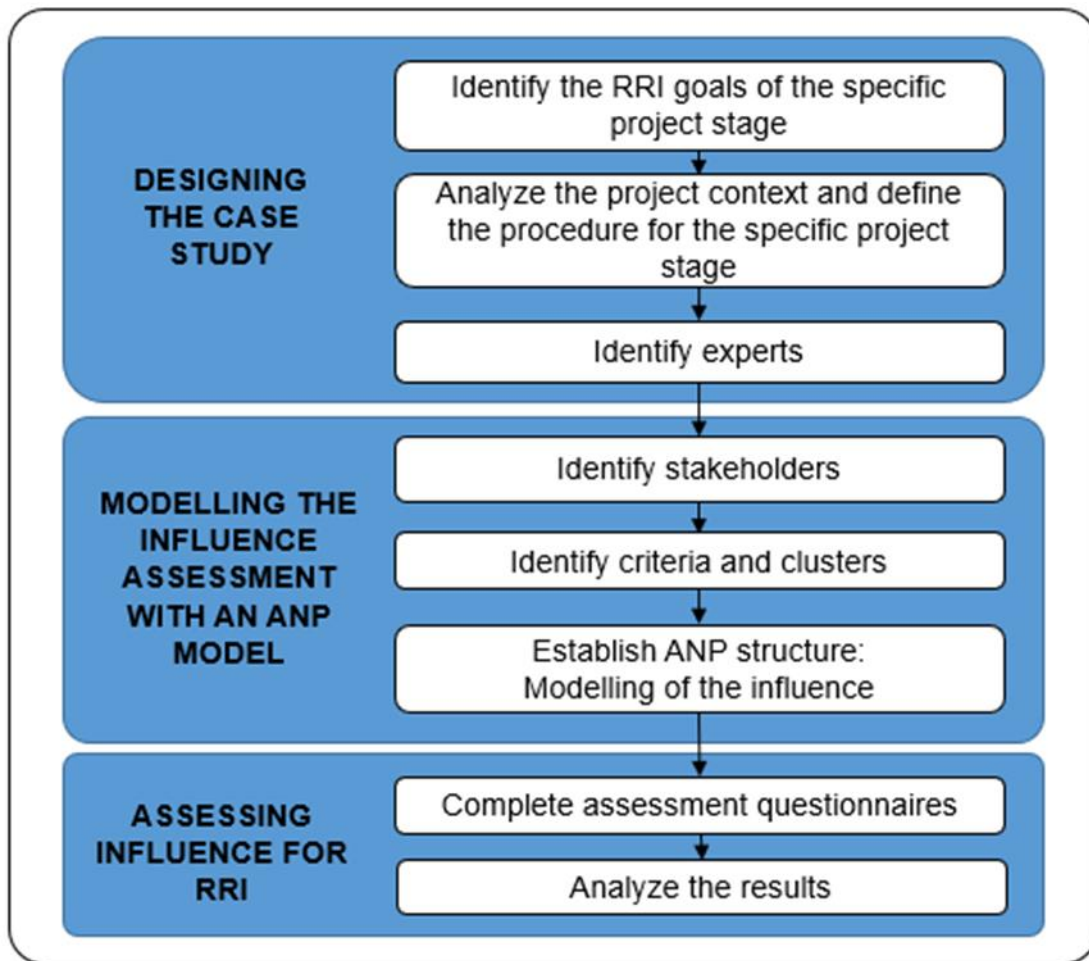


Figure 1. Methodology proposed

### 2.3 Designing the case study

This phase is divided into three stages:

- i) "Identify the RRI goals of the specific project stage". At this stage, the RRI challenges to be addressed are identified by the research team based on their knowledge of the discipline. It is a preselection of RRI issues that will be later reviewed with the selected prioritized stakeholders.

The six key areas for social desirability of the research activity proposed by the European Commission help in designing a starting set of questions.

- ii) "Analyze the Project context and define the procedure". This stage is carried out in two steps. The first step continues the previous stage, but focusing now on the context of the project. That means, identifying how the people, culture, infrastructure, institutions, etc. directly related to the project may be impacted socially, environmentally, economically, etc. Also, whether the impacts are positive or negative. Finally, who in particular may be most harmed or who the potential beneficiaries, partners, etc. may be.

In the second step, a procedure based on ANP is designed to determine the assessment of stakeholders. In this first contact with ANP the goal is set. For the

purpose of this investigation, the goal of the ANP is: To assess how much stakeholders contribute to the anticipation of the responsibility of the project and the exploitation of its outcomes.

That means, the dependence among elements will be the influence of each element on the others towards the achievement of the ANP goal.

- iii) "Identify Experts". In this stage it is determined who can develop an ANP model of the problem **to be solved**. Those experts identify the elements of the model: alternatives and criteria; arrange them into a network of several layers and clusters, the ANP model; and judge which element is preferred to which element, and to what extent, in pairwise comparisons of the same cluster.

## ***2.4 Modelling the influence assessment with an ANP model***

This phase is also divided into three stages:

- i) "Identify Stakeholders": The Stakeholders represent the alternatives that are evaluated in the project. **Thus**, in this stage the work is focused on identifying all possible Stakeholders; **singling** them out and arranging them into a list of different stakeholders, although they may have dependencies among them; and **identifying** who represents those stakeholders and may act as their spokespersons.
- ii) "Identify criteria and clusters": At this stage, the **remaining** elements are identified, i.e. decision making criteria. Hence, experts identify which characteristics of the stakeholders act as criteria for assessing their contribution to the ANP goal. Later the criteria that arise (generally not generated in an orderly manner) are hierarchically ranked into clusters using the ANP procedure.
- iii) "Establish ANP structure": After having the alternatives and criteria, this third stage comprises two steps: first, experts establish the structure of the ANP model by finding out dependencies that connect elements among them. Then, questionnaires are elaborated for judging those dependencies, in this case, judging how much more one element or another influences a third one. The influence meaning the contribution to anticipating the responsibility of the innovation project.

## ***2.5 Assessing stakeholders' influence for RRI by means of ANP***

In this phase, experts complete the questionnaires and analyse the results. All the time they were supported by the ANP facilitators. Also they worked in coordination with the project research team. The latter will decide later how to manage the prioritized stakeholders. A detailed description of the methodology implementation is presented in the case study in the **following** sections.



### **3 CASE STUDY: ASSESSING STAKEHOLDERS' CONTRIBUTION TO THE ANTICIPATION OF THE RESPONSIBILITY OF A RESEARCH PROJECT.**

#### **3.1 Case study design**

##### *3.1.1 Identify the RRI goals of the specific project stage*

The model has been applied to ongoing research. The project aims to develop a real-time recommendation system with dynamic content based on the context of the user in mobility and their social networks to reduce the human interaction with the mobile device and improve the user's experience. The system is a novel Information and Communication Technologies (ICT) application aimed at encouraging consumption in smart cities based on consumer preferences. Allowing local businesses to offer personalized products and services in real time through an app in the beneficiaries' smartphones.

This project is currently in an early stage (phase 1 of 9) of development. The six key areas of RRI were reviewed and, based on the researchers' experience, they were all selected for the research. They found challenges to be correctly anticipated in all the six areas.

##### *3.1.2 Analyse the Project context and define the procedure*

In this case the project is developed **in order to improve** the tourist experience and support local businesses for a city. It consists of the following phases:

1. Analysis, requirements and specifications of information consumption **regarding** mobility: The purposes of this first phase are to identify, describe and specify the most relevant requirements of end users, stakeholders and technology, at a detailed level to inform and guide the research project and development work on subsequent phases.
2. User profiles and clustering: This phase focuses on the storage of large amounts of data, a variety of information sources, and high capacity data processing and modelling.
3. Cognitive processes of the user: The main objective here is to offer a comprehensive understanding of the different clusters of potential end-users of the platform and their needs.
4. Tools for the analysis and semantic management of conversations in Social Networks: The main objective of this phase is to provide the methods for semantic analysis of conversations on social networks.
5. Real-time recommendation systems: This phase addresses creating a real-time **advisory** system based on the management and exploitation of information in the context of mobile users and social media participation.

6. Mobile app: Here, a robust mobile application is developed for the purposes of the research.
7. Validation and evaluation: The aim of this phase is to carry out a user-centred design process throughout the project, involving the end user in all phases of the project.

The project is currently in its first phase, developed by a multidisciplinary team from a local University, a Local Tourist Office and several firms in the private sector.

### *3.1.3 Identify Experts*

Three experts have been selected for the procedure, representing different approaches to the problem. Expert 1 is a project **manager; a person with an engineering background with years of experience in management** of research projects. Management ranging from technical issues of small projects to complex management of multiyear big projects with **dozens** of human resources, hundreds of thousands of Euros budget, several scientific disciplines involved, etc.

Expert 2 is **an** RRI researcher. This person started in Corporate Social Responsibility and in the last 5 years has participated in European and national projects about RRI and how to operationalize it. Expert 2 has experience the analysis of RRI in both publicly and privately funded research and innovation projects

Expert 3 has a wide experience in **stakeholder** participation, multicriteria decision making and negotiation methods. Expert 2 usually participates in great scope projects with complex interaction with different stakeholders that produce important social, environmental and economic impacts, both positive and negative.

In ANP, due to the kind of information available, the quality of experts is more important than the number of them, as discussed in [Referencia al paper de Antonella: An AHP-Topsis Integrated Model for Selecting the Most Appropriate Tomography Equipment, el que nos pide el reviewer 2]. To be considered an appropriate expert for the research, requisites were: broad experience on the issue, to belong to a specific **category** of key actors of the problem: expert on research projects, RRI expert, or **stakeholder** expert. and willingness to learn the procedure. Only the above listed experts fulfilled all the requirements. Unfortunately, other experts who could have enriched the outcomes were not available or not suitable. In order to prevent biasing the results, only one expert per approach was selected.

### **3.2 Modelling the ANP Model**

The first step to build the ANP model **is** to **determine** the main goal. In this case **it** is “To assess how much stakeholders contribute to the anticipation of the responsibility of the project and the exploitation of its outcomes in a **context of RRI**”. Afterwards the elements of the model were identified (section 3.2.1 and 3.2.2). The authors of this paper acted as ANP facilitators.

### 3.2.1 Identification of stakeholders

Stakeholders are considered the first cluster of elements in the ANP model. They represent the elements that will be evaluated. A first list of stakeholders was developed based on a literature review. An initial list was elaborated with 14 stakeholders.

Later, a panel of interested actors was arranged to discuss the list of stakeholders based on the project activities and expected outcomes, the experience of the members of the project consortium, and the early stage at which the project **stands** currently. The panel was formed by the ANP experts, the authors of the paper and selected members of the project consortium. 7 of the former stakeholders were discarded as “not influential now”: “Media”, “Regional government”, “Suppliers”, “Labour unions”, “Competitors”, “Law institutions” and “Owners of the business **or** partners in the consortium”.

Finally, of the seven stakeholders in the list, “Neighbourhood associations” (they are directly affected or benefited by tourism) and “NGO’s” (interested in the social-environmental impacts of tourism) were also discarded. They were found to be much less influential than the other five for this specific project at this current stage, and it was not necessary to assess them.

Hence, five stakeholders **were** finally added to the ANP model:

- S1. Users: they are beneficiaries of the project. Anyone who is or could be interested in the city’s offer. Mainly: Tourists, visitors or residents. The main interest of this group in the project is in the services of the final results, the app for smartphones.
- S2. Business: they are also beneficiaries. Anyone who offers an activity of leisure or entertainment in the city, e.g., restaurants, museums, hotels, mobility and transportation, concerts, events, exhibitions, etc. Their main interest is to improve the communication of their offer of products and services.
- S3. Local Tourism Office (LTO): It takes the role of the stakeholder “policy maker”. In this case, the policy maker would be the LTO, which is the most relevant authority in terms of tourism management. Its main interest is contributing to the tourist development of the city.
- S4. Developers: It takes the role of the stakeholder “employees”. The group that creates and designs all the digital content. They are the intermediators between users’ preferences and business offer.
- S5. The National Ministry of Economy: It takes the role of “funders” It provides the economic resources and demands to meet the goals, deadlines and quality requirements of the project.

### 3.2.2 Identification of criteria and clusters

The rest of the network elements are the criteria which could evaluate the influence of stakeholders in the project responsibility. Elements that have a general character to evaluate influence in terms of RRI **were** identified at the cluster level. Each of them was further divided into sub-elements (criteria). According to the method followed in other AHP/ANP applications (Saaty 2001; Sipahi and Timor 2010)

An initial list of criteria for each cluster was defined based on a literature review (Claudia et al. 2014; Rosso et al. 2014; Strand et al. 2015; Aragonés-Beltrán et al. 2017; Lubberink et al. 2017; RRI-TOOLS project). It was necessary to make sure that these criteria were relevant and not redundant (Saaty 1990; Yüksel and Dagdeviren 2007; Görener 2012). With the assistance of the experts, the final criteria list was obtained. Experts **established** the definition and the purpose of each criterion, making sure that each expert understood them. The final list has 16 criteria grouped in three clusters (Table 1).

Table 1. Evaluation criteria

Cluster	Definition	Criteria	Definition
C1. Knowledge of RRI areas	<p>Criteria aimed at assessing stakeholders' knowledge of RRI concepts.</p> <p>In general this is a weak point, since there is a general lack of knowledge of the topic, which implies the need to inform the stakeholders about the most basic concepts of responsibility.</p> <p>The Criteria of this cluster are the eight key areas of the RRI.</p>	C1.1 Public engagement	It refers to the societal commitment to provide encouragement, opportunities and competences in order to empower citizens to participate in debates around R & I, with potential feedback and feed-forward for the scientific process.
		C1.2 Gender equality	Promotes the equal participation of men and women in research activities and the inclusion and integration of gender perspectives in R & I content.
		C1.3 Science education	The need to enhance the current education process to better equip future researchers and other societal actors with the necessary knowledge and tools to fully participate and take responsibility in the research and innovation process.
		C1.4 Ethics	Related to research integrity and good research practice, the protection of the objects of research and, the societal relevance and ethical acceptability of R & I outcomes.
		C1.5 Governance	Any form of coordination designed to foster and mainstream RRI within an organization or in the interaction with other stakeholders
		C1.6 Open access	Practice in which the scientific process is shared completely and in real time.
		C1.7 Sustainability	Evaluates to what extent a research field, a research program or an RRI initiative contributes to sustainable growth.
		C1.8 Social justice	Impact of research and its effect on social justice/inclusion. Considered from the relationship between the researchers and the research subjects; and the participation of social groups in benefits arising from research.

Cluster	Definition	Criteria	Definition
C2. Diffusion	Refers to some attributes that allow stakeholders to engage in the dialogue and spread the project, to generate debates and networking and to identify relevant aspects.	C2.1 Transversality	It refers to the diversity of stakeholders, to how complex it is.
		C2.2 Group size	The number of members in society of a stakeholder.
		C2.3 Activism	How active, critical or proactive a stakeholder is.
		C2.4 Relations with the project	Evaluates how the relationships between the project consortium and the stakeholders are. It takes into account previous relationships.
C3. Possible resources providers	Refers to the willingness and capability of one stakeholder to provide the project with resources.	C3.1 Financial	How much a stakeholder can contribute with financial resources to anticipate the project responsibility.
		C3.2 Communication	How much a stakeholder can spread out and communicate the project to help achieve the desired anticipation.
		C3.3 Personal	How much a stakeholder can contribute with human resources to anticipate the project responsibility.
		C3.4 Hard-data	How much a stakeholder can contribute with reliable and accurate data to help to anticipate the project more responsibility

### 3.2.3 Establishing ANP structure

After the identification of the elements, dependencies among them were determined by experts using a relationship matrix, where one (1) means that the element of the column depends on the element of the row, and zero (0) means that there is no dependence among them (Table 2). Dependence of A on B, as explained, means B influences A as regards the ANP goal, i.e. B influences A for the assessment of how much a stakeholder contributes to the anticipation or RRI issues of the project. For example, cell a<sub>12</sub> = 1 means the element 1.2. Gender equality is influenced by the element 1.1. Public engagement for the assessment. And experts considered that on the grounds that for identifying gender inequality issues public engagement is needed. But the contrary was found to be true too, element 1.1 is influenced by element 1.2 and experts filled cell a<sub>21</sub> = 1. That is so because they consider that if there is gender inequality the public will more easily get engaged in the debate about the desirability of the projects and their outcomes, and go beyond the specific gender issues.

Table 2. Dependence matrix of all elements of the model

	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	S1	S2	S3	S4	S5
1.1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1
1.2	1	1	0	0	1	0	0	1	1	0	1	0	0	0	0	0	1	1	1	1	1
1.3	1	0	1	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	1	1	1
1.4	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	1	1	1	1	1	1
1.5	1	0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	1	1	1	1	1
1.6	0	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	1	1	1	1	1
1.7	1	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1
1.8	1	1	0	0	0	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1
2.1	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1
2.2	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	1	1	1	1	1

2.3	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1	1
2.4	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
3.1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
3.2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	1
3.3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1
3.4	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	1	1
S1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
S5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The proposed model is illustrated by the network shown in Figure 2. The arrows indicate dependencies between clusters. That is to say, the elements in a cluster (i) exert some influence over elements in another cluster (j). Feedback arrows mean that there are influences among criteria belonging to the same cluster. Bidirectional arrows indicate influences in both directions.

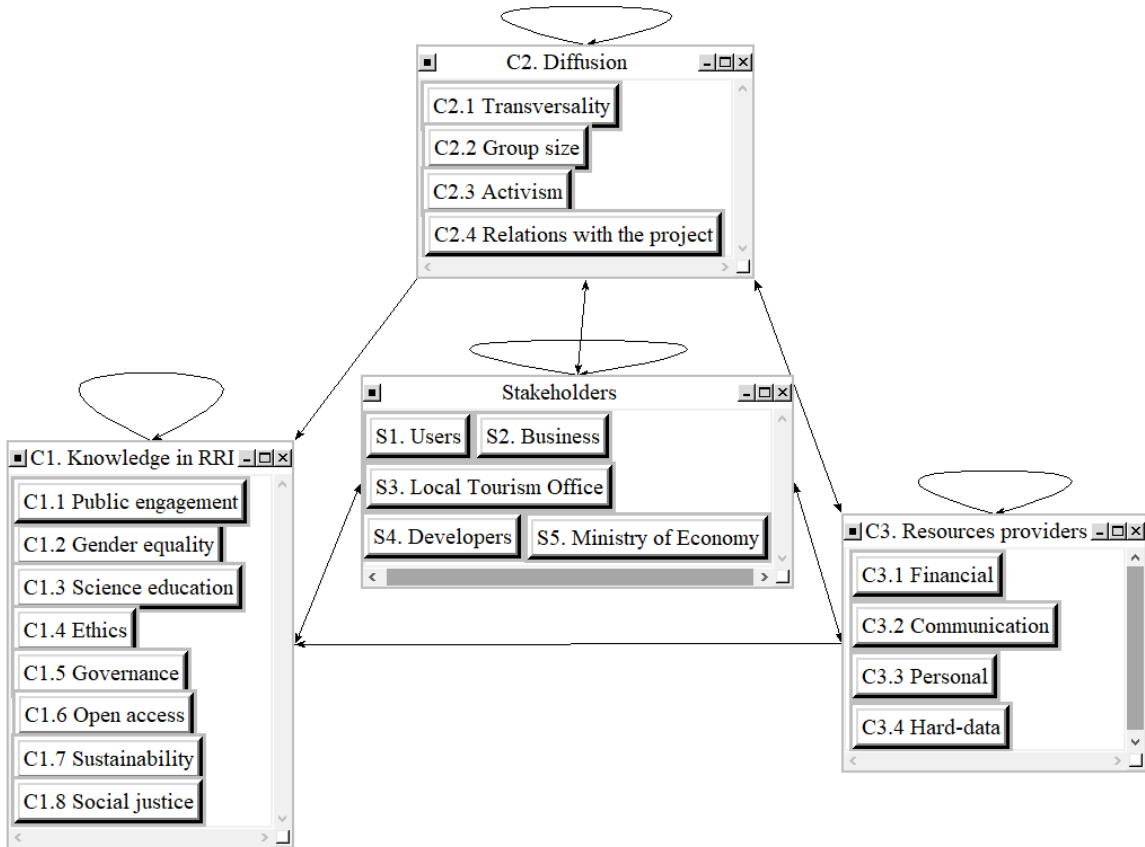


Figure 2. ANP network model of the case study.

### 3.3 Assessing stakeholders' influence by means of ANP

Once the model was agreed upon, the ANP questionnaire was designed with the aim of determining a *relative importance* for each stakeholder with regard to all the

considered criteria. That is to say, how much each stakeholder can contribute to the anticipation of the responsibility of the project. The required judgements were collected from the experts through a questionnaire designed with pairwise comparisons. Figure 3 shows an example of one of the questions.

In your opinion, which of the two criteria influence more on the criteria C1.1 Public engagement? Place an X where appropriate.																		
	Extreme	Very strong	Strong	Moderate	Equal	Moderate	Strong	Very strong	Extreme									
C1.2 Gender equality	9	8	7	6	5	5	x	2	1	2	3	4	5	6	7	8	9	C1.3 Science education
The answer in this example indicates that the Criteria C1.2 Gender equality is moderately more influential on the element C1.1 Public Engagement than C1.3 Science education.																		

Figure 3. Example of a question used for the ANP questionnaire

All the calculations were performed using the Superdecision© v.2.0.8. software. Once experts finished all pairwise comparisons, a limit supermatrix per expert was obtained.

The final limit matrix has the same values in all the columns. It shows the weight obtained for each element, a non-dimensional value that can be considered as their relative importance as regards the ANP goal. These values were normalized (by multiplying them by a constant that is the reciprocal of their sum (Saaty 1990)) to obtain the final results. Care was taken to ensure that all pairwise comparison matrices had a consistency ratio (CR) of less than 10%, as required by the method.

Since 3 experts were interviewed, 3 individual results were obtained. Each one shows the relative importance according to their judgments. Aggregation of Individual Judgments (AIJ) was performed in order to obtain a global judgement for all the experts, that is to say, a new limit supermatrix with the aggregation by means of the geometric mean of the judgments of the three experts. Then another final limit matrix was calculated showing the aggregated preferences of the experts.

#### 4 DISCUSSION OF RESULTS

In order to present the results, three different analyses have been carried out. First, the weights of the clusters have been obtained and compared both for the individuals and for the group. Secondly, criteria have also been analysed for the individuals and for the group. Thirdly, the ranking of the analysed stakeholders has been obtained, which is the final aim of this whole evaluation process.

#### 4.1. At the cluster level

The cluster weighting provides some important insights into the overall perspective and underlying participants' conception of how the project consortium could involve stakeholders in responsible research. Individual preferences show that Expert 1 and Expert 3 give the highest importance to *C2. Diffusion* (Table 3 and Figure 4). This means that in order to anticipate the RRI issues of the project, these experts consider it to be more important to take advantage of the stakeholders' potential to spread out the project engaging people in the debate. While for Expert 2 *C1. Knowledge of RRI* areas is clearly more important than any other characteristic or resources that a stakeholder might have.

The aggregated result shows more balanced weights, as usual. The most important clusters are *C2. Diffusion* (0,341) and *C1. Knowledge in RRI Areas* (0,316). In a second level *C3. Resources* (0,144) would be classified.

Table 3. Results obtained for the clusters

Cluster	Expert 1	Expert 2	Expert 3	Aggregation
C1. RRI Areas	0,0965	0,6884	0,1645	0,2698
C2. Diffusion	0,4094	0,1816	0,4330	0,3868
C3. Resources	0,2895	0,0501	0,0939	0,1348
Stakeholders	0,2047	0,0799	0,3085	0,2086

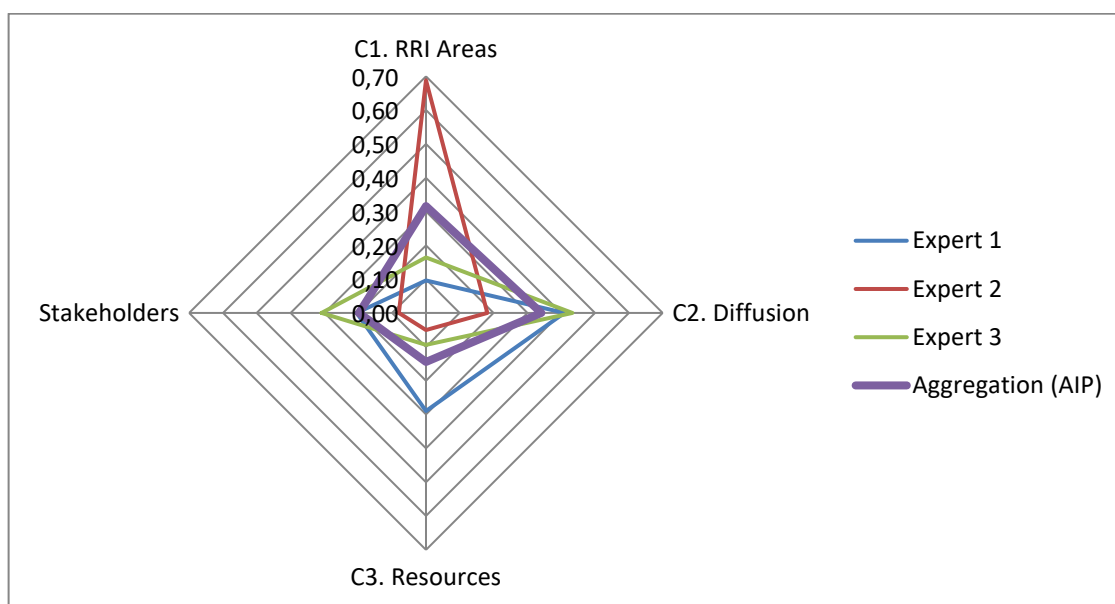


Figure 4. Cluster results according to experts, and aggregated results.



## 4.2 At the criteria level

Regarding these results the main conclusion is that the most relevant criterion is *C1.1 Public engagement* (Table 4). In fact, it is the first criterion for Experts 2 and 3, and the second most important for Expert 1. Following in importance we obtain a group of criteria formed by, *C1.8 Social Justice*, *C2.4 Relations with the project* and *C2.1 Transversality*. Expert 2 shows different preferences compared with Experts 1 and 3, who show more similar profiles.

The most important criteria after *C2.4 Relations with the project* for Expert 1 are *C1.1 Public engagement*, and *C2.1. Transversality*. For expert 2 there are two main criteria: *C1.1 Public engagement* and then *C1.8 Social justice*, the others fall clearly behind. Finally, Expert 3 considers as **does** Expert 1 that *C2.4 Relations with the project* is most influential, then *C1.1 Public engagement*, and then *C2.1. Transversality*.

Table 4. Results obtained for the criteria

Criteria	Expert 1	Expert 2	Expert 3	Aggregation
C1.1 Public engagement	0,115	0,230	0,115	0,152
C1.2 Gender equality	0,034	0,107	0,062	0,068
C1.3 Science education	0,073	0,060	0,024	0,052
C1.4 Ethics	0,022	0,079	0,040	0,047
C1.5 Governance	0,039	0,101	0,078	0,073
C1.6 Open access	0,046	0,022	0,026	0,031
C1.7 Sustainability	0,012	0,057	0,030	0,033
C1.8 Social justice	0,059	0,171	0,099	0,110
C2.1 Transversality	0,113	0,060	0,113	0,095
C2.2 Group size	0,037	0,014	0,065	0,039
C2.3 Activism	0,101	0,025	0,084	0,070
C2.4 Relations with the project	0,129	0,033	0,148	0,103
C3.1 Financial	0,087	0,009	0,042	0,046
C3.2 Communication	0,055	0,017	0,014	0,029
C3.3 Personal	0,027	0,006	0,024	0,019
C3.4 Hard-data	0,051	0,012	0,037	0,033

Global results of table 3 are shown in Figure 5 for clarity. As can be seen, after the highlighted criteria: *C1.1.*, *C1.8.*, *C2.4* and *C2.1*, follows a group of criteria formed by *C1.5 Governance*, *C2.3 Activism* and *C1.2 Gender equality* with an importance of between 6 and 8%. The least important criteria are: *C3.4 Hard-data*, *C1.7 Sustainability*, *C1.6 Open access*, *C3.2 Communication* and *C3.3 Personal*, that have an importance of 3% or less. In general, as introduced, criteria of cluster 3 *Resources* are less valued for the anticipation of the responsibility of the project.

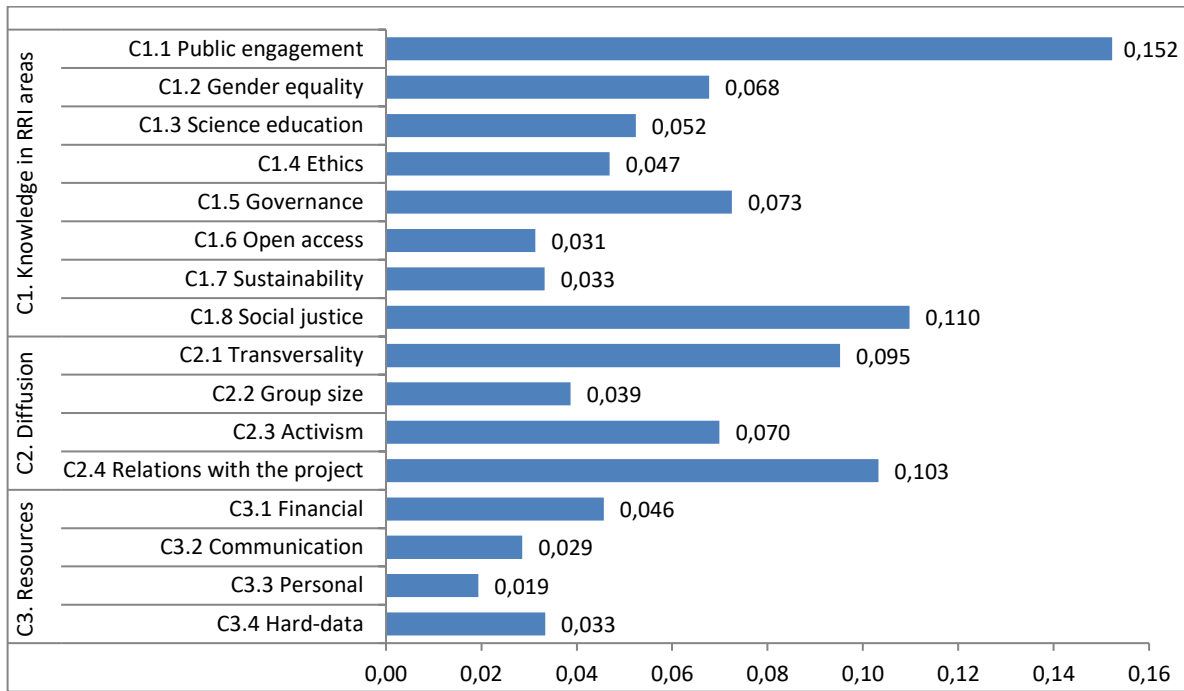


Figure 5: Results for the criteria.

To end with the discussion of the results for assessment criteria, the case under study has specific characteristics that, together with those of the consortium members, have shaped the most important features to select the influential stakeholders. That criteria related to **stakeholder** competence and willingness to debate, and their closeness to the research members, are so influential, **which** does not mean that features like **stakeholder** group size, activism or possibility to add their own resources to the anticipation of RRI issues may not be more valued **by** other research teams in other projects, at other development stages.

### 4.3 Stakeholder influence

An overall preference for each stakeholder with regard to all the considered criteria has been obtained. It assesses **the** relative importance of each stakeholder with regards to the ANP goal. Therefore, the higher the preference, the more influential the stakeholder is. Table 5 show the values of the final limit matrixes and the normalised values. As can be seen, on average the most influential stakeholders are: S4. Developers (24,8% of the total weight), S5. Financial support (23,1%) and S3. Local administration (21,8%). In a second group fall S1.Users (18,6%) and S2. Business (11,6%).

Table 5. Limited and Normalized values for the stakeholders

Sta		Expert 1		Expert 2		Expert 3		Aggregated	
		Limit	Normalized	Limit	Normalized	Limit	Normalized	Limit	Normalized
		S1. Users	0,052	0,151	0,068	0,176	0,079	0,231	0,065

S2. Business	0,037	0,106	0,062	0,162	0,028	0,081	0,040	0,113
S3. Local Tourism Office	0,077	0,223	0,090	0,233	0,068	0,198	0,078	0,220
S4. Developers	0,092	0,267	0,075	0,194	0,097	0,283	0,087	0,248
S5. The National Ministry of Economy	0,087	0,252	0,090	0,234	0,071	0,208	0,082	0,233
	<b>0,345</b>	<b>1,000</b>	<b>0,385</b>	<b>1,000</b>	<b>0,343</b>	<b>1,000</b>	<b>0,353</b>	<b>1,000</b>

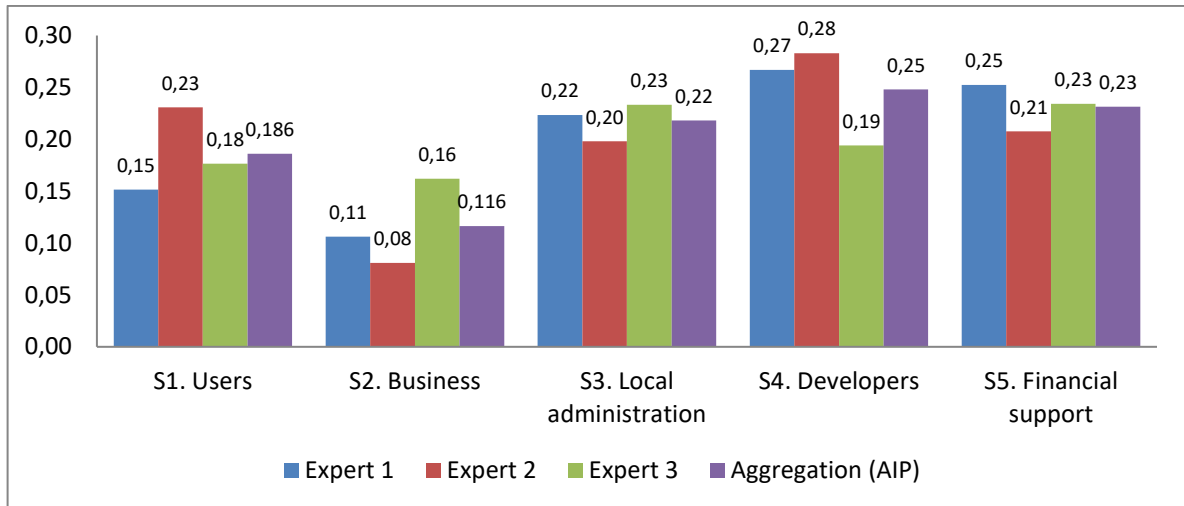


Figure 6: Results for the stakeholders

The results also **allow us to analyse** the experts' individual preferences. Based on the obtained results (Table 5, Figure 6), the different experts show some differences in the ranking order of the five stakeholders. For expert 1 the ranking order of stakeholders would distinguish S4 Developers, S5 The National Ministry of Economy, and S3 Local Tourism Office from the rest. For expert 2 only S5 The National Ministry of Economy and S3 Local Tourism Office would be highlighted. And for Expert 3, only S4 Developers and S1 Users would be the most preferred.

The results, besides, allow **us** to differentiate groups of stakeholders based on their importance. This differentiation is qualitative and open to different interpretations, **and** here the decision of the project consortium members is shown. Based on the procedure and its learning, **and** also looking at the differences among **stakeholders'** final ANP values, three groups were made. It is important to mention that all stakeholders of this classification are influential and ought to be managed. But in a situation of limited resources and some **reluctance of the stakeholders to tackle** the challenge of RRI, it is advisable to devote more resources: time, people, effort, money, etc. to the most influential ones. And hence the interest to classify them.

The first group was called the most influential **one** (S4 Developers, S5 The National Ministry of Economy, and S3 Local Tourism Office) including those who, according to the **experts'** judgments are the stakeholders who can contribute more to the

anticipation of the responsibility of the project. Therefore, they should be the ones who the consortium should focus on managing.

The second group (*S1 Users*) is called just influential, as they are less clearly preferred at that moment for the RRI analysis. However, Users are key to the project and involved in the research itself in the user-centred design. In fact, their influence on the RRI issues may change as the project evolves into a new phase where the procedure of the application will be further developed and, for example data privacy, offers discrimination, environmental information, or other project decisions will be more relevant. Also, the ranking of stakeholders, or the inclusion of new ones, may be needed as the team follows the RRI self-learning process and moves on to Reflection, Deliberation or Responsiveness (Stilgoe et al. 2013).

Finally, (*S2 Business*), are the least preferred among the influential at the moment. The experts have found the other stakeholders to be preferred for debating the responsibility of the research at its current development phase. Later, when the detailed determination of the app contents demands from Users and Business a closer participation, their role in the responsibility of the project is expected to be clearly more influential.

ANP also allows us to analyse why some of the alternatives are preferred to others. In this case, this analysis shows those stakeholders to be more influential on C1.1. Public Engagement, C1.8. Social Justice and C2.4. Relations with the project, obtained the higher values.

## CONCLUSIONS

In this paper we have provided a novel application of an MCDM technique to evaluate the stakeholder influences on a project, which in this case is applied to their contribution to the anticipation of the responsibility of the project and its possible outcomes. By means of the model the global concept of influence is broken down into sixteen criteria, evaluating different aspects that together enable us to define a preference. The preference measures the greater or lesser influence of stakeholders on research responsibility within a framework of RRI. Thus, they can prioritize based on their expected contribution to the anticipation of the issues related to the social desirability of the activity.

Stakeholder management is normally a key activity in research, and particularly so in responsible research. Within stakeholder management, stakeholder analysis is critical for identifying, understanding and proposing strategies for involving them as much as decided. The existing methods of stakeholder analysis can be complemented with the results of the investigation herein presented. The ANP method has shown useful to rank and order the stakeholders, a purpose other methods do not cover, or address

very indirectly. Besides, ANP can be adopted and applied to other types of influence assessment.

According to the RRI perspective, as the project develops, a more inclusive stakeholder dialogue will be necessary, including a broader spectrum of stakeholders. For example, in this case study, experts discarded firstly listed stakeholders like *S7 Neighbourhood associations* (they are directly affected or benefited by tourism) and *S6 NGO's* (interested in the social-environmental impacts of tourism). However, those stakeholders can vary their influence later in the project's development. Or in a following stage of the team's RRI self-learning process: Reflection, Deliberation or Responsiveness.

As regards the results of the case study, the ANP goal was to assess how much stakeholders contribute to the anticipation of the responsibility of the project and the exploitation of its outcomes. Based on that, Expert 1 the project manager and Expert 3 the stakeholder manager give similar evaluations to criteria, highlighting the criterion C2.4. Relations with the project, and C1.1. Public engagement. While Expert 2, the RRI researcher, does not give importance to C2.4., gives importance to C1.1., and gives importance to C1.8. Social justice itself is not really considered by the other experts. The aggregation of the experts' judgments leads to the assignment of the highest importance to criterion C1.1., followed by C1.8. and C2.4. And the least importance to C3.3. Personal and C1.6. Open access.

The most influential stakeholder of the case study evaluated is "*S4 Developers*", based on the ANP goal. For the experts and the paper authors this is understandable as, considering the early stage the project is in, and going through Anticipation in the self-learning process of the project consortium, this stakeholder is key in the usability, inclusivity, energy consumption and other features that will make the greatest social-environmental impacts, should the project be finally carried out, and its foreseen app become a success.

The selected experts have found those stakeholders best related to the project, and more able to engage the public in a debate about the project's RRI issues. They are indeed the ones that can contribute the most to the anticipation of those issues.

As recommended by the developer of ANP, once the results are obtained a sensitivity analysis should be carried out in order to demonstrate the robustness of the ranking obtained, particularly in case some alternatives achieve very similar results. This was the case of this paper, although the sensitivity analysis only gives changes in the order of ANP elements within the identified groups, i.e. the classification of criteria or stakeholders based on their influence. Therefore, the groups of most and least influential criteria and alternatives have the same components, all through the sensitivity analysis.

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