Unravelling interactive innovation through a stakeholder-associated risk analysis: Evidence from two case studies in Spain

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Abstract

Interactive innovation is the innovation process that is co-produced by the interaction of actors, such as farmers, land managers, researchers, policy makers and consumers. It connotes complex and socio-scientific problems that utilize participatory methodologies to bring in diverse perspectives of stakeholders, who have control over the development and decision-making process. Most failure or information absence come from insufficient communication transfer, which can result in conflicts between stakeholders, especially in projects with multi actor partnership and multidisciplinary stakeholders. Rural innovation is addressed by measuring stakeholder interactions that take place in the project. By identifying the risks in the network and the stakeholders associated to the risks, we find the underlying cause of the problem in two case studies in Spain. Results reveal that lack of communication among internal stakeholders was the main threat in both projects. Recommended action plans included establishing an effective communication strategy, establishing a well-defined terminology to avoid miscommunication among internal stakeholders and taking into account ethical and cultural differences among stakeholders to avoid mistrust. The risk analysis provides stakeholders with a holistic view over the project in knowing the location of the resources and where the problem lies. This way stakeholders can scrape out the wound.

Keywords: *Interactive innovation, Risk network analysis, Rural innovation, Stakeholder interaction.*

1. Introduction

Rural innovation is co-produced through interaction between actors, such as farmers, land managers, advisory services, brokers, intermediaries, consumers, researchers, private sector, policy researcher (Hall *et al.*, 2001; Imperiale and Vanclay, 2016; Quiedeville *et al.*, 2017; Smits and Kuhlmann, 2004). When stakeholders interact and jointly identify problems and come to a solution it creates knowledge, which gives advantages and disadvantages to the project (Gray *et al.*, 2012). The creation of potential solutions to a problem through the collective learning process of stakeholders is marked as co-innovation (Dogliotti *et al.*, 2014; Nederlof *et al.*, 2011). Co-innovation is still an abstract concept which combines systems theory, social learning, design and monitoring and evaluation and utilizes participatory multi-stakeholder methodologies (Botha *et al.*, 2014; Dogliotti *et al.*, 2014). As

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co-innovation has been widely conceptualized as a process, the integration of participatory environmental decision making into the process has become inevitable (Lee *et al.*, 2020; UCT and UNITAR, 2006; Wu *et al.*, 2014), where multi-stakeholders, including community are encouraged to take control over the development process and decisions over resources (Allen and Kilvington, 1999; Neumeier, 2012).

In the rural context, the innovation process is challenged by the complex environment where it unfolds calling for diverse perspectives from stakeholders with various background (Douthwaite *et al.*, 2017; Preskill and Gopal, 2014) and so their multiple perspectives have significant influence on decision-making (Graef *et al.*, 2018; Hall *et al.*, 2001; McNie, 2007). Bringing in their perspectives on the problem and their participative action is crucial to identify the underlying cause of the problem which can then motivate innovative thinking to find adaptive innovative solutions (Lee *et al.*, 2020; Tecco *et al.*, 2016).

Lee *et al.* (2020) have identified from literature review that stakeholders in their innovation projects are concerned with finding the fundamental cause of the problem. This is the first step toward finding a solution. Finding the cause of the problem then allows stakeholders to discuss and come to an agreement on what needs to be done and what further opportunities exist. However, in the process of looking for solutions, interdependent interactions exist among multiple stakeholders who are the participants along the process (Freeman, 1994; Rowley, 1997). Their continuous feedback are the valuable insights allowing for new perspectives thus creating value-added to the project. The value creation promotes the enhancement in a network through (innovative) capacity development and community empowerment (Douthwaite *et al.*, 2003; Graef *et al.*, 2018; Paz-Ybarnegaray and Douthwaite, 2017; Quiedeville *et al.*, 2017). The collaborative actions through innovative thinking and community empowerment can facilitate an innovative environment (Eichler and Schwarz, 2019), which is crucial in enhancing the decision-making process in a multi-stakeholder context.

A stakeholder-based life cycle assessment has been proposed by Thabrew *et al.* (2009) that provides stakeholders a holistic view over the whole project by visualizing a broader set of upstream and downstream consequences of decisions in planning and implementation. Another useful tool that to be applied for enhancing decision-making is a stakeholder map. A stakeholder mapping is the visualization of a network created through interactions between stakeholders and has been used in several studies in order to gain insight of resource allocation and interactions between stakeholders (Scott *et al.*, 2005; Thabrew *et al.*, 2009; Yang and Zou, 2014). Schneider and Buser (2018) went on further to analysing the degree of stakeholder interaction in specific projects. This increased the probability to reach the intended contribution goal; allocate efficiently and effectively time and resources and reduce participation fatigue and project failure. The study of Yang and Zou (2014) went on beyond analysing the interaction of stakeholders and created a stakeholder-associated risk map that enabled them to identify which type of risk was associated to whom. That way strategic management plans for reducing the risk or planning ahead for mitigation actions were possible.

Many problems in projects are associated to stakeholders and their interactions (Khan *et al.*, 2020; Thabrew *et al.*, 2009; Yang and Zou, 2014), thus analysing what problems stakeholders face and with whom that risk is associated to will give clues what actions to take to mitigate that risk. Previous studies show that the role of stakeholders in identifying the risks can no longer be left out. As stated by Prum and Del Percio (2009), in a project, risk sources should be analysed and each stakeholder should assess their risks and take measures to mitigate the possible impacts. Qin *et al.* (2016) studied the risk factors such as political, social, certification, financial/cost, quality/technological and managerial risks according to stakeholder's perception of risk importance. Similarly, in agricultural production, risk has been discussed in line with climate-related disasters, especially in areas where food insecurity is prevalent (Carter *et al.*, 2007; Gaiha and Thapa 2006; Drollette, 2009). To reduce the risk and make farmers and societies adapt to new farming practices and change their cropping patterns (IPCC, 2014; Jha, 2015;

Swami and Parthasarathy, 2020) studies on the level of farmer's perception, knowledge and awareness on climate-related risks were carried out by Khan *et al.* (2020) and Qin *et al.* (2016). Moreover, social problems such as food security and poverty involve more complex risks such as price stability, agricultural production and population growth. Understanding and analysing food security, therefore need to be conducted by digging deeper into the structure of the risks that exist along the value chain (Capitanio *et al.*, 2019; Lacirignola *et al.*, 2015). The results of these studies served as a reference point for policymakers in future appropriate adaptation policies to facilitate rural communities in sustaining their livelihoods. Eventually, analysing the risk contributes to effective decision-making and efficient communication.

What kind of risk analysis is important?

As projects, that embed economic, social, technical, and environmental risks seek for innovative solutions, society demands that these projects deliver more sustainable and efficient outcomes. Robichaud and Anantatmula (2011) emphasized the importance of stakeholder analysis and considered the most significant challenge to delivering a successful project to be "communication and coordination across a multidisciplinary team" to accommodate specific user, regulatory, or community needs and therefore mitigate the risks (Robichaud and Anantatmula, 2011, p. 54). One crucial problem during the planning process is that important information is not transferred or transparent enough to make a consent decision (Arts and Faith-Ell, 2012). Lack of information for decision making implies that social risk exist such as miscommunication and conflicts among stakeholders. In social contexts interorganizational and social networking play crucial roles and remain key factors to be investigated (De Hoyos-Ruperto *et al.*, 2013; Johannisson and Nilsson, 1989). In most cases, these relationships are locally embedded and engagement in local networks provides access to local resources (McKeever *et al.*, 2014).

Regarding agriculture and forestry projects, the abandonment of farmland can have severe environmental consequences, such as threatening farmland biodiversity (Plieninger *et al.*, 2014; Zakkak *et al.*, 2014) and provisions for ecosystem services (Benayas *et al.*, 2007). Terres *et al.* (2015) aimed to identify the main drivers in farmland abandonment in Europe and showed that low farm dynamism/adaptation capacity, aging farmer population, enrolment in specific agricultural schemes and weak land market, amongst others. The farming community faces multiple risks including climate change (global warming, climate variability and extremes), social, economic, market and political risks (Smit and Skinner, 2002). Even technical and environmental risk have social consequences. For example, modelling farmer's behaviour and perception is very important to find answers to farmer's adaptation to the socio-economic conditions, such as new agricultural practices (Javed *et al.*, 2020; Kuang *et al.*, 2020; Swami and Parthasarathy, 2020). The cause of the risk and moreover risk mitigation plans is associated with social issues, such as stakeholder's perception of risks or information flow and control. Social factors including the risk of people and their interaction should be discussed to take mitigation action and set up strategic plans. To study and explore on the risks faced by stakeholders in their project, a network map of stakeholder associated risk is drawn and coded to comprehend with a holistic view what risks are embedded in the project and which actions should be taken to reduce or eliminate the risk. A deeper look into what risks exist and with whom this difficulty is encountered by directly interviewing the stakeholder facing that risk will give us explicit answers.

This research aims to answer the following research questions in order to dwell upon stakeholder associated risks and the interactions between them to find out the critical risks that hinder the project from a successful outcome.

1. What risks are faced by stakeholders in the project and to whom are the risks related to?
2. Which of these risks are considered the most critical?
3. What could be the mitigation action plans?

The methodology chapter starts with the description of the two case studies that were used for the analysis. It is followed by stakeholder's interview and then followed by the methods and steps used for this research. A list of stakeholders and their risks were obtained by conducting online interviews (Chapter 2.2). A visualization of the risk network and further interpretation along with a mitigation action plan is given in Chapter 3. Finally, authors conclude with implications of the research.

2. Case study and research activity

This section describes step by step the materials used for the study. The two case studies were taken as the two most interactive innovation case studies in Spain because of the long supply chain comprising of various stakeholders in their project. The descriptions are explained in Chapter 2.1 and is followed by a figure that explains the methods taken for this research. Finally, the stakeholder's interview and the categorizing of risks and stakeholders follow.

2.1. *Description of case studies*

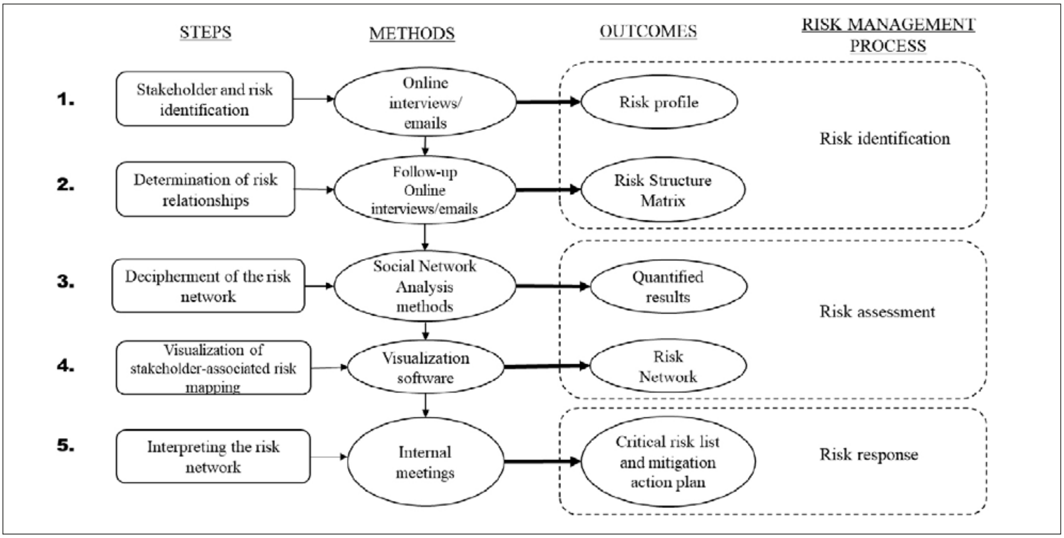
Two case studies were analysed to address the 'how' type of question in order to understand how risks are connected in the rural development sector. The case study selection was not random but was based on a prior systemic sampling. In Spain, 35 cases were identified to deal with interactive innovation based on stakeholder questionnaire that was funded by the European H2020 project LIAISON, which aims to optimize interactive innovation and networks and thus build capacities for more productive interaction and improve European innovation policies in agriculture, forestry and rural development. From the 35 selected projects, authors have identified two representative cases based on their multi actor partnership and multidisciplinary stakeholders. One deals with efficient water irrigation management (hereafter project 1) and the second deals with agroforestry management (hereafter project 2).

Project 1, which began in 2013, is an "Efficient Irrigation Management" project under the Research, Development and Innovation initiative promoted by a public company, with the aim of optimizing the energy and water efficiency of irrigated areas in Spain and thus achieve economic viability and social-economic sustainability. It is responding to the Irrigation Communities for the management and maintenance of the irrigation infrastructure works that the Ministry of Agriculture, Fisheries, Food and Environment executed during the years 2007 to 2012, within the framework of the National Irrigation Plan and the Irrigation Modernization Shock Plan. The project has 4 teams each having its own work: the electricity market that identifies the best alternatives for contracting electrical energy to reduce costs; the renewable energy team that identifies renewable energies (wind, photovoltaic, mini-hydraulic, or other) applicable to the intervention areas to produce clean and economical energy; the energy efficiency team that implements energy efficiency practices and procedures, making use of technology and considering characteristics of each irrigation community; and water efficiency team that studies and implements new technologies (humidity probes, remote sensing, or other) to optimize (timely) irrigation.

The key stakeholders in this project are besides the project coordinators, the four working teams responsible for electricity, renewable energy and its efficiency and water efficiency and the irrigation community. Irrigation communities are similar to pilot case studies to the whole project. The communities provide data on their irrigation for energy and water optimization, hence they are playing a crucial role to the whole project. Some large irrigation communities have participated in the design of the project, by offering their point of view. The long supply chain and stakeholders with different interests correspond to the multi actor setting in a project. Therefore, their interaction is assumed to be complicated and complex.

Project 2, that had ended in 2019 was an EU Horizon 2020 project, aimed to foster the exchange and the knowledge transfer between scientists and practitioners in agroforestry. The project emphasized on five specific objectives which was to establish the system and methodological basis for knowledge exchange on agroforestry further building on a knowledge cloud

Figure 1 - Steps and methods for the stakeholder-associated risk management.



that will not only enable the exchange of knowledge and practices but bring synergies between European, national, and regional policies related to the agroforestry sector to support the effective implementation. The project was based on a thematic network, where key stakeholders range from universities, research centres and NGOs in nine countries across Europe. Communication and information transfer and the transparency of information was key for knowledge transfer across the nine countries across Europe. Moreover, terminologies such as agroforestry and the relevant practices for agroforestry differed from country to country according to their culture. This multi actor partnership in a multinational setting awakened the interest to examine on the interaction between stakeholders.

2.2. *Stakeholders' interviews*

The first part was to gather information on risks that will feed into the network analysis. 50 online interviews were conducted with stakeholders from the two described innovative projects. The interviews were carried out from mid-March to the first week of July in 2020.[1] Before the online interviews, the project coordinators were contacted through email and were explained the intention of the project[2] and the intention of the risk network analysis. Authors were given a list of relevant stakeholders (researchers, practitioners, technicians…) to contact from the coordinators of the projects. All interviewees were then contacted by email prior to the online interview and were asked for consent. Interviewees were asked what risks they faced during the project process and with whom the risk was associated to (stakeholder-associated risk). They were then asked what impact the risk might have on the project outcome and were asked to rate the risk from 1 to 5; 1 being very low impact to 5 having very high impact. Inferring to risk occurrence and the likelihood of impact gave the authors exploratory answers.

2.3. *Methods taken in the research*

A figure that explains the methods and steps undertaken for this research is shown below (Figure 1). The most left column explains the

[1] Due to the COVID 19 circumstances travelling across the country was prohibited and therefore all 50 interviews were conducted via Zoom or Skype.

[2] This research has been carried out in parallel with the Europe H2020 project LIAISON.

Table 1 - Risk category.

Risk category	*Explanation*
Time	risk related to time management
Cost (financial)	risk related to cost increase and return; usually funds
Policy and standard	risk related to change in regulation and funding policy or environmental regulation
Organization and management (interaction and communication)	risk related to organization structure, knowledge and relationship management
Quality and technical	risk related to quality of material, technology advancement (or failure)
Environmental	risk related to environmental extremes (eg. weather)

five steps taken in this research. The method column explains each method or methodology undertaken for each of the five steps. The third column then shows what outcomes are expected from each step. The risk management process on the far right, is the process undertaken by the authors to get to the final outcome of this research.

The first step is the identification of stakeholder and risk and the data were gathered through online interviews and email exchanges. The second step was the determination of risk relationships. A Risk Structure Matrix was done through interviews from the first step and follow-up online interviews where necessary. Through the Risk Structure Matrix, the decipherment of the risk network in step 3 was possible. The third step was the risk network taking the Risk Structure Matrix in step 2 and deciphering it with STATA and UCINET, which are statistical tools for the Social Network Analysis method used to quantify the results. The fourth step was the visualization of the stakeholder-associated risk map. Software such as UCINET and Netdraw were used to draw the risk network. Finally, in the fifth step the risk network was interpreted with several internal meetings and discussions by authors. A critical risk list was made, and mitigation action plans elaborated using discussion outcomes by authors.

3. Results and discussion

3.1. *Risk profile*

This section explains the grouping of the risks and stakeholders. The sub chapters that follow explain thoroughly how the categorization for risks and stakeholders has taken place.

There is no standard classification of risks. However, this study has referred to the risk category used by Yang and Zou (2014). Although the study by Yang and Zou relate the risk category to the green building sector, there are several reasons why the authors have realized a small overlap and have referred to this: (1) risk analysis in green building projects is very much advanced and several attempts have been made to list the risks, which makes the risk category relatively reliable and suitable to the related sector (2) the complexity and problematic characteristics of the construction industry which are described as "extremely conservative and subject to slow rates of change due to regulatory… and limited technology transfer from other sectors of society" (Kibert *et al.*, 2000) are to a great degree comparable to those of the rural development sector.

The six risk category used for this study are: time, cost, policy and standard, organization and management, quality and technical and environment (Table 1). The risk organization and management are very much related to risk in communications and therefore problems in interaction. Below the table shows the risk categorization adapted and modified from Yang and Zou (2014).

3.1.1. *Categorizing the stakeholders*

In the rural development sector, there is no standard stakeholder list, because the characteristics of stakeholder are very much dependent on each project. Thus, this study does not refer to any of the stakeholder list identified in previous studies, instead refer to the five social interactions identified in the LIAISON project. LIAISON has determined five interaction types in innovation

Table 2 - Stakeholder category and risks for project 1.

Stakeholder category	*Number of risks*	*Stakeholders*
Internal stakeholder	26	S1: Energy Efficiency team; S2: Irrigation Community; S3 Group Tragsa (project coordinator); S11: Tragsatec; S13: renewable energy team
Government	3	S4: regional government
External stakeholder	2	S6: investors; S7: contractors
Consultant	1	S12: University of Valencia
Others (non-controllable)	6	S5: other (economical); S8: electric sector (supplier); S9: external risk (technical); S10: external risk (environmental); S14 energy (supplier)

Table 3 - Stakeholder category and risks for project 2.

Stakeholder category	*Number of risks*	*Stakeholders*
Internal stakeholder	4	S1: University of Santiago de Compostela (project coordinator); S3: all stakeholders in the project
Government	7	S2: European Commission; S6: regional government; S7: administration
External stakeholder	6	S4: farmers; S5: other actors related to case studies of the project; S8: all stakeholders not directly related to the project

systems (Cronin *et al.*, 2021): I) interaction with policy; II) interaction within the project; III) interaction with external stakeholders; IV) interaction of the project and the context and V) interaction with the surrounding environment. In the fourth interaction, the stakeholders are not related to the project and do not have direct authority or control over it, however their behaviour may influence the project indirectly. Authors have identified five groups of stakeholders according to these types. The groups are government, external stakeholders (including policy makers) associated to interaction I; internal stakeholder associated to interaction ii, consultant and other external stakeholders associated to interaction III and interaction IV. The fifth interaction is not related to a stakeholder group, because it cannot be controlled by them; these are environmental risks.

The internal stakeholder group refers to actors that are within the project network and can have effect on decision-making over the process of the project. When conducting the interview, authors have realized that quite an amount of risk arises from interaction with internal stakeholder. This also means that there have been discussions, communications and argumentation during the process of the project. The government is usually referred to as the government or regional government who sets out regulations and has decisions over the funding process. External stakeholders are other investors and (sub) contractors to the project. The fourth group, consultant, refer to advisors or research centres that provide knowledge to the project. Here any government advisory is excluded from the group. The fifth group, others, refer to external risks, which are often not controllable by stakeholders, for example, risks due to weather extremes or software failure. These are environmental risks not directly related to a specific stakeholder, but somehow involve a certain group of stakeholders.

Next, is the stakeholder category for project 1 (Table 2). It is evident that risks are confronted with internal stakeholders (within the project), with 26 risks counted. The second serious threat is non-controllable risks such as weather conditions or wage inflation and is not associated to a specific stakeholder category.

Table 3 shows the results of stakeholder category and the risks encountered. A total of 8 stakeholders were categorized into 3 groups: internal stakeholder, government and external stakeholder.

Table 4 - Risk category and associated stakeholders for project 1.

Risk category	*Number of stakeholders*	*Risks*
Time	2	Project timeout
Cost	9	R6: Wage inflation; R7: changes in price of materials/energy/water; R8: high sustainability costs; R9: additional costs; R16: budget cut; R20: inaccurate project cost estimate
Policy and Standard	6	R4: Change in government financing policy; R5: fiscal changes (in general); R10: opposition or lack of political support (government discontinuity); R11: delay in obtaining consent; R12: legislative or regulatory changes
Organization & management	3	R1: Pressure from internal actors (disagreements, lack of trust, demotivation); R3: lack of support from senior management; R29: social problems (raising awareness among farmers, new adaptation to sudden technological changes); R32: unavailable information
Quality & technical	5	R2: Ambiguity in the scope of the project / change; R13: Changes and problems in available technology; R14: Change in design and engineering; R19: Inadequate analysis of the complexity of the project; R21: Lack of experience in sustainable design and project management; R22: Unsuitable, untested or unreliable materials, products or sustainable systems; R23: Uncertainty in the performance of sustainable materials and equipment
Environmental	3	R15: Unfavourable climatic conditions to carry out the project

Results show that government is the stakeholder in the project with the most risk encountered, meaning that most of the risks in project 1 is associated with the (regional government). Funding issues, project implementation delay due to administration process or problems in the legislative requirements are critical risks associated with government.

3.1.2. *Categorizing risks*

This section shows the results of the risks and associated stakeholders in the two innovative projects in Spain. All risks identified during the interview were categorized according to the risk category (Chapter 3.1). The middle column shows the number of associated stakeholders encountering the risk described in the left column. On the right column of the table are listed the actual risks that were encountered during the project. Note that one risk can be associated to one or more stakeholder group.

A total of 47 risks were counted for project 1 with 14 stakeholders. These were then categorized according to the risk and stakeholder category (Table 4). Due to limited space availability not all risks are shown in the far right column of Table 3. However, all 32 risks were grouped during data process by authors.

In project 1 risk related to cost is the most threatening risk associated with numerous stakeholders followed by risks related to policy & standard. Risk related to time such as project timeout and environmental risks such as climatic conditions and land expropriations are minimal and not considered critical threats.

Table 5 is the risk category of project 2. A total of 14 risks were categorized into time, cost, policy & standard and organization & management with 8 stakeholders. One stakeholder can be associated with one or more risks, that is why the number of stakeholders (middle column) does not add up to 8. There are no risks related to quality & technical and environment. The rightest column shows in specific what the risks are.

Project 2 considers risks related to policy and standard the biggest obstacle to the project followed by risks related to organization and management, such as miscommunication among partners due to a lack of common language. From Table 5, we can see that the project is

Table 5 - Risk category and associated stakeholders for project 2.

Risk category	*Number of stakeholders*	*Risks*
Time	2	R7: Time delay at implementation stage because going to the next step was stuck at the level of recommendation, policy, regulation
Cost	1	R3: Lack of funds
Policy and Standard	6	R1: Project modification due to European Commission request; R10: ethical issue in different regions; R9: discrimination of policies and regulations; R14: lack of administration and legislation requirements for implementation
Organization & management	4	R2: unclear methodology; R4: lack of common definition of key terms; R5: Miscommunication or lack of communication; R6: difficulties to reach interested case studies/farmers/people due to large distances; R13: ignorance in management in silvopastoral

Table 6 - Risk Structure Matrix.

(frequency/impact)	*R1 S1*	*R2 S1*	*R3 S2*	*R4 S3*	*R5 S4*	*R6 S4*
R1 S1			(2,5)	(1,1)		(1,1),
R2 S1				(2,5)	(2,5)	(2,3)
R3 S2	(1, 4)	(3,4)				(3,4)

very much dependent on policies and standards, which means that policy making and change in policies can have significant effects on the project and its outcome.

3.2. *Risk Structure Matrix*

This step is defining the interrelationships of risks following Fang *et al.* (2012) and Marle *et al.* (2013). This method represents relations and dependencies among objects. The impact between the two nodes and the possibility of occurrence is designed in a Risk Structure Matrix (Table 6). The first row and column are the risk ID coded in the risk profile. The digital numbers inside the cells indicate frequency (calculated as possibility of occurrence) and impact: the left element is the impact between the risks (5 scales with "5" meaning extremely high, and "1" meaning extremely low); the right element is the likelihood of the impact (5 scales with "5" meaning extremely high and "1" meaning extremely low). For example, (1,4) indicates that the third risk associated to stakeholder 2 (R3S2) has low level of occurrence, however has a high level of impact on the first risk associated to stakeholder 1.

3.3. *Quantified results*

For a comprehensive overview of the risk-stakeholder network the density and cohesion were calculated first, then the degree, betweenness centrality and status centrality were measured to see individual nodes and links.

Density is the ratio of all possible existing ties in a network. The equation is given below (see equation. 1)

$$\text{Density } (G) = \frac{K}{N(N-1)} = \sum_{S*Ri,S\#Rj \in G} (RSM_{S*Ri,S\#Rj}) / N(N-1) \quad (1)$$

It is calculated by Network G, K the existing relationships, N the total number of risks in the data set, and the interrelated risks in the Risk Structure Matrix.

Cohesion is a measure of the complexity of risk network based on risk reachability. The higher the cohesion, the more complexity of the risk network is. It calculates the distance, or the number of links, to reach nodes in a network. The equation to calculate the cohesion value is given below,

$$\text{Cohesion } (G) = \frac{\sum_{\text{S*Ri,S\#R}j \in \text{G; n}\in\text{N}} \text{AdjMz}}{N(N-1)} \quad (2)$$

Where AdjM^z is the adjacency matrices with network N, nodes labelled by i=1; 2; n. It is assumed that aij > 0 if there is a direct/indirect link from node j to node i and a_{ij} = 0 otherwise. AdjM^d, give the number of walks of length z from each node to each other node. Number z is calculated by the average walks between each pair of nodes in the network.

Further, in order to specify the location of the risks and the associated stakeholders in the network and see their interrelations, the degree, betweenness centrality and status centrality were calculated using the software UCINET and STATA (Borgatti *et al.*, 2002; StataCorp, 2015). Degree of nodes helps to identify risks which have higher immediate impact on others. In-degree (eq. 3) refers to risks that are impacted by other risks, whereas out-degree refers (eq. 4) to risks that have impact on other risks. The degree difference which is the Gap-degree (eq. 5) is the out-degree minus in-degree. The higher the difference, the stronger the impact of the risk to the others compared to impact received. The degree calculation only shows us the immediate connectivity from node to node.

$$\text{InDegree}_{\text{S*R}i} = \sum_{S\#Rj\in G} \text{RSM } S\#Rj, \text{S} * \text{R}i \quad (3)$$

$$\text{OutDegree}_{\text{S*R}i} = \sum_{S\#Rj\in G} \text{RSM } S\#Rj, \text{S} * \text{R}i \quad (4)$$

$$\text{GapDegree}_{\text{S*R}i} = \text{OutDegree}_{\text{S*R}i} - \text{InDegree}_{\text{S*R}i} \quad (5)$$

The betweenness centrality identifies risks and interrelations which have control over the impact passing through it. It measures the node/link that falls between two or more other nodes/links based on the shortest path calculated. The betweenness centrality can be calculated with eq. 6 and eq. 7, where σ S#′ Rk, S#Rj is the number of shortest paths from node S#′ Rk to node S#Rj.

$$\text{Node Betweenness}_{\text{S*R}i} = {}_{\text{S\#}'\text{R}k,\ \text{S*R}i,\ \text{S\#R}j \in \text{G};\ \text{S\#}'\text{R}k \neq \text{S*R}i \neq \text{S\#R}j}\ \sigma_{\text{S\#}'\text{R}k,\ \text{S\#R}j}(\text{S*R}i) / \sigma\ \text{S\#}'\text{R}k,\ \text{S\#R}j \quad (6)$$

$$\text{Link Betweenness}_{\text{S*R}i \to \text{S\#R}j} = {}_{\text{S*}'\text{R}p,\ \text{S*R}i,\ \text{S\#R}j,\ \text{S\#}'\text{R}q \in \text{G};\ \text{S*}'\text{R}p \neq \text{S*R}i \neq \text{S\#R}j \neq \text{S\#}'\text{R}q}\ \sigma_{\text{S*}'\text{R}p,\ \text{S\#}'\text{R}q}(\text{S*R}i, \text{S\#R}j) / \sigma\ \text{S*}'\text{R}p, \text{S\#}'\text{R}q) \quad (7)$$

Status centrality helps to identify risks which have higher overall impact in the whole network. It measuring the relative influence of a node within a network. The number of the immediate neighbours (first degree nodes) and all other nodes in the network that connect to the node under consideration through these immediate neighbours are measured so that the relative influence of a node within a network can be computed. The out-status centrality indicates the extent to which a risk can affect another risk, meaning the higher the value the greater the impact of the risk in the network. The equation for the out-status centrality is given…, where is the distance between the nodes, ∝ is the weight assigned to each path or connection between a pair of nodes andis the adjacency matrices given the number of walks of length d from each node to another.

$$\text{StaC}_{\text{S*R}i} = \sum_{d=1}^{\infty} \sum_{\text{S\#R}j \in \text{G; S*Ri} \neq \text{S\#R}j} \propto^{d-1} (\text{AdjM}^{\text{d}})_{\text{S*R}i \neq \text{S\#R}j} \quad (8)$$

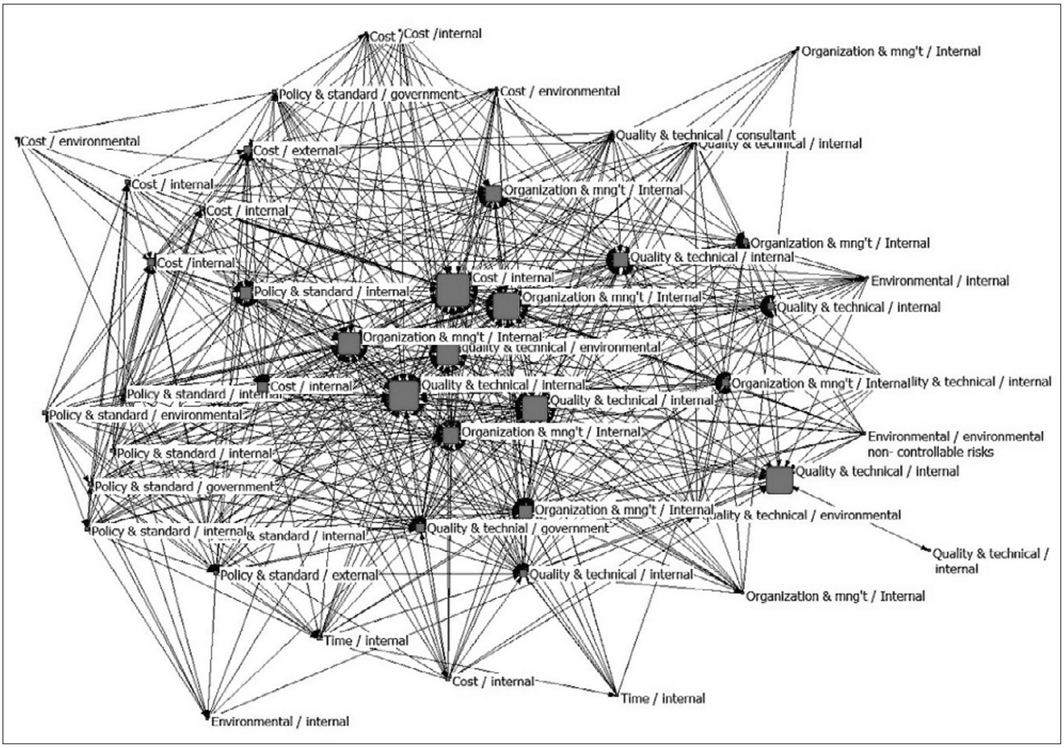
The Risk Structure Matrix from Chapter 3.5 and the deciphered results from 3.6 were used to draw a stakeholder-associated risk map. This followed by an elaborated critical risk list and mitigation action plan.

3.4. *Risk network*

The network measures, which is the density and cohesion show that the risk interrelations and complexity of the risk network was high for the two projects. Results for density, which ranges from 0 to 1, are 0.30 and 0.37 for project 1 and project 2, respectively. Results for cohesion are 0.93 and 1.2 for project 1 and project 2, respectively. An example of the risk network map is shown below in Figure 2. The figure demonstrates that the network is very complex.

The bigger the node the higher the control of that node in the whole network. Figure 2 shows that risk related to cost, quality & technical are critical more than risks related to organization

Figure 2 - Risk network of project 1.



& management. However, the mostly associated stakeholder group is the internal stakeholder group. Partners within the project have more control over these risks.

Figure 3 shows the risk network of project 2. It is less complicated than project 1, however we can see that risk related to policy & standard and associated to government is by far the critical risk. A closer look into the network shows that risk related to organization &management is another critical risk that should be paid attention to.

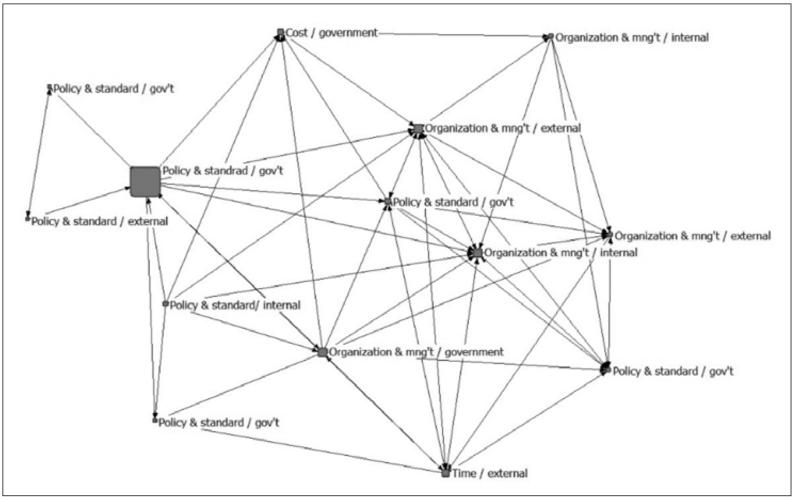


Figure 3 - Risk network of project 2.

Table 7 - Key risks according to betweenness centrality and status centrality for project 1.

Rank	*Risk ID*	*Node betweenness centrality*	*Risk ID*	*Link betweenness centrality*	*Risk ID*	*Out-status centrality*
1	R20 S3	162.90	R9_S1 => R9_S3	47.25	R10 S1	47.00
2	R19 S1	143.96	R22_S1 => R22_S2	47.00	R24 S13	47.00
3	R16 S3	112.26	R5_S2 => R5_S4	47.00	R15 S10	47.00
4	R5 S2	107.80	R3_S1 => R3_S3	46.10	R10 S2	46.5
5	R14 S9	87.13	R1_S1 => R1_S2	46.00	R12 S2	46.00
6	R23 S1	82.55	R16_S3 => R16_S11	46.00	R12 S4	46.00
7	R11 S7	81.95	R17_S3 => R17_S11	46.00	R12 S8	46.00
8	R22 S1	77.63	R19_S1 => R19_S2	45.00	R29 S2	44.00
9	R3 S1	63.02	R19_S1 => R19_S12	44.00	R7 S2	44.00
10	R25 S3	53.72	R16_S3 => R17_S3	42.15	R29 S14	42.75

3.5. *Critical risks and mitigation action plan*

Table 7 through table 10 show the critical ten risks and interactions for the two projects calculated by the software UCINET and STATA. Node and link betweenness centrality identify risk interactions passing through that node or link. This means that a node or a link with a high value of betweenness centrality has a high level of control over the impact, because more risks and are passing through that node/link. Out-status centrality calculates the extent to which the risk has an impact on other risks, differing with degree difference in that it looks at the whole network rather than individual node to node impact. Table 7 looks at the risk and its interactions through the whole network, whereas Table 8 looks at the single node as an individual risk.

The results for node betweenness centrality show that the critical nodes that have high control over the other nodes are mostly risks related to cost (R20, R16, R11, R5,) quality & technical risks (R23, R22, R19 and R14) followed by organization & management (R3, R25). The stakeholders are mostly internal, meaning that actors who are directly involved in the project and have high influence and control over the risks. R19 S1, which is 'inadequate analysis of the complexity of the project' and is associated to the internal energy efficiency team, appears to be a critical risk in terms of link betweenness. It is linked to the same risk faced by the irrigation community (internal) and with the University of Valencia (consultant).

The out-status centrality column shows that 'lack of political support' (R10) and 'legislative or regulatory changes' (R12) are two main risks in the whole network. There are also two non-controllable risks, which are 'risk due to weather conditions and 'unfavourable climatic conditions'. These differ significantly to the betweenness centrality, which face more cost and quality & technical related risks rather than political discontinuity or regulatory changes.

The degree difference (Table 8) gives us the results of risks that have higher impact on other risks than received. The results differ with the results of Table 7.

The top five risks that have higher impact on other risks than received, are related to lack of

Table 8 - Key risks according to degree difference for project 1.

Rank	*Risk ID*	*Degree difference*
1	R10 S1	22
2	R10 S2	20
3	R12 S2	18
4	R12 S4	18
5	R12 S8	18
6	R16 S11	16
7	R19 S2	16
8	R19 S12	15
9	R5 S4	14
10	R24 S13	14

Table 9 - Key risks according to betweenness centrality and status centrality for project 2.

Rank	*Risk ID*	*Node betweenness centrality*	*Risk ID*	*Link betweenness centrality*	*Risk ID*	*Out-status centrality*
1	R9S4	43.06	R8_S4 => R9_S4	20.58	R6S4	7.25
2	R8S4	29.49	R4_S3 => R1_S1	19.45	R4S3	7.25
3	R6S4	20.58	R6_S4 => R8_S4	14.17	R12S2	6.75
4	R4S3	15.51	R11_S2 => R9_S4	12.5	R8S4	6.5
5	R1S1	6.95	R10_S8 => R9_S4	12	R7S1	6.5
6	R12S2	6.58	R9_S4 => R11_S2	11.5	R5S4	6.25
7	R3S2	3.64	R9_S4 => R10_S8	11	R9S4	6.00
8	R13S7	3.13	R3_S2 => R6_S4	10.14	R3S2	5.87
9	R7S1	2.63	R5_S4 => R8_S4	7.83	R13S7	5.5
10	R5S4	2.43	R7_S1 => R8_S4	7.83	R2S1	5.25

political support/government discontinuity (R10) and legislative or regulatory changes (R12). The two main risks are associated to internal stakeholders of the project. The energy efficiency team that is responsible for the energy supply during the process of the project and the irrigation community are examples of internal stakeholders.

Other critical risks are ‘inadequate analysis of the complexity of the project’ (R20), ‘lack of support from senior management’ (R3), ‘lack of access to funds’ (R9), ‘increase in price of materials (water, energy)’ (R32), ‘raise awareness among farmers’ (R33) and ‘unsuitable, untested or unreliable materials, products or sustainable systems’ (R23). These are mostly associated to internal stakeholders. It proves that most of the risks are associated to internal partners of the project as it was proven in Table 3.

Table 9 shows the risk interaction for project 2. Like project 1, risk and their interactions were given attention, so the node/link betweenness centrality and out-status centrality were calculated.

Critical nodes (see node betweenness centrality) that have high control over the other nodes are mostly risks related to policy & standard (R1, R7, R9, R12) and risk related to organization & management (R4, R5, R6, R13). The risks are mostly associated with external stakeholders (for example farmers) and equally same with government and internal stakeholders. Results for critical risk interactions (see link betweenness centrality) R9_S4, which is ‘discrimination of policy’ associated with farmers (external stakeholder) seems to be the mostly influential risk throughout the whole network.

The degree difference (Table 10) shows the results of risks that have higher impact on other risks than received. The results do not differ much from Table 8, in that the most critical risks are related to policy & standard (R1, R9, R10, R11) and organization & management (R2, R5, R9).

In project 2, a common risk has been identified: lack of common definition of key terms. This risk is critical in that it is related to communication among all stakeholders, whether internal or external and also with government. Less or misleading communication can lead to mistrust and eventually to discrimination of policy, which has been identified has a critical risk interaction in Table 9.

Table 10 - Key risks according to degree difference for project 2.

Rank	*Risk ID*	*Degree difference*
1	R1S1	5
2	R13S7	5
3	R9S4	4
4	R2S1	2
5	R8S4	1
6	R11S2	0
7	R10S8	0
8	R5S4	-1
9	R12S2	-1
10	R7S1	-2

Table 11 - Risk mitigation action plan according to the main risk interaction for project 1.

Risk interactions	*Mitigation action plan*
R9_S1 => R9_S3	To apply to additional funding should not be difficult to stakeholders (otherwise lack of trust and miscommunication can happen)
R22_S1 => R22_S2	Project design before implementation should be thoroughly reviewed to avoid further malfunction of the project (untested materials, products etc.)
R5_S2 => R5_S4	Fiscal changes are unavoidable, but must be communicated in advance
R3_S1 => R3_S3	Communication between senior management and all partners should communicate closely throughout the whole project.
R1_S1 => R1_S2	All partners should be aware of the timing of the project. A timeline with milestones and deliverables are useful.
R16_S3 => R16_S11	Budget shortages should be communicated
R17_S3 => R17_S11	Time shortages can be flexibly responded by project coordinators at the same time notifying all partners
R19_S1 => R19_S2	Preparation plans for complexity of the project should be known before the implementation stage; additional complexity during the project should be verbally and often communicated.
R19_S1 => R19_S12	Preparation plans and mitigation action plan for the complexity of project should be verbally communicated with external stakeholders of the project.
R16_S3 => R17_S3	Additional budget should be planned to deal with sudden budget cut

To mitigate the risks and reduce their impact on the whole project, the critical risks were removed. The top ten risks according to the node betweenness centrality from Table 6 and Table 8 were considered as critical nodes to be removed, since they are the strongest nodes having high control over the impact in the whole network. When removing the ten risks the nodes have been reduced from 47 nodes to 37 nodes and 637 paths to 258 paths for project 1, and from 14 nodes to 9 nodes and 67 paths to 17 paths for project 2.

The network density has been reduced from 0.3 to 0.2 (a decrease of 34.3%) and the cohesion value reduced from 0.93 to 0.61 (a decrease of 34.4%) for project 1. For project 2, network density has been reduced from 0.37 to 0.24 (a decrease of 36%) and the cohesion value from 1.20 to 0.83 (a decrease of 31%).

The main risk interactions are identified with the link betweenness centrality values. By cutting of these links we can separate the main risks into simplified parts and reduce them by proposing possible mitigation action plans (Table 11 and Table 12).

According to the results in Table 11, communication between the risks and associated stakeholders could be improved. Proposed mitigation action includes, for example:

Communication between senior management (often the project coordinator) and all partners should happen regularly using effective measures and strategies before and throughout the project;

Communication on technical difficulties, time shortages, access to additional funds and other changes should be done (written communication, if necessary) using an effective communication platform.

From the results, we can see that communication enhancement between stakeholders will reduce lack of trust and miscommunication between partners. Unnecessary risks can be reduced with effective and efficient communication strategy plans.

Table 12 shows the top ten risk interaction for project 2. Here, like the results of project 1, communication enhancement is a key mitigation action plan that can improve many difficulties. Proposed plans are:

A well-defined terminology and transferring of the terminology to the different partners avoids future miscommunication;

Consideration of end-users (farmers, local community) culture, ethics, traditional practices into the project design and well communication of “new” practices will avoid mistrust between stakeholders.

Table 12 - Risk mitigation action plan according to the main risk interaction for project 2.

Risk interaction	*Mitigation action plan*
R8_S4 => R9_S4	Differences in agricultural practices between tradition and European policies must be acknowledged and well communicated.
R4_S3 => R1_S1	Differences in agricultural practices can begin by establishing a common definition of terms and communicating them well among partners
R6_S4 => R8_S4	Large distances between farmers (case studies) put more distances in terminology and communication, so other measures for communication strategy should be taken to shorten the gap
R11_S2 => R9_S4	Lack of common definition and guidelines should be overcome to avoid mismanagement and discrimination
R10_S8 => R9_S4	Dealing with end-users (farmers, local community) means considering their culture, ethics in working. This may avoid future and bigger discrimination.
R9_S4 => R11_S2	Well established management system may lead to full support of policies and less discrimination.
R9_S4 => R10_S8	Discrimination of policy is, when broken down into small parts, leads to ignorance of ethical difference among partners. This should be overcome by considering partners needs and accustoms first.
R3_S2 => R6_S4	A plan with all possible actions that could happen within the project should be made and a flexible funding system accordingly.
R19_S1 => R19_S12	Establishing a common definition on terminology and efficient communication will lead to a well project process.
R16_S3 => R17_S3	Adapting to new agricultural practices may lead to 'going to the next step (innovation)' level. Adapting farmers to new practices includes considering their perspectives in the project.

The most critical risk interaction and their mitigation action plan demonstrate that communication is a key tool to reduce the risk network. Careful consideration of what kind of communication with which stakeholder is a way to enhance the communication type and structure. Communication type and structure may differ by project according to their characteristics, but it has been proven that better communication can lessen the risk network. Recalling that communication is (inter) action between two or more stakeholders, careful revision and study of interaction is necessary.

As literature states that elaborating on stakeholder interaction and mitigating uncertainties can improve the overall performance of the project, this research supports through empirical analysis that the Social Network Analysis is a promising tool for analyzing risks and stakeholder interaction. Stakeholder interaction may be defined by their risk preference (Khan *et al.*, 2020), knowledge on their decision-making process (Senapati, 2020), their awareness on climate-related risks (Qin *et al.*, 2016). The knowledge of stakeholders and integrating them is described as complex. However, many innovative projects are required to find solutions to the complexity. Being aware of the diverse perspectives and knowledge of stakeholders and establishing a constructive and systemic way of thinking enhances critical reflections and assess the effectiveness of process. Thus, systemic thinking gives way out of complex situations. As such, the Social Network Analysis is proposed as an evaluation tool of comprehensiveness, integration and systemic approach in order to achieve a high performance in innovation management.

4. Conclusions

The study draws on a stakeholder-associated risk network map that provides the stakeholder with a more holistic view of interactions in the project. The social network perspective can improve stakeholders' insight of the whole interrelations of the risk and associated stakeholder and thus provide a better risk management and decision-making process. Previous studies on risk analysis have evolved from analysing technical, environmental and social risk to stakeholder-oriented risk perspective. Adinolfi *et al.* (2020) in their study have analyzed women's rural economic participation, networking and access to rural policies and finds that more participation of women may lead to sustainable, developmental and innovation ways in the rural areas. As such, risk is no longer an individual phenomenon, but happens through the interaction of stakeholders and must be regarded at organizational and institutional level. Through exploratory analysis and empirical evidence this study finds several important points: (1) internal stakeholders play more important role than government or external stakeholders in allocating resources (2) communication among the stakeholders within the project is the most critical risk faced (3) establishing a well-defined terminology is critical for better communication among stakeholders (4) acknowledging the diversity, such cultural and practice differences among stakeholders is a critical risk to overcome and a step to start better communication.

A key finding from the risk network analysis, is that communication is the key risk that is stretched over the network and is critical to reduce the negative impact. Like the above example, an analysis based on stakeholder interaction is promising in examining the impact or evaluating interactive innovation processes. In line the study brings forward two main findings for future policy implications.

First, stakeholder interaction should be regarded as an essential subject in the analysis of risk network and network management due to their impact on better decision-making process and sustainable development. The diversity of stakeholders and their networks result in more distributed control and requires more cooperation and network management (Kemp *et al.*, 2007). Networks can facilitate collective action (Powell and Grodal, 2005; Lejano and de Castro, 2014) and boost innovation by steering knowledge acquisition and transfer, resource mobilization and cooperation (Bodin and Crona, 2009; Dessie *et al.*, 2013; Reed and Hickey, 2016). However from a micro perspective, knowing stakeholder's preference and perception on their decision-making processes will help to identify the determinants of how they adapt to new agricultural management practices (Swami and Parthasarathy, 2020).

Second, stakeholder interaction and risk network mapping as an integrative innovation process should be regraded with a system thinking approach. Stakeholders co-produce knowledge, experiences and practices that are often described as complex socio-scientific problems and by integrating diverse knowledge into management their ideas contribute to bringing more resilient outcomes and adaptable system (Agrawal, 1995; Berthet and Hickey, 2018; Ingram *et al.*, 2020). The knowledge produced should be continuous and feed into repeated learning cycles so that it can adapt to new changing circumstances during the process of the project (Paz-Ybarnegaray and Douthwaite, 2017). The adaptation itself allows us to see the developmental process of a project, which then allows to view the project from a broader perspective to see overall structures and interaction patterns within the structure.

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References

Adinolfi F., Capitanio F., De Rosa M., Vecchio Y. 2020. Gender differences in farm entrepreneurship: Comparing farming performance of women and men in Italy, *New Medit*, 19(1): 69-82.

Agrawal A., 1995. Dismantling the divide between indigenous and western knowledge. *Development and Change*, 26: 413-439.

Allen W., Kilvington M., 1999. *Why involving people is important: the forgotten part of environmental information systems management*. Landcare Research, NZ. Presented at the 2nd International Conference on Multiple Objective Decision Support Systems for Land, Water and Environmental Management (MODSS 99), Brisbane, Australia, August 1-6.

Arts J., Faith-Ell C., 2012. New governance approaches for sustainable project delivery. *Procedia*, 48: 3239-3250.

Bello M., Salau E., Galadima O., Ali I., 2013. Knowledge, perception and adaptation strategies to climate change among farmers of Central State Nigeria. *Sustainable Agriculture Research*, 2(3): 107-117..

Benayas J.M.R., Marins A., Nicolau J.M., Schulz J.J., 2007. Abandonment of agricultural land: an overview of drivers and consequences. *CAB Review: Perspective in Agriculture, Veterinary Science, Nutrition and Natural Resource*, 2(57): 129.

Berthet E.T., Hickey G.M., 2018. Organizing collective innovation in support of sustainable agro-ecosystems: The role of network management. *Agricultural Systems*, 165: 44-54. doi.org/10.1016/j.agsy.2018.05.016.

Bodin Ö., Crona B.I., 2009. The role of social network in natural resource governance: what relational patterns make a difference? *Global Environmental Change*, 19(3): 366-374.

Borgatti S.P., Everett M.G., Freeman L.C., 2002. *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Botha N., Klerkx L., Small B., Turner J.A., 2014. Lessons on transdisciplinary research in a co-innovation programme in the New Zealand agricultural sector. *Outlook Agriculture*, 43: 219-223.

Capitanio F., Adinolfi F., Goodwin B.K., Rivieccio G., 2019. A copula-based approach to investigate vertical shock price transmission in the Italian hog market, *New Medit*, 18(1): 3-14.

Carter M.R., Little P.D., Mogues T., Negatu W., 2007. Poverty traps and natural disasters in Ethiopia and Honduras. *World Development*, 35(5): 835-856.

Cristiano S., Proietti P., 2018. Evaluating interactive innovation processes: Towards a developmental-oriented analytical framework. In: *Proceedings of the 13th European IFSA Symposium on Integrating Science, Technology, Policy and Practice*, Chania, Greece, July 1-5.

Cronin E., Fosselle S., Rogge E., Home R., 2021. An Analytical Framework to Study Multi-Actor Partnerships Engaged in Interactive Innovation Processes in the Agriculture, Forestry, and Rural Development Sector. *Sustainability*, 13(11): 6428. https://doi.org/10.3390/su13116428.

De Hoyos-Ruperto M., Romaguera J.M., Carlsson B., Lyytinen K., 2013. Networking: A Critical Success Factor for Entrepreneurship. *American Journal of Management*, 13(2): 56-72.

Dessie Y., Schubert U., Wurzinger M., Hauser M. 2013. The role of institutions and social learning in soil conservation innovations: Implications for policy and practice. *Environment Science Policy*, 27: 21-31.

Dogliotti S., Garcia M., Peluffo S., Dieste J., Pedemonte A., Bacigalupe G., Scarlato M., Alliaume F., Alvarez J., Chiappe M., 2014. Co-innovation of family farm systems: a systems approach to sustainable agriculture. *Agricultural Systems*, 126: 76-86.

Douthwaite B., Kubyb T., Van de Fliert E., Schulz S., 2003. Impact pathway evaluation: an approach for achieving and attributing impact in complex systems. *Agricultural Systems*, 78: 243-265. https://doi.org/10.1016/S0308-521X(03)00128-8).

Douthwaite B., Mur R., Audouin S., Wopereis M., Hellin J., Moussa A., Karbo N., Kasten W., Bouyer J., 2017. *Agricultural Research for Development to Intervene Effectively in Complex Systems and the Implications for Research Organizations*. KIT Working Paper, 2017:12. Amsterdam: Royal Tropical Institute.

Drollette S., 2009. *Managing production risk in agriculture*. Department of Applied Economics, Utah State University. AG/ECON/2009-03RM.

Easterly W., 2001. *The Elusive Quest for Growth*. Cambridge, MA: MIT Press.

Eichler G.M., Schwarz E.J., 2019. What Sustainable Development Goals do Social Innovations Address? A Systematic Review and Content Analysis of Social Innovation Literature. *Sustainability*, 11(2): 522.

Fang C., Marle F., Zio E., Bocquet J.-C., 2012. Network theory-based analysis of risk interactions in large engineering projects. *Reliability Engineering & System Safety*, 106: 1-10.

Freeman R.E., 1994. The politics of stakeholder theory: Some future directions. *Business Ethics Quarterly*, 4(4): 409-421.

Gaiha R., Thapa G., 2006. *Natural Disasters, Vulnerability and Mortalities – A Cross-country Analysis*. International Fund for Agricultural Development Working Paper. Rome: IFAD.

Graef F., Hernandez L.E.A., König H.J., Uckert G., Mnimbo M.T., 2018. Systemising gender integration with rural stakeholders' sustainability impact assessments: A case study with three low-input upgrading strategies. *Environmental Impact Assessment Review*, 68: 81-89. https://doi.org/10.1016/j.eiar.2017.10.004.

Gray S., Chan A., Clark D., Jordan R., 2012. Modeling the integration of stakeholder knowledge in social-ecological decision making: Benefits and limitations to knowledge diversity. *Ecological Modelling*, 229: 88-96.

Hall A., Bockett G., Taylor S., Sivamohan M., Clark N., 2001. Why research partners really matter: Innovation theory, institutional arrangements and implications for developing new technology for the poor. *World Development*, 29: 783-797.

Imperiale A.J., Vanclay F., 2016. Using Social Impact Assessment to Strengthen Community Resilience in Sustainable Rural Development in Mountain Areas. *Mountain Research and Development*, 36(3): 431-442. DOI:10.1659/MRD-JOURNAL-D-16-00027.1.

Ingram J., Gaskell P., Mills J., Dwyer J.C., 2020. How do we enact co-innovation with stakeholders in agricultural research projects? Managing the complex interplay between contextual and facilitation processes. *Journal of Rural Studies*, 78: 65-77.

IPCC (Intergovernmental Panel on Climate Change), 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part a: Global and Sectoral Aspects*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, New York: Cambridge University Press.

Javed S.A., Haider A., Nawaz M., 2020. How agricultural practices managing market risk get attributed to climate change? Quasi-experiment evidence. *Journal of Rural Studies*, 73: 46-55.

Jha P.K. (ed.), 2015. *Proceedings of International Conference on Biodiversity, Livelihood, and Climate Change in the Himalayas*. Kathmandu: Central Department of Botany, Tribhuvan University.

Johannisson B., Nilsson A., 1989. Community entrepreneurs: Networking for local development. *Entrepreneurship & Regional Development*, 1(1): 3-19.

Kemp R., Loorbach D., Rotmans J., 2007. Transition management as a model for managing processes for co-evolution towards sustainable development. *International Journal of Sustainable Development of World Ecology*, 14(1): 78-91.

Khan I., Lei H., Shah I.A., Ali I., Khan I., Muhammad I., Huo X., Javed T., 2020. Farm households' risk perception, attitude and adaptation strategies in dealing with climate change: Promise and perils from rural Pakistan. *Land Use Policy*, 91: 104395.

Kibert C.J., Sendzimir J., Guy B., 2000. Construction ecology and metabolism: natural system analogues for a sustainable built environment. *Construction Management and Economics*, 18(8): 903-916.

Kuang F., Jin, J., He, R., Ning, J., Wan X., 2020. Farmers' livelihood risks, livelihood assets and adaptation strategies in Rugao City, China. *Journal of Environmental Management*, 264: 110463.

Lacirignola C., Adinolfi F., Capitanio F. 2015. Food security in the Mediterranean countries. *New Medit*, 14(4): 2-10.

Lai X., Liu J., Georgiev G., 2016. Low carbon technology integration innovation assessment index review based on rough set theory – an evidence from construction industry in China. *Journal of Cleaner Production*, 126: 88-96.

Lee S.Y., Diaz-Puente J.M., Vidueira P., 2020. Enhancing Rural Innovation and Sustainability through Impact Assessment: A Review of Methods and Tools. *Sustainability*, 12(16): 6559.

Lejano R.P., de Castro F.F., 2014. Norm, network and commons: the invisible hand of community. *Environment Science Policy*, 36: 73-85.

Marle F., Vidal L., Bocquet J., 2013. Interactions-based risk clustering methodologies and algorithms for complex project management. *International Journal of Production Economics*, 142(2): 225-234.

McKeever E., Anderson A., Jack S., 2014. Entrepreneurship and Mutuality: Social Capital in Processes and Practices. *Entrepreneurship & Regional Development*, 26(5-6): 453-477. DOI: 10.1080/08985626.2014.939536.

McNie E.C., 2007. Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. *Environment Science Policy*, 10: 17-38.

National Research Council, 2008. The effects of public participation. In: Dietz T., Stern P.C. (eds.), *Public Participation in Environmental Assessment and Decision Making*. Washington, DC: National Academies Press, pp. 75-93.

Nederlof E.S., Wongtschowski M., Van der Lee F. (eds.), 2011. *Putting heads together: Agricultural innovation platforms in practice*. Bulletin 396. Amsterdam: KIT Publishers.

Neumeier S., 2012. Why do social innovations in rural development matter and should they be considered more seriously in rural development research? Proposal for a stronger focus on social innovation in rural development research. *Sociologia Ruralis*, 52(1): 48-69. DOI:10.1111/j.1467-9523.2011.00553.x.

Paz-Ybarnegaray R., Douthwaite B., 2017. Outcome Evidencing: A Method for Enabling and Evaluating Program Intervention in Complex Systems. *American Journal Evaluation*, 38: 275-293. DOI: 10.1177/1098214016676573.

Plieninger T., Hui C., Gaertner M., Huntsinger L., 2014. The impact of land abandonment on species richness and abundance in the Mediterranean basin: A meta-analysis. *Plos One*, 9(5): e98355.

Powell W.W., Grodal S., 2005. Networks of Innovators. In: Fagerberg J., Mowery D.C. (eds.), *The*

Oxford handbook of innovation. Oxford: Oxford University Press, pp. 56-85.

Preskill H., Gopal S., 2014. *Evaluating Complexity. Propositions for improving practice*. Available at: http://www.fsg.org/publications/evaluating-complexity (accessed on February 2, 2020).

Prum D.A., Del Percio S., 2009. Green building claims: What theories will a plaintiff pursue, who has exposure, and a proposal for risk mitigation. *Real Estate Law Journal*, 37(4): 243-277. Available at: http://works.bepress.com/darren_prum/5.

Qin X., Mo Y., Jing L., 2016. Risk perceptions of the life-cycle of green buildings in China. *Journal of Cleaner Production*, 126: 148-158.

Quiedeville S., Barjolle D., Mouret J.C., Stolze M., 2017. Ex-post evaluation of the impacts of the science-based research and innovation program: A new method applied in the case of farmers' transition to organic production in the Camargue. *Journal of Innovation Economics & Management*, 22: 145-170.

Reed G., Hickey G.M., 2016. Contrasting innovation networks in smallholder agricultural producer cooperatives: insights from the Niayes region of Senegal. *Journal of Cooperative Organization Management*, 4(2): 97-107.

Robichaud L.B., Anantatmula V.S., 2011. Greening project management practices for sustainable construction. *Journal of Management Engineering*, 27(1): 48-57.

Rowley T.J., 1997. Moving beyond dyadic ties: A network theory of stakeholder influences. *The Academy of Management Review*, 22(4): 887-910.

Schneider F., Buser T., 2018 Promising degrees of stakeholder interaction in research for sustainable development. *Sustainability Science*, 13(1): 129-442.

Scott J., Tallia A., Crosson J.C., Orzano J.A., Stroebel C., DiCicco-Bloom B., O'Malley D., Shaw E., Crabtee B., 2005. Social Network Analysis as an Analytical Tool for Interaction Patterns in Primary Care Practices. *Annals of Family Medicine*, 3(5): 443-448.

Senapati A.K., 2020. Evaluation of risk preferences and coping strategies to manage with various agricultural risks: evidence from India. *Heliyon*, 6(3): e03503.

Smit B., Skinner M.W., 2002. Adaptation options in agriculture to climate change: a typology, mitigation and adaptation strategies for global. *Climate Change*, 7: 85-114.

Smits R., Kuhlmann S., 2004. The rise of systemic instruments in innovation policy. *International Journal of Foresight Innovation Policy*, 1(1-2): 4-32.

StataCorp., 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.

Swami D., Parthasarathy D., 2020. A multidimensional perspective to farmers' decision making determines the adaptation of the farming community. *Journal of Environmental Management*, 264: 110487.

Tecco N., Baudino C., Girgenti V., Peano C., 2016. Innovation strategies in a fruit growers association impacts assessment by using combined LCA and s-LCA methodologies. *Science Total Environment*, 568: 253-262.

Terres J.M., Scacchiafichi L.N., Wania A., Ambar M., Anguiano E., Buckwell A., Coppola A., Gocht A., Kallstrom H.N., Pointereau P., Strijker D., Visek L., Vranken L., Zobena A., 2015. Farmland abandonment in Europe: Identification of drivers and indicators and development of composite indicator of risk. *Land Use Policy*, 49: 20-34.

Thabrew L., Wiek A., Ries R., 2009. Environmental decision making in multi-stakeholder contexts: applicability of life cycle thinking in development planning and implementation. *Journal of Cleaner Production*, 17: 67-76.

UCT (University of Cape Town) and UNITAR (United Nations Institute for Training and Research), 2006. *Draft Observations, Conclusions and Recommendations*. National Workshop on Public Participation in Environmental Decision Making in South Africa, Cape Town.

Van Bueren E.M., Priemus H., 2002. Institutional barriers to sustainable construction. *Environment and Planning B: Planning and Design*, 29(1): 75-86.

Wu J., Chang I.S., Lam K.C., Shi M., 2014. Integration of environmental impact assessment into decision-making process: Practice of urban and rural planning in China. *Journal of Cleaner Production*, 69: 100-108. DOI: 10.1016/j.jclepro.2014.01.100.

Yang R.J., Zou P.X.W., 2014. Stakeholder-associated risks and their interactions in complex green building projects: A social network model. *Building and Environment*, 73: 208-222.

Zakkak S., Kakalis E., Radović A., Halley J.M., Kati V., 2014 2017. The impact of forest encroachment after agricultural land abandonment on passerine bird communities: the case of Greece. *Journal for Nature Conservation*, 22: 157-165.