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Prioritizing stakeholders to boost collaborative R&I projects benefits: an analytic network process approach

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Abstract

A methodology was developed to prioritize stakeholders of a collaborative research and innovation (R&I) project in the circular bioeconomy area, towards enhancing its benefits from a multi-perspective point of view. The concept of R&I project benefits was broken down into criteria, evaluating different attributes related to the project outputs and outcomes, to the project management processes, and to the social, environmental and economic dimensions. The devised methodology was based on a combination of the analytic network process multicriteria decision making method and the key benefit categories from the P5 standard for sustainability in project management. The P5 standard has been shown to adequately frame the benefits to stakeholders of R&I projects in the topic of circular bioeconomy. Key benefits identified by the experts relate to the categories "society and costumers" and "consumption". The following stakeholders should have priority in the development of the project stakeholder management plan: research team members, leaders at the consortium organizations, project management team members and environmental NGOs. Future research will include a longitudinal study of the perceived stakeholder and benefit categories priority over time.

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Keywords: stakeholder management; project benefits; R&I impact; analytic network process; research management; university-industry collaborations

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1. Introduction

Research and innovation (R&I) is crucial for the economy competitiveness, being innovation one of the most important strategies to achieve organizational and societal growth. R&I projects increasingly involve a diverse array of entities such as higher education institutions, industry, end-users, policy-makers, etc. However, collaborative R&I projects are often complex to manage as they have unique characteristics, e.g. in what concerns stakeholders and risks complexity, that influence project management (PM) approaches [1].

The increasing private and public investment in collaborative R&I projects has increased the society pressure to make R&I consortia accountable and to demonstrate the value of the projects undertaken. This concern is not new as back in 1997 Stevens and Burley already reported that approximately 40% of the average product development projects failed to achieve market benefits [2]. Besides outputs such as publications or patents and outcomes such as economic achievements, successful projects are increasingly required to clearly show what their benefits beyond scientific and technical dimensions are for the society at large, although only to a limited extent [3, 4].

In the PM literature, the imperative of achieving impact, namely from the social, economic and environmental points of view has led to the uprise of a new school of thought labelled as "sustainable project management" [5]. Recent developments include the development of the 'P5 standard for sustainability in project management' [6], that goes beyond the Triple Bottom Line (Profit, People, Planet) and includes the project product impacts and the project management processes impacts in a set of focus areas to consider when managing the benefits of a project [6].

In the specific topic of the circular bioeconomy (CBE), at the intersection of the bioeconomy and circular economy realms [8], there is a lack of a specific benefit evaluation framework that considers its sustainability dimensions (from the social, economic and environmental points of view). Therefore, the use of the P5 standard as a proxy for project benefits categorization is particularly relevant for CBE projects. To the best of our knowledge, there are no reports in the literature that use this approach.

The international standard for guidance on PM (ISO 21500:2012) suggests the relevance of a detailed analysis of stakeholders and their impact on the project. However, the role of sustainability has not yet been explored through the relationship between stakeholders and PM [9]. Sustainability implies a difficult balance between the economic, social, and environmental dimensions of relationships between organizations and stakeholders. Typically, PM does not consider stakeholders in the broader perspective associated with sustainability. Also, generally, it does not consider what happens in the long term, once a project ends [9]. Consequently, the exploration of the interactions among R&I activities, stakeholder management, and PM is particularly relevant. This important area of research, the focus of this paper, is a crucial tool for incorporating socioeconomic and environmental variables that affect stakeholder management processes, influencing project benefits.

A revised thinking of project stakeholder management is required due to many different demands on the project, including their sustainability dimension [10]. Within stakeholder management, stakeholder analysis is critical for identifying, understanding and proposing strategies for involving them. The existing methods of stakeholder analysis (e.g., based on their legitimacy, power and urgency – the salience model [11]) can be complemented with the results of the investigation herein presented. The multicriteria Analytic Network Process (ANP) method has shown to be useful to rank and order stakeholders [12], a purpose other methods do not cover, or address very indirectly.

In this paper we present a methodology to measure stakeholders importance within a project from the point of view of sustainability. Answering the research question 'How to prioritize stakeholders based on their contribution to the benefits of collaborative R&I projects from a sustainability perspective?', a methodology is put forward based on the ANP as the tool and the use of the P5 standard for sustainability in project management as a framework to define the R&I project benefits categories.

2. Literature review

2.1. Benefits of research and innovation projects

R&I projects are often initiated as a means to fulfill an organization strategic plan, be it for example entering a new market segment for companies or becoming scientific leaders in a specific technological field for research institutes. Therefore, R&I projects have been increasingly requested to incorporate organizational values and concerns into their scope instead of simply considering the potential profitability and/or scientific impact presented by their outputs and outcomes. Environmental concerns include for example its attitude and actions around climate change issues. Other concerns include social aspects such as diversity, human rights and consumer protection, and economic factors such as employment creation. Recently, such societal needs have been suggested as functional requirements for the design and development of new research projects [13]. Thus, the increasing demand for accountability and societal impact of collaborative R&I projects, namely those publicly funded, calls for the development of specific frameworks, methodologies and tools.

In this context, an example of a relevant standard is the GPM Global 'P5 Standard for Sustainability in Project Management' (P5: People, Planet, Profit, Process, Products). This PM standard aims to reduce project level risk, from an environmental, social and economic perspective while expanding the range of benefits to be achieved. According to P5, sustainability objectives are translated to project objectives by scoring indicators relevant to the project and collecting amendment strategies in a Sustainability Management Plan [14]. This standard can be considered as an extension of the 'Triple Bottom Line' (TBL) or 'Triple-P (People, Planet, Profit)' concept. The latter states that sustainability is about the balance or harmony between economic sustainability, social sustainability and environmental sustainability. P5 adds two other "P"s: Product and (PM) Processes. This is in-line with the fact that from the emerging literature on the integration of sustainability and PM, two types of relationship can be identified [15]: the sustainability of the project's product (the deliverable that the project realizes) and the sustainability of the project's process of delivering and managing the project [5]. The five P5 standard focus areas are divided into a total of 16 subtopics (defined as benefit categories in this study) (Fig. 1).

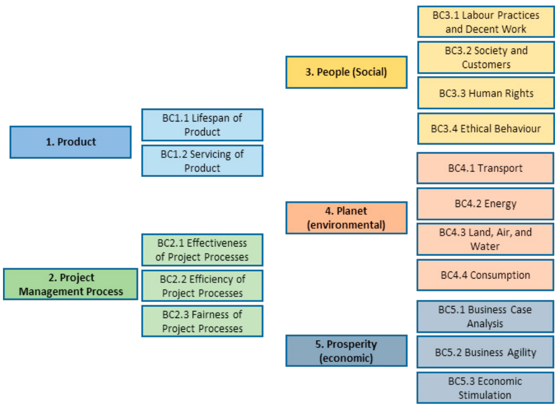

Fig. 1. Overview of the P5 standard focus areas [6].

To ensure a project's sustainability, the different perceptions of stakeholders should be understood and consequently managed [16]. This fact leads to a higher degree of complexity within the project scope, and highlights the need to manage this complexity [17], as briefly discussed next.

2.2. Stakeholder management

Project stakeholders management is one of the most important knowledge areas in the PM discipline, as the project success is measured based on stakeholders satisfaction, which can vary according to the different perspectives [18]. R&I projects in particular are often executed by consortia that gather industry, universities, research labs, public authorities, etc [1]. This stakeholder diversity makes these projects significantly complex to manage. Also, as the overall directions of the R&I are frequently changing during the development process, managing the relationships among the stakeholders in R&I projects is extremely complicated [19]. For example, Klimstra and Potts [20] found that project management in research is required to cope with interpersonal and group relationships and to maintain the equality of power and influence among project stakeholders. Thus, stakeholders have tremendous influences on the performance of R&I projects [21, 22]. In fact, the lack of adequate stakeholder management strategies [23], including difficulties in identifying stakeholders [24], has been considered a critical barrier for R&I projects' success [25].

Moreover, stakeholder engagement has been found to play an important role in encouraging sustainable outcomes of R&I projects [24]. Stakeholders have to be identified and taken into account, especially for the evaluation of societal relevance and sustainability of R&I projects [26]. Martens and Carvalho [27] included stakeholder management among the key factors for sustainability in the PM context. Robichaud and Anantatmula [28] stated that sustainable projects require a more detailed communications analysis and plan to keep stakeholders informed throughout the project. Banihashemi et al. [29] found that having stakeholders who support sustainable delivery is central to the success of integrating sustainability into PM practices. Therefore, effective sustainable PM should aim for, among other things, the proactive involvement and engagement of stakeholders in project activities, from the definition of requirements, assessment of costs and benefits, project planning and scheduling, identification and assessment of risks, handling of issues, and project reporting [30].

However, from a practical perspective, there is still the tendency to favor the traditional management of stakeholders, dominated by the 'iron triangle' (time, cost, quality), instead of their engagement from the sustainability point of view [31]. Although extensive research has been carried out on the evaluation of stakeholder engagement in many contexts of R&I projects, no single study exists which specifically looks at the evaluation of stakeholder engagement through the lens of sustainable project management, namely framed in the P5 standard.

A stakeholder analysis is a process, which provides insights into, and understanding of, the interaction between a project and its stakeholders. Careful selection of diverse stakeholders better positions project managers to overcome the challenges and meet project objectives [32]. Common stakeholder analysis methods include e.g. i) the Power, Legitimacy and Urgency approach [33]; 2) the Assertiveness and Cooperativeness approach; and 3) the Influence and Interest approach [34]. Nevertheless, none of those approaches are suitable for assessing the influence of stakeholders on the sustainability of a R&I project, or of the future exploitation of its outcomes. Features like interests, power, legitimacy, impact for the promoters, etc. are too indirectly related to sustainability.

In face of the above, it is proposed herein to perform stakeholder analysis in R&I projects framed in the P5 standard and using ANP as a multicriteria decision making technique that allows the relative measurement of intangible criteria, as proposed by Saaty [35].

2.3. Analytic network process

ANP is a universal form of the Analytic Hierarchy Process (AHP) used in multicriteria decision making problems. Both theories offer a framework to deal with decision making. AHP is valuable for hierarchical decision-making problems. ANP can also model network structures [36]. It has been applied to several decision-making problems in the PM field, such as contractor [37], project [38] and supplier [39] selection, performance evaluation [40], quality improvement [41] and risk prioritization [42]. Some recent applications of ANP to the area of stakeholder management are found in stakeholder evaluation [43]. ANP provides a clearer representation of the intricate interactions, interdependencies and feedback relationships among the different components of issues such as R&I benefits [44]. A comprehensive review of AHP and ANP can be found e.g. in Sipahi and Timor [44].

In ANP, a problem is modelled as a network comprised of different components (criteria and alternatives), clustered in groups and connected to each other by influences among them. To ascertain the relative importance of the model elements, they need to be assessed in pairs [36]. The pairwise comparisons allow to rate how many times more dominant is a component than another component being compared with respect to a particular criterion. The rating procedure is frequently carried out by experts using Saaty's nine-point scale [35]. The ANP prioritizes not just components but also clusters of elements.

The local priorities of the compared options are computed over the comparison matrices derived from the pairwise comparisons. For this purpose, the priorities vector is determined as shown in Eq. (1).

$$\widehat{A} \cdot \vec{p} = \lambda_{max} \cdot \vec{p} \quad (1)$$

where $\hat{A}$ is the comparison matrix, λ_{max} is the principal eigenvalue of the matrix $\hat{A}$, and $\vec{p}$ is the priorities vector.

The consistency ratio (CR) of a comparison matrix is a crucial aspect of the ANP computations. To achieve a higher degree of model trustworthiness, the expert judgments must be adequately coherent. Thus, the CR of a comparison matrix should stay on within a specific limit [36], usually lower than 10%. The CR is calculated using a two-step process. The first step consists in computing the consistency index according to Eq. (2):

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

where CI is the consistency index, λ_{max} is the principal eigenvalue of the comparison matrix, and n is the size of the square comparison matrix. In the second step, the CR is calculated by dividing the CI by the corresponding random index value, as shown in Eq. (3):

$$CR = \frac{CI}{RI} \tag{3}$$

where CR is the consistency ratio, and RI is the value of the random index. The RI includes the experimental values proposed by Saaty [35] for different matrix sizes.

When the required consistency is assured for each comparison matrix, global priorities of the model elements are computed through three-step supermatrix operations. A supermatrix is a two-dimensional matrix created by bringing the elements of different matrices together [36]. The first step is to develop the unweighted supermatrix by placing priorities vectors in the appropriate columns. This process is used to obtain global priorities through a single supermatrix by placing the resulting relative importance weights (eigenvectors) in pairwise comparison matrices within the matrix. The second step is converting the unweighted supermatrix into a weighted supermatrix by multiplying its values with the corresponding cluster weights. The cluster weights are defined by the pairwise comparisons of the related clusters. The weighted supermatrix is a column stochastic matrix, where values at each column sum up to one. In the third step, the weighted supermatrix is transformed into a limit supermatrix. To that end, the weighted matrix is raised to limiting powers until the weights converge and remain stable (limit matrix). As a result of these calculations, a limit supermatrix is obtained that shows the relative importance weights for every element in the ANP model.

3. Research methodology

3.1. Research design

The Design Science Research Methodology (DSRM), illustrated in Fig. 2 was adopted in this study [45]. The identified problem is the need for a method to prioritize stakeholders based on their contribution to the sustainability benefits of collaborative R&I projects. The design and development activity is the core of the DSRM and, in this study, relates to the artifact that is the combined use of the ANP as the tool and of the P5 standard as a framework to identify the R&I project benefit categories. The demonstration activity reveals the use of this method to provide a solution to the identified problem. An evaluation is performed to observe and measure how the method constitutes a solution to the problem. Regarding the last activity of the DSRM, communication, it is performed namely through this paper, wherein the relevant issues are presented.

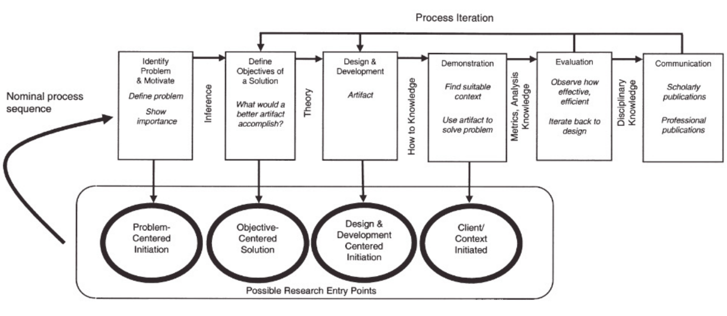

Fig. 2. DSRM process model, retrieved from [45].

3.2. Case study description

Wine production is one of the oldest and most important agricultural activities worldwide [46]. The project seeks to develop a new innovative process, that includes the extraction, purification and concentration of bioactive compounds present in winemaking residues. It is well known that these residues are rich in bioactive compounds and this project wants to prove that the residues processing can bring an added value, namely to the pharmaceutics, food and cosmetics and civil construction industries. The gain in terms of environmental sustainability of the company, resulting from the implementation of the aforementioned technologies will be estimated by a life cycle analysis approach. The project is currently in an early stage of development (first of three years). It is being developed by a multidisciplinary team with 20 members from a firm (the consortium leader) and three research centers, and with the collaboration of several international experts, a university-industry interface entity and partner firms.

4. Stakeholder prioritization methodology

The stakeholder prioritization methodology proposed is organized in three main phases, described next: (1) define the case study, (2) develop the ANP model for stakeholder importance and (3) collect responses from experts and run the ANP model for stakeholder prioritization.

(1) Case study design

The first phase includes the identification of the P5 benefit categories applicable to the specific project and a pre-selection of relevant stakeholders. For the initial selection of P5 benefit categories, a rating model was developed using as criteria the level to which each benefit category i) can be assessed, i.e. its attainment be appraised, either qualitatively or quantitatively, and ii) is actionable in the context of the project, i.e. the level to which it can actually be influenced by the project activity. Each criterion was classified for each benefit category according to a 5 point-scale (very low, low, medium, high, very high). A simplified AHP model was used where the objective was to determine the relevance of each P5 benefit category, with both criteria having the same weight (50%) in the final classification. Goals with a final classification greater than 75% were preselected.

(2) Development of the ANP model for stakeholder importance

The dependences and relations between the preselected criteria, the corresponding clusters, and the preselected stakeholders needed to be determined. This could involve intra-cluster and inter-cluster influences. A group of experts in the topic area of the R&I project discussed the potential dependences and relations, and decided the final ANP model, through deductive reasoning, analytical induction, and expert judgment.

(3) Collection of responses from experts and running the ANP model for stakeholder prioritization

In ANP, due to the kind of information available, the quality of experts is more important than their number [47]. To be considered an appropriate expert for this study, the requisites were: broad experience on the research topic (i.e., on CBE topics), belong to a specific category of key actors of the problem (experts on R&I projects, sustainability, and project management), and availability to participate in the study.

In the ANP model implementation, experts judged which element is preferred to which element, and to what extent, in pairwise comparisons of the same cluster. The data was collected in the form of questionnaires. Due to the large number of criteria (P5 benefit categories) and alternatives (stakeholders) in the case study, the number of pairwise comparisons was reduced through a first iteration using solely model data from expert nr. 1, specialized in collaborative R&I project management. This allowed to reduce the number of pairwise comparisons to a level adequate to the collection of responses from the other experts. Otherwise, the questionnaire would be too large to be feasible. A second iteration was then performed with the help of expert nr 2 (specialized in circular economy) and the results discussed in light of those obtained for step one.

5. Application of the stakeholder prioritization methodology

5.1. Rating model for preselection of benefit categories and key stakeholders

The preselection of benefit categories and of relevant stakeholders applicable to the specific case study was carried out by the project manager, who used its experience and knowledge about the project scope and context.

The computation of the rating model resulted in a reduction of the original 16 to 8 benefit categories, 2 per cluster (Fig. 3). The excluded criteria correspond to indicators whose classification in what concerns "assessment viability" and "actionability" was too low, resulting in a final classification lower that 75%.

An initial list was elaborated with 13 stakeholder categories: team members – research (S1), team members – management (S2), leaders at the consortium organizations (S3), suppliers (S4), partners (not part of the consortium) (S5), funders (S6), media (S7), costumers (producers/sellers/users of the technology to be developed) (S8), public authorities (certification, licensing, etc.) (S9), local communities (citizens) (S10), sectorial associations/networks (S11), NGOs (environmental, etc.) (S12) and competitors (S13). A consultation with research team members resulted in the withdraw of "competitors" due to confidentially issues.

This initial list of P5 benefit categories and stakeholders was confirmed by members of the research team in a consensus meeting.

5.2. ANP model development

After the identification of the ANP model elements (8 benefit categories (criteria) and 12 stakeholders), dependencies among them were determined by experts (members of the research team and the project manager) in a focus group. The proposed model is illustrated by the network shown in Fig. 3. The arrows indicate dependencies between clusters.

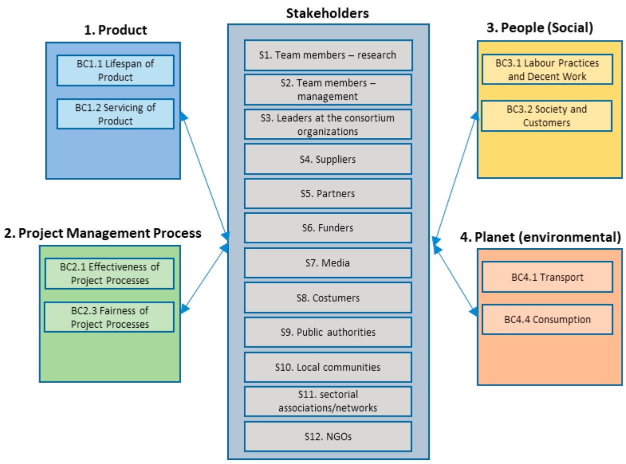

Fig. 3. ANP model.

5.3. The *ANP model output - stakeholder prioritization*

Two experts were selected, representing different perspectives to the problem. Expert nr 1 is an experienced project manager, with an engineering and scientific background, and long experience in managing and executing collaborative R&I projects (from small to large scale projects and teams, multiple disciplines involved). Expert 1 has a wide experience in stakeholder management. Expert nr. 2 is a renowned circular economy researcher, with extensive experience in European and national projects on the topic, both from the scientific/theoretical and technical/practical points of view. He has experience in projects with complex interaction with different stakeholders that produce important social, environmental, and economic benefits.

A questionnaire was designed with the aim of determining the relative importance of the 8 benefit criteria for each stakeholder. The required judgements were collected using a survey created with pairwise comparisons, exemplified in Fig. 4.

		9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
S1. Team members – research	BC1.1 Lifespan of Product									x									BC1.2 Servicing of Product
	BC2.1 Effectiveness of Project Processes					x													BC2.3 Fairness of Project Processes

Fig. 4. Example question for judgment by the experts.

The response shown in this example indicates that according to the expert's perspective: i) the lifespan of the project product (BC1.1) and the servicing of the project product (BC1.2) are equally important to the research team members (S1); and ii) the effectiveness of the project management processes (BC2.1) are more important to the research team members (S1) than their fairness (BC2.3).

Once experts finished all pairwise comparisons, a limit supermatrix per expert was obtained, as explained above. Care was taken to ensure that all pairwise comparison matrices had a CR of less than 10%.

Due to the large number of criteria (8 benefit categories) and alternatives (12 stakeholders), the global number of pairwise comparisons added up to 582. This was considered unpracticable due to the length of time and effort that would have to be requested from the experts. Thus, in a first step, only expert nr. 1 evaluated all the 582 pairwise comparisons. In a following step, for the second expert evaluation, only the stakeholders and criteria with a classification greater than ca. 50% in the first step were selected. The reduced version of the ANP model, with 6 benefit categories and 8 stakeholders resulted in 184 pairwise comparisons. In Table 1 are compared the relative classifications of the 8 stakeholders and 6 benefit criteria categories by expert nr 1 (in the first step) and by expert nr. 2 (in the second step).

Table 1. Stakeholder and benefit category classification (normalized by cluster).

Stakeholder	Expert nr 1	Expert nr 2
S1. Team members – research	100%	94%
S2. Team members - management	85%	100%
S3. Leaders at consortium organizations	90%	71%
S6. Funders	62%	37%
S7. Media	58%	22%
S8. Costumers (Producers/Sellers/Users)	47%	31%
S10. Local communities (citizens)	52%	30%
S12. NGOs (environmental, etc)	70%	62%

Criteria (benefit category)	Expert nr 1	Expert nr 2
BC1.1 Lifespan of Product	50%	44%
BC1.2 Servicing of Product	50%	56%
BC2.1 Effectiveness of Project Processes	50%	45%
BB2.3 Fairness of Project Processes	50%	55%
BC3.2 Society and Customers	60%	100%
BC4.4 Consumption	61%	100%

It can be observed that the four most important stakeholders coincide for both experts: "S2. Team members – management", "S1. Team members – research", "S3. Leaders at consortium organizations" and "S12. NGOs (environmental, etc.)". The remaining stakeholders were classified by expert nr 2 well below 50% in terms of importance related to the criteria used. Also, it can be observed that the criteria considered most important for the identified stakeholders are: "BC.3.2 Society and Customers" and "BC4.4 Consumption". However, all the criteria considered were rated ca. 50% or higher. The different relative positioning of stakeholders and criteria importance for experts nr 1 and 2 reflects their different perspectives but there is a clear agreement as to the critical stakeholders that should be considered at this stage in the project development.

6. Conclusions and future work

The P5 standard has been shown to adequately frame the benefits to stakeholders of R&I projects in the topic of circular bioeconomy. The prioritization of stakeholders as a function of their importance for the attainment these benefits can be performed using ANP. Moreover, the method employed allows for the prioritization of the project benefit categories in face of their importance for each stakeholder, as perceived by the experts.

The importance of each benefit category to each stakeholder has been determined using the judgements from experts in project management and in circular bioeconomy. The following stakeholders should have priority in the development of the project stakeholder management plan: research team members, leaders at the consortium organizations, project management team members and environmental NGOs. Key benefits identified by the experts relate to the categories "society and costumers" and "consumption".

A limitation of this study is the use of judgments from only two experts. This will be overcome in a follow-up study by collecting judgments of experts belonging to the identified key stakeholder types. The relative importance of each key benefit category to each key stakeholder will be assessed in a longitudinal study as the perceived priority of stakeholders will vary over time with criteria varying in weight and stakeholders varying in importance.

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