Project Report

Experimenting with RRI tools to Drive Sustainable Agri-Food Research: The SASS Case Study from Sub-Saharan Africa

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Abstract: The need to develop experimental tools for a responsible research and innovation (RRI) framework is relevant for managing research agendas and policy making that seriously take into account the complex conditions of innovation development (linked to multidisciplinarity and interaction processes) between the researchers and their fieldwork activities. The adoption of an RRI framework is even more important for multidisciplinary and complex issues, such as the agri-food system. In this context, the SASS (Sustainable Agri-food Systems for Sustainable Development (SASS) project represents a good example for verifying the application of the RRI strategy in a varied research group committed to the development of sustainable agri-food systems in Sub-Saharan Africa. The project, which involves more than 50 researchers from different fields of knowledge and theoretical backgrounds, showed the importance of the processes of reflection, re-driving, and convergence in the definition of research objectives and strategies. This process started by experimenting with new dedicated RRI tools in order to allow interactions between the researchers, including exchanging their experience in data collection and theoretical reflection development. With respect to this analysis, it was interesting to analyze how the RRI tools and strategies have been activated between researchers and different stakeholders, generating reflections capable of re-adapting the results towards shared and accessible innovation for the extended society. Following the discussion based on the description of the SASS-RRI agenda tools and following an internal verification given from an RRI-based web survey, this contribution provides new insights, in terms of tools and strategies, to promote and refine RRI approaches. This work underlines how RRI methods have promoted internal and external interactions to connect the research objectives towards a model of open innovation.

Highlights:

RRI in research resolves problems by transforming scientific results in innovations

RRI in multidisciplinary teams promotes re-driving/convergence of research aims

RRI tools and strategies influence research outcomes and policy making on wide topics

Keywords: agri-food systems; multidisciplinarity; open innovation; peer connection meetings; responsible research innovation; research management; theory of change

1. Introduction

Mainstream innovation theory suggests that economic growth and technological change are strongly intertwined, where economic progress elicits new technological trajectories contributing to the creation of new market opportunities and wealth [1]. More recent studies have identified how trading products resulting from innovation frameworks may often translate into situations of uneven development. Economic wealth is not necessarily equally distributed in the population and increasing inequalities occur both within different regions and nations and among different social categories and contexts [2,3]. These inequalities bring social and environmental costs with them, driving strong implications in health and mortality, as well as in education and crime [4,5], thus reducing the ability for entire sections of the population to participate with their jobs, competencies, and skills in the creation of wealth [2].

Given these assumptions, in this contribution we focus on the relationship between research policy and innovation and on the role of the responsible innovation (RI) concept [6] that has been adopted by several public agendas, including all of the European research agendas [7,8]. For example, a framework of responsible research innovation (RRI) has found its clearest research policy application in the Horizon 2020 research strategy, where the necessity to include ethical, environmental, and social issues in any project phase is clearly stated [8–10].

In this work, we tested the efficacy of the RRI framework on a multidisciplinary research project dedicated to the sustainability of food systems. Specifically, we tested the efficacy of RRI tools to improve the research plan and the research strategies of the team involved in a project dedicated to the agri-food systems. The project, entitled 'Sustainable Agri-food Systems for Sustainable Development' (SASS) is devoted to analyzing the production, distribution and consumption of agricultural products in Sub-Saharan Africa and to identify the most suitable strategies for improving the sustainability of food systems at the social, environmental, and economic levels.

Smallholder farmers provide over 70% of the food consumed in Sub-Saharan Africa. Hence, this category plays a decisive role in terms of facilitating food security on the local, national, and global levels [11,12]. For example, in Tanzania, agriculture accounts for 25% of gross domestic product and more than 80% of the workforce are employed in the sector [13]. Agricultural development in Sub-Saharan regions is difficult to achieve due to multiple constraints impeding growth and productivity improvements not only at the production level but also at the distribution and consumption ones. Some of these factors are poor product quality and access to markets, low levels of risk-taking capacities by farmers and distributors, insufficient risk-coping options, missing access to capital and credit, and the weak role of administrations and public support management [13,14]. Several studies [15] suggest that support strategies for smallholder farmers represent the most effective strategy to guarantee a reliable and sustainable development. For this reason, the final goal of SASS is to define a dedicated food policy and regulatory choices to be scaled up in terms of multi-dimensional innovations, directed to markets and social organizations.

In terms of providing new insights into the RRI concept, this project was chosen for three reasons:

1) The research on agri-food systems is usually multidisciplinary, with many perspectives for innovation. The definition of problems in agricultural supply chains has often been analyzed in depth only by one or a few disciplines, causing problems when spreading technological and organizational progress. For example, the genetic improvement of crops was mainly promoted by agronomists and biologists, but these disciplines rarely took into consideration social, ethical and economic aspects. There are several examples of successful GMO crops at the biological level that do not reach the market due to economic, cultural, or legal critiques [16–18]. The RRI approach could help address these critical issues by sharing strategies and responsibilities with stakeholders and transforming scientific results into agronomic innovations for farmers [6,19], evidence for public policy making, and financial strategies for the banking industry.

2) The project SASS involves researchers belonging to several disciplines such as biology, agronomy, nutritional science, sociology, anthropology, economics, and policy making. To date, very few tools have been proposed and tested to support RRI assessment in such a large and diverse

research consortia (e.g. [20]). Although the adoption of multidisciplinary research strategies has largely been encouraged in those public EU research programs dealing with food (i.e. [21]), only a few projects related to the "food and health" topic were developed under a multidisciplinary view, as suggested in the EU-FAHRE program [22]. Moreover, several scholars have noticed how the adoption of measures to promote open innovation processes between multidisciplinary agri-food research consortia and the engagement of SMEs, civil society organizations, and local community groups is still fragmented (i.e. [23–27]).

3) The project SASS represents the opportunity to recognize and explore the practical dimension of RRI in agri-food research in those contexts characterized by a strong separation between technological innovation and political power imbalances, cultural asymmetries, the management of environmental resource exploitation, and socio-economic inequalities [28]. Sub-Saharan Africa is a particularly risky context, where the adoption of agricultural technologies underwent a complex process influenced by both extrinsic and intrinsic cultural variables [29,30]. A mechanistic understanding of these factors and their interactions through an RRI strategy could represent a valuable approach to reassess and converge the research outcomes towards the adoption of new technologies and production organization (e.g. the adoption of intercropping), helping to target policies suitable for ensuring sustainability [31]. Moreover, it is important to underline that the results and policy outcomes of SASS would be transferred in order to ameliorate non-resilient agricultural systems that are suffering from the erosion of the local environmental resources (e.g. [32]) and increasing social vulnerability (e.g., [33]). Therefore, it is essential that the critical issues highlighted by all the stakeholders are taken into account and that only the best shared and sustainable strategies will be translated into practical actions.

In this paper, we considered the RRI approach starting from the composition of the project research team, with the aim of pushing researchers from different disciplines to share their research process and to evaluate any step based on anticipation, reflexivity, inclusion, and responsiveness. Therefore, we developed dedicated tools to compare the researchers' aims, strategies, and expected results and to share data and information within the whole SASS team, without excluding the feedback achieved through interactions with external stakeholders (e.g., farmers and local institutions).

2. Background: Responsible Research and Innovation

The emphasis on innovation in research may be connected to the generally acknowledged commitment of managing technology, the need to demonstrate and communicate the impact of the research at social, environmental, and economic scales, and the need for a better integration between science and industry [34–37]. In this debate, the concept of RRI has emerged when discussing the impact of science on society and the co-production of solutions to deal with global sustainability goals and purposeful science [38,39], upstream engagement [40], and reflexive responsibility of innovation actors [34]. In research projects, the definition of an RRI strategy differs from the establishment of a research governance scheme by putting more emphasis on the open definition of purposes and motivations and not merely on the products of scientific evaluation [34]. Furthermore, RRI focuses on responsiveness, considered as "the capacity to change shape or direction in response to stakeholder and public values and changing circumstances" [41]. According to von Schomberg [42] RRI is: "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability, and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)".

The RRI approach includes four interconnected key points [34]: (1) The processes of mutual exchange in setting and re-driving research and innovation direction (Diversity & Inclusiveness); (2) socially desirable science and innovation (Anticipation); (3) participatory and accessible methodologies experimented in the research agenda and the dissemination of its outcomes (Openness and Transparency); (4) flexible, reflexive, and socially responsible governance of the process (Responsiveness and Adaptation to Change).

These elements demand specific tools and mechanisms of interaction for the management of multidisciplinary research agendas [43] with multi-sectoral impacts (e.g. [20]). In this perspective, an effective RRI process should "help scientists and innovators to identify four dimensions in their activities: anticipation, reflexivity, inclusion, and responsiveness" [44]. This means that an RRI-committed research team should be able to understand (and anticipate) how the current processes will impact the definition of future needs. This kind of team is asked to examine possible actions and spill-over effects concerning all aspects of the RRI: "from daily routines, planning assumptions and personal interactions, all the way up to institutional values and strategies" [45]. A wide range of stakeholders should be involved in an inclusive way throughout the whole research process in order to generate diverse perspectives and expertise. Finally, the research activities should be flexible and open to adaptation to existing organizational structures in response to evolving environments, values, and insights.

3. Testing the New Proposed Frameworks of 'Internal RRI' and 'External RRI'.

To address complex issues, such as sustainable agricultural production, it is often necessary to include many disciplines involving different approaches and tools. This strategy was adopted during the SASS project. Other projects such as NUCLEUS [46], founded by Horizon 2020, investigated how to make responsible research and innovation (RRI) a reality in a research institution to address multidisciplinary issues. The team of the SASS project identified some institutional barriers that prevent the alignment of research action with society's needs. Among these, the structural differences of the disciplines could also represent an obstacle [47]. In general, multidisciplinary research is interested in practical problems such as difficulties in integrating the methods and by structural challenges, such as the definition of a shared research process and knowledge production, including the analysis of impacts.

Therefore, before starting the dialogue with the stakeholders, we believe it is essential to start a constructive dialogue within the research consortium. For this reason, the first objective of the methodology experimented in this research was to test the distinction between two novel conceptual frameworks of RRI that we called 'internal RRI' and 'external RRI'. From our perspective, the actors of the internal RRI are the researchers of the team and the aim of this framework is to implement a revision of the project through a constructive discussion towards the identification of a shared vision of the objectives, tools, and expected results and also responsibility. In other words, the internal RRI allows a critical analysis of the single research actions and a shared re-driving of researchers' strategies.

The same researchers are also involved in the external RRI framework, but this also includes a wider plethora of stakeholders who are asked to converge in terms of project aims, tools, and outputs. This would result in the identification of responsible strategies to enhance the impact of the project results. The external RRI aims at grouping members of local communities, regulatory and governmental institutions, and any other stakeholder interested in the research topics. We strongly believe that these interactions will create a trading zone of knowledge exchange between experts and civil society members (The trading zone concept [47] is often used in the field of planning and decision making studies to describe local platforms and support systems for participation in public policy, knowledge production, decision making, and local conflict management and community action: "through specific community engagement policies, depending on the proper representation of needs and social demand, or as a way to enable engagement of weak community groups" [27]) as previously advocated by several authors [26,48,49].

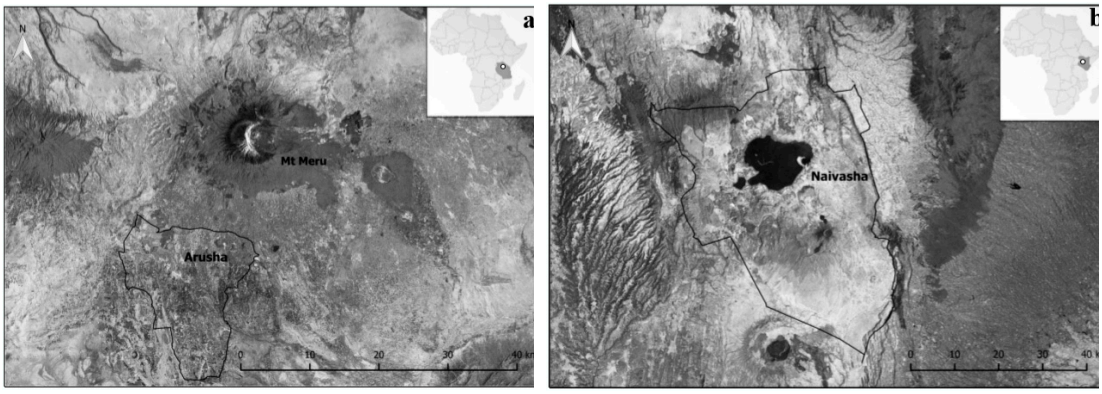
In this paper, we mainly focus on the internal RRI actions, keeping an eye on how, in some conditions of multidisciplinary research, this approach can be preparatory to better implement the next external RRI step. At the research management level, the main question that this paper intends to address is 'which strategies and tools can be adopted to manage an internal RRI process evaluation?'. This step considers both the efficacy of different tools in terms of critical evaluation, comparison, and synthesis and the effects of these on the whole research agenda workflow. At the policy level, the main research questions that this work intends to address are: 'how and why is the

adoption of an RRI shared framework able to create a shared responsibility?' and 'why is this framework so important in multidisciplinary research, such as addressing agri-food topics?'. To achieve the proposed aims, we developed three tools dedicated to performing internal RRI actions, and 15 months after the project kick-off we distributed a survey to each researcher in the team to evaluate how they used these tools in interpreting the 4 key RRI pillars.

4. Methodology

4.1. Framing the "SASS" Research Agenda

The main objective of the SASS project (36 months; Jan 2017–Dec 2020) is the research-driven development of tools for implementing sustainable food and agricultural systems in Sub-Saharan Africa, through strategies of scientific, technological and socio-economic innovation, and collaboration with local institutions and governments. The study areas are the Sub-Saharan regions of Arumeru (Tanzania) and the rural area surrounding the Naivasha Lake in Kenya (Figure 1). Both areas show similar pedoclimatic conditions in terms of access to water and soil resources and share the same risk factors (i.e., intensification of agriculture, overexploitation of natural resources, and fragmentation of food supply chains).



(a) **(b)**

Figure 1. The study areas of the sustainable agri-food systems for sustainable development (SASS) project. (**a**) Arumeru region, Tanzania and (**b**) Naivasha lake, Kenya.

The project team investigated the local agri-food systems and their sustainability at the production, distribution, and consumption levels and identified the most critical and valuable elements to be analyzed at both the technical-scientific and the socio-economic and political points of view. Specifically, preliminary results and recent literature suggests that small and medium smallholder farms (5–10 hectares) almost doubled the share of Tanzanian marketed crop production in the last decade. Such an increase indicates that this farm category can really act as a dynamic driver of agricultural transformation in Sub-Saharan Africa [50]. However, several challenges are still posed by the fragmentation of productions, the huge spread of staple crops and the limited access to mechanization in both soil processing and the harvesting and storage of agriculture products [15,51]. In this context, the team of SASS decided to support the model of small- and medium-holder farms at both the rural and urban level to study the role of conservation agriculture [52] strategies in preserving natural resources (soil and water) and biodiversity. Moreover, the SASS team also evaluated the role of minor local crops (also known as Neglected and Underutilized Species—NUS [53]) and their intercropping with staple crops [54] to enhance local productivity.

At the distribution level, it is known that one of the most diffused problems in Sub-Saharan Africa is the lack of transports from rural farming areas to the urban and market centers, as already documented by a previous project conducted by part of the SASS research team [55]. For this reason, in the SASS project the research team focused on the analysis of the local markets structure and on the food value chain because the improvement of transport and logistics processes represent an

essential step to connect food production and consumption sectors and to enhance the access to food of better quality [56].

Moreover, preliminary data that emerged during the first activities of SASS suggested that although most farmers in Tanzania are integrated into agricultural markets, their level of commercialization is very low, with an average of only 30% of their crop production sold [57]. The SASS research team intended to analyze the critical elements linked to the various intermediaries of the market, as well as the characteristics and technical problems related to the steps of the local supply chains (e.g., transport, transformation, and conservation).

Regarding the consumption phase, it is well-known that Sub-Saharan Africa has been facing the problem of nutritional transition [58,59] and a widespread behavior is the imitation of European or American diets that are rich in terms of sugars and meat. Given these assumptions, the SASS project addressed the biological and nutritional characteristics of local products and the impact on diet and health [59], and evaluated the strategies of traceability and commercial valorization. Based on this analysis, the research team intended to define practical actions to improve the well-being of the African population by acting both on the structure of agricultural supply chains, on the nutritional quality of agricultural products, and on the related food consumption strategies.

In a broader perspective, the interventions that will finally arise from the project aim at strengthening and supporting the knowledge, political dialogue, and collaboration between Africa, Europe, and the UN-based agencies in Rome (Committee on World Food Security and Global Alliance on Climate—Smart Agriculture). The diagram in Figure 2 describes the general structure of the SASS project.

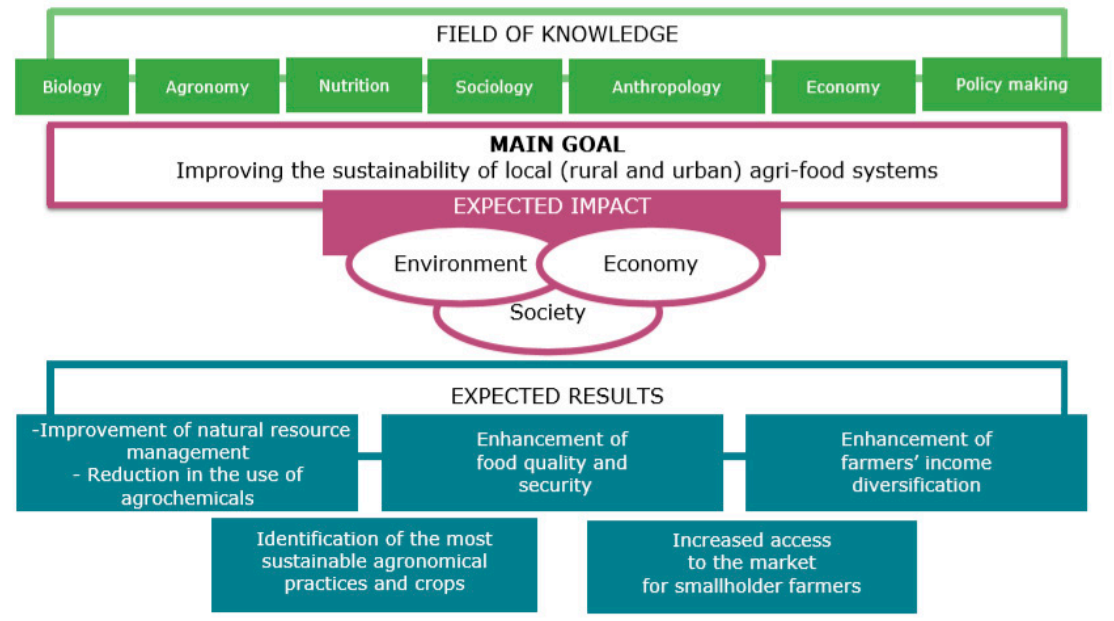


Figure 2. Schematic framework of the SASS Project.

4.2. SASS Research Team

The SASS consortium included 7 internal research sectors, 5 research bodies, and 57 researchers involved (see Table 1).

Table 1. List of disciplines, affiliations and number of participant researchers in the SASS consortium.

Sustainable Agri-Food Systems for Sustainable Development Team Composition		
Discipline	**Affiliation**	**Number of researchers**
Biology	University of Milano-Bicocca (Milan, Italy) University of Gastronomic Science (Pollenzo, Italy)	23
Agronomy	Catholic University (Piacenza, Italy)	7
Nutrition	University of Pavia (Pavia, Italy)	4
Sociology	University of Milano-Bicocca (Milan, Italy)	3
Anthropology	University of Milano-Bicocca (Milan, Italy) University of Gastronomic Sciences (Pollenzo, Italy)	8
Economics	University of Pavia (Pavia, Italy) University of Gastronomic Science (Pollenzo, Italy)	6
Policy	European Center for Development Policy Management, Maastricht, the Netherlands (Maastricht, the Netherlands)	6

4.3. RRI Tools

In order to perform an internal RRI evaluation to improve the project strategies through a constructive discussion among researchers, we proposed and tested three RRI tools:

Peer Connection Meetings: these were mainly devoted to the first two pillars of RRI ('Diversity & Inclusiveness' and 'Anticipation') and were adopted to discuss the activities of each researcher or research team and to share goals, methodologies, and expected results at the technical level. A similar approach was previously adopted by Van Kleef and co-workers [60] to address a multidisciplinary investigation aiming at developing new food products.

In the SASS project, during these meetings (organized twice a year), the PI of the project introduces goals, technical aspects, and strategies to work on the three phases of the food supply chain (production, distribution, and consumption). Thereafter, each researcher discusses her/his data and problematic issues based on her/his skills and knowledge. Then, the meeting proceeds with a plenary discussion section (organized in a way to discuss the general topics, such as socio-economic, agronomic, and nutrition) in order to share information and tools and define shared technical strategies of investigation. Finally, the PI merges the main questions, data, and results. A schematic structure of this tool is shown in the Appendix A Figure A1.

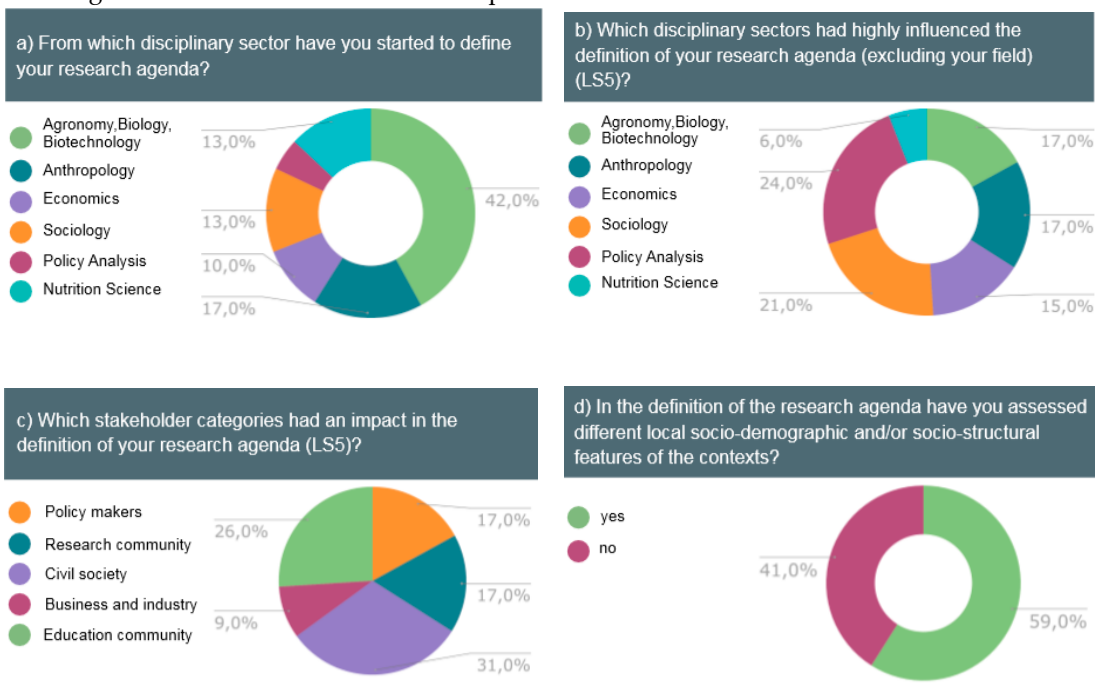
Theory of Change Table: this tool allows the research team to plan processes, articulate project goals, and identify the critical points to be solved to meet the project objectives [61]. Therefore, in an RRI context, this tool is mainly adopted for addressing the 'Diversity & Inclusiveness', 'Openness and Transparency', and 'Responsiveness and Adaptation to Change' RRI pillars [62]. It consists of a shared living document (Appendix A Figure A2) providing details on the technical results obtained during the Peer Connection Meetings and on the expected scientific results for each research team. Every researcher works on the living document to merge her/his data with those retrieved by other researchers/research teams. In the case of the SASS projects, the data were assessed at three sustainability levels (i.e., environmental, social, and economic) and in order to have an impact on the entire food system, the policy research team evaluated the effect of the sustainability goals on the

three main steps of the food supply chain (i.e., production, distribution, and consumption). This tool is essential for planning policy activities and preparing the RRI activity for external stakeholders. The Theory of Change Table was selected because it represents a real participatory process, that also enhances accountability and promotes a greater sense of ownership, hence increasing the likelihood of achieving the desired results [61].

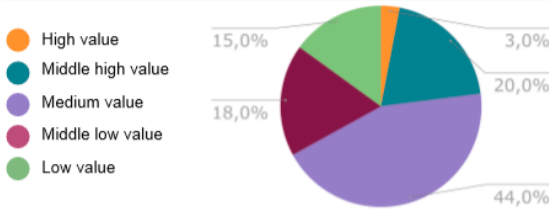
Field Missions: in the internal RRI framework, the field missions serve as a validation tool for the efficacy of experimental plans and to collect field data. This tool consists of three distinct activities: mission meeting preparation, field mission, and mission reports. Starting from the Peer Connection Meetings and the Theory of Change Table, each researcher plans her/his practical activities to be adopted in the field (e.g., interviews, biological sampling, and landscape description metrics). The missions are essential for testing the original hypotheses, collecting samples and data, and highlighting unexpected problems deserving further attention. The mission report describes the main field results and represents the key document to start the next Peer Connection Meeting event. Field missions have an impact on all the 4 RRI pillars and represent the bridge with the external RRI framework.

4.4. Survey

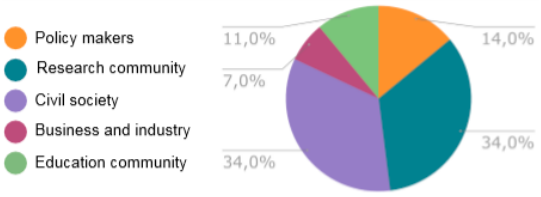
A survey was set up with the aim of evaluating the efficacy of the three RRI tools described above and the consequent development of the project (project re-driving) due to the application of these tools. The survey was organized in four sections (see Figure 3) dedicated to the four RRI pillars. Questions ranged from multiple choice answers to rankings based on the Likert scale. Each question was specifically designed to explore perception-based aspects involved in the implementation of the RRI agenda. The anonymous web-based survey was undertaken in July 2018 on a sample of 47 researchers belonging to the SASS project team. A total of 42 researchers responded to the survey by providing information to at least 90% of the questions.



e) How would you assess the re-driving of your research agenda based on SASS research team and external stakeholders feedbacks?

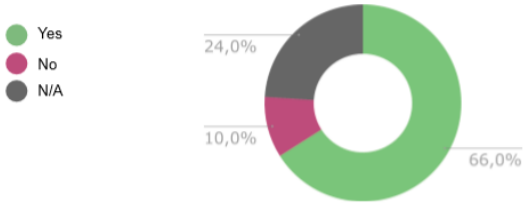


f) Among all the stakeholders which ones highly influenced the re-driving of your research (LS5)?

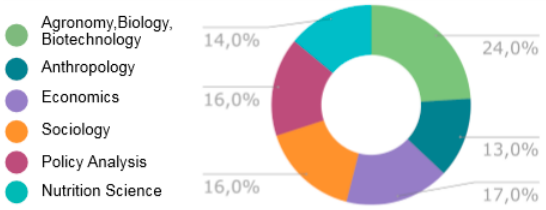


g) Environmental, economic and social values reconsidered during the redriving of your research agenda

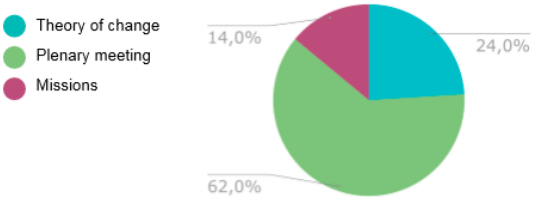
h) Have you shared or accessed data, reports and deliverables obtained by other research groups?



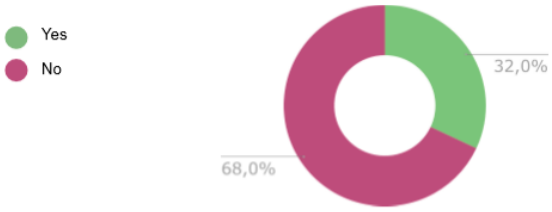
i) Research group/s engaged in sharing data, reports and deliverables



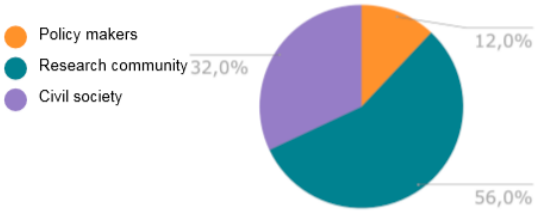
j) Tools used to share the data



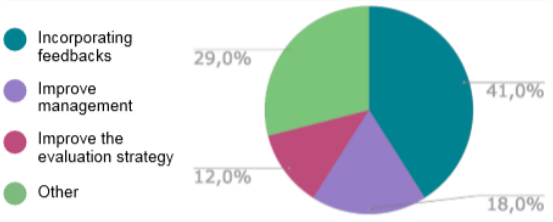
k) Have you shared your data, reports and deliverables with external stakeholders?



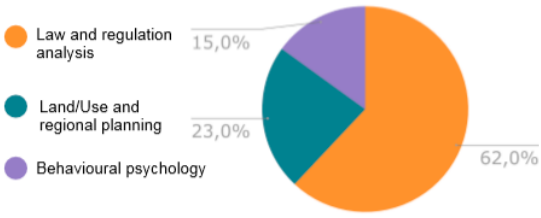
l) stakeholders category engaged in sharing data, reports and deliverables



m) Which strategies would you recommend to improve the responsiveness and project effectiveness?



n) Would you include new competencies and research units in SASS project?



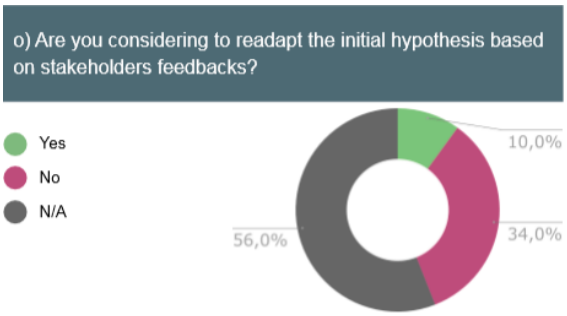


Figure 3. Survey results: main results of the survey on the SASS project research team aimed at evaluating the efficacy of the three responsible research and innovation (RRI) tools and the implementation of the project (project re-driving) due to the application of such tools.

4.4.1. Section I. Diversity and Inclusiveness

The Section on Diversity and Inclusiveness (D&I) was arranged in order to assess the functioning of the RRI agenda in addressing specific dynamics of interaction between researchers. It was conceived as research *with*, *by*, or sometimes *for* the researchers and in contrast to research *on* them [63,64]. The rationale behind the first part of the section was to assess the influence of the different research group members on the whole project design. The D&I section included the description of the different skills and disciplinary backgrounds of the team members, providing different perspectives about project activities. The second part describes the inclusion of different researchers in the setup of the research agenda. The idea was to highlight the extent to which different research sectors were part of the research objectives, if multiple stakeholders were included in various moments, and if the consultations with other researchers and local communities lead to the inclusion of diverse features in the project agenda.

4.4.2. Section II. Anticipation and Reflection

The section devoted to Anticipation and Reflection (A&R) in RRI has been organized in order to assess the evolution of re-driving research objectives and strategies due to the incorporation of feedback obtained from the SASS researchers and the other stakeholders by applying the three selected RRI tools (i.e., Peer Connection Meetings, Theory of Change Table, and Field Missions). This analyzed the background, contexts, and deliberations on the values, perceptions, needs, and interests of the problem at issue in the research and the use of these data to improve the research agenda.

4.4.3. Section III. Openness and Transparency

By Openness and Transparency (O&T), the honest and clear (re)presentation of practical details and open and clear communication about the processes of deliberation and decision-making about the results of the practice is intended. This also includes the selection of appropriate means of communication and education to stakeholders, as well as the openness to critical scrutiny from all SASS researchers and stakeholders.

4.4.4. Section IV. Responsiveness and Adaptation to Change

The step of Responsiveness and Adaptation to change (R&A) requires that the whole research implementation takes the opportunity and perspective of adapting its path in response to changing circumstances, values, ideas, and needs, both belonging to the stakeholders and to the wider public. Criteria to foster R&A included the following possibilities: providing a structure for seeking and incorporating feedback, flexible process management, development and implementation of evaluation strategies, flexible attitudes to revise views and actions, shifting responsibilities, and the application of results.

5. Results

5.1. The Effect of the Internal RRI Analysis on Research Project Development

To evaluate the role of internal RRI tools on the SASS workflow, we used a survey dedicated to the researchers involved in the project. This survey helped to evaluate how (and with which effect) the adopted tools were used to drive and implement the project. The survey was organized based on the four RRI pillars, the first of which is Diversity and Inclusiveness. According to the obtained responses, about 42% of the researchers were agronomists and biologists, 17% were anthropologists, and 13% worked on nutrition science with a main focus on medicine and diet issues. Only 23% of the researchers belonged to the sociology and economy fields and the remaining 5% were policy analysts (Figure 3a). Conversely, as shown in Figure 3b, the most influential disciplines in the first year of the SASS project were policy analysis (24%), sociology (21%), and biology-agronomy and anthropology (17%). However, this condition changed soon after the first field mission because since that, the SASS research agenda was mostly influenced by social actors (7 preferences) followed by the education and research community (6 + 4 preferences, see Figure 3c).

The last question of this section referred to the evaluation of the socio-structural features in the contexts investigated by the researchers. About 60% of the participants took into account the local socio-economic suggestions (Figure 3d), whereas the remaining 40% included the researchers that had no opportunity to participate in the field missions or to develop a fruitful discussion with the local stakeholders.

The second survey section regarded the Anticipatory and Reflective pillar. A total of 44% of respondents declared that their research plan had been moderately influenced by other researchers and external stakeholders, while 20% indicated a medium-high influence (Figure 3e).

Concerning the stakeholders that influenced the re-driving of the SASS plan (Figure 3f), the survey indicated a predominant role of the research community in defining the first SASS activities and the integration of the civil society to drive the project aims and actions. To understand which factors influenced the Reflection activity and contributed to modifying the research agenda, we selected 6 main issues from the final discussion of the Peer Connection Meeting (see Figure 3g). Of these, the SASS research team indicated as most relevant i) the problem of seed access and biodiversity preservation, ii) the importance of the improvement of local markets and the resilience of farmers, and iii) the labelling of local products (i.e. NUS) and food quality.

The third survey section was dedicated to the Openness and Transparency pillar. Survey results depicted in Figure 3h indicate that the majority of SASS researchers (66%) shared their information with other colleagues from the SASS consortium (about 24% did not answer, because during the first year they did not obtain relevant results). Moreover, the results underline that there were no relevant differences between the various research areas to which the data have been shared (Figure 3i). The most utilized tool for sharing information (Figure 3j) was the Peer Connection Meeting (about 62% of the respondents).

With regard to openness and transparency with external stakeholders, the SASS consortium declared that about 68% of the respondents (Figure 3k) shared their data with the local research community (56%) and the civil society (32%) as indicated in Figure 3l.

Concerning the 'Responsiveness and Adaptation to Change' pillar, in our survey we used open questions. The first asked which strategies were considered the most suitable for improving project effectiveness. Although a few researchers proposed a solution, we considered the three more frequent suggestions belonging to the RRI strategy of the responsive section: i) to incorporate feedbacks, ii) to improve project management, and iii) to identify the efficacy of the experimented RRI tools and approaches (e.g., the Theory of Change Table) (Figure 3m). The second question dealt with the problem of skills and the possibility of expanding the number of disciplines to improve the project. Also in this case, we used an open question. Out of 12 respondents, 8 stressed the importance of law and regulatory aspects (Figure 3n). This suggestion underlines a weakness of the SASS consortium as it did not take into account this kind of knowledge during the project definition.

The last question was directed at understanding whether the researchers were keen on adapting to new contexts to better fit with the needs of the local stakeholders. About 60% of respondents positively scored this opportunity with some concerns about the time required to adopt this strategy (Figure 3o).

5.2. Sharing Responsibilities through Internal RRI Strategies

A suitable RRI strategy should lead to sharing the responsibility of the different (research) actions. Surely, the advantages of working in a multidisciplinary context through the Peer Connection Meetings and the subsequent redriving actions can be considered as a form of sharing responsibility concerning the expected results of the project. Regarding the issue of multidisciplinarity, in our survey, some researchers commented for example that "it constitutes a clear advantage that allows to conceptualize your own research within the broader context of variables and relations among variables. Furthermore, the integrative analysis of data from multiple fields of research has the potential to show new arguments and relationships within the local food system. At the policy level, this integration helps the formulation of policy proposals that take into account the complex links of social–ecological systems and the outcomes of proposals' implementation'' (researcher in anthropology). Another researcher declared that multidisciplinarity "is a great opportunity to increase awareness about the different aspects related to the project and to identify important parameters in order to readdress the main objectives considering issues about whom you are not specialized" (researcher in agronomy, biology and biotechnology). Both sentences suggest a wider vision of the SASS researchers that was able to overcome the specific scientific results of the project towards the identification of the best strategies and practices to improve local wellness.

The element of sharing of responsibility was also obtained with the local African community and emerged from some notes that the researchers wrote in the survey. For example, an anthropologist declared: "during fieldwork we realized that, also due to the dry season, the food diversity in markets was very low and mainly composed of globalized staples like tomatoes and potatoes. We felt there was not much to pursue there in terms of addressing the importance of food diversity in markets for local livelihoods and the material and cultural importance of selected foods. Hence, we focused on informal exchange (rather than trade) networks and we investigated the informal networks of food exchange among workers of the flower farms, finding there a diversity of products and knowledge that are exchanged along tribal and inter-tribal networks and that act as social capital for household resilience and food diversity, as well as for cultural meaning".

6. Discussion

6.1. The Efficacy of RRI Tools to Improve the SASS Project

Today, world agriculture and food systems are called to play the protagonist role in achieving sustainable development goals (SDG) and especially the SDG 2 "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture". A drastic transformation is, in other words, required to reposition the global food and agriculture systems from being an important driver of environmental degradation and climate change to becoming a key contributor to the transition to sustainability, while at the same time increasing total food production and quality and improving rural livelihoods. During the preparation of the SASS project, researchers of different disciplines took into account the general goal of SDG 2 and defined specific project goals and work packages (WPs) for improving Sub-Saharan agricultural systems. Unfortunately, during the definition of the research plan, each discipline worked separately to reach its objectives. Only a few comparison actions were organized by the project PI to share research aims and project workflow. Therefore, during the first year of the SASS project, some technical and scientific changes were performed on the project agenda due to the internal RRI tools.

The first activities of SASS project devoted more attention to the issues of agriculture production, distribution, and consumption. The findings raised from the first aspect (i.e., production) were the fragmentation in small-scale farms and the reduced access to mechanization during the harvesting

and storing of the agricultural products. Concerning distribution, the main aspects that emerged from research activities were the absence of adequate packaging and conservation facilities as well as the lack of efficient transport facilities. Finally, at the level of consumption, the research team of SASS identified an alarming process of nutritional transition, especially at the urban level, causing a marked reduction of diet variability and an unbalanced increase in the consumption of sugar and meat. These data were obtained during the first field mission and from literature analysis. A possible strategy towards a condition of sustainable development and consistent with the guidelines of Bioversity International and FAO (Food and Agriculture Organization of the United Nations) is the re-discovery or enhancement of NUS. These indigenous vegetables represent a valuable resource, sustainable in terms of production, and beneficial in terms of a healthy diet. This strategy become the starting point of the next SASS activities. Moreover, the Conservative Agriculture principles and the adoption of intercropping could enhance productivity and preserve natural resources [52]. Concerning the distribution and consumption phases, we hypothesize that only a national intervention plan, able to improve transport corridors and to support local market in the diffusion of high-quality vegetables (including NUS), could contrast malnutrition and connect rural and urban areas [59].

Given that, the internal RRI tools supported the constructive discussion between the researchers involved in the project and the interactions with local stakeholders. Figure 4 describes the timeline of the first 18 months of the project. Specifically, it shows the application of the three RRI tools within the research consortium (internal RRI) and the changes driven by the application of these tools at the scientific and technical levels.

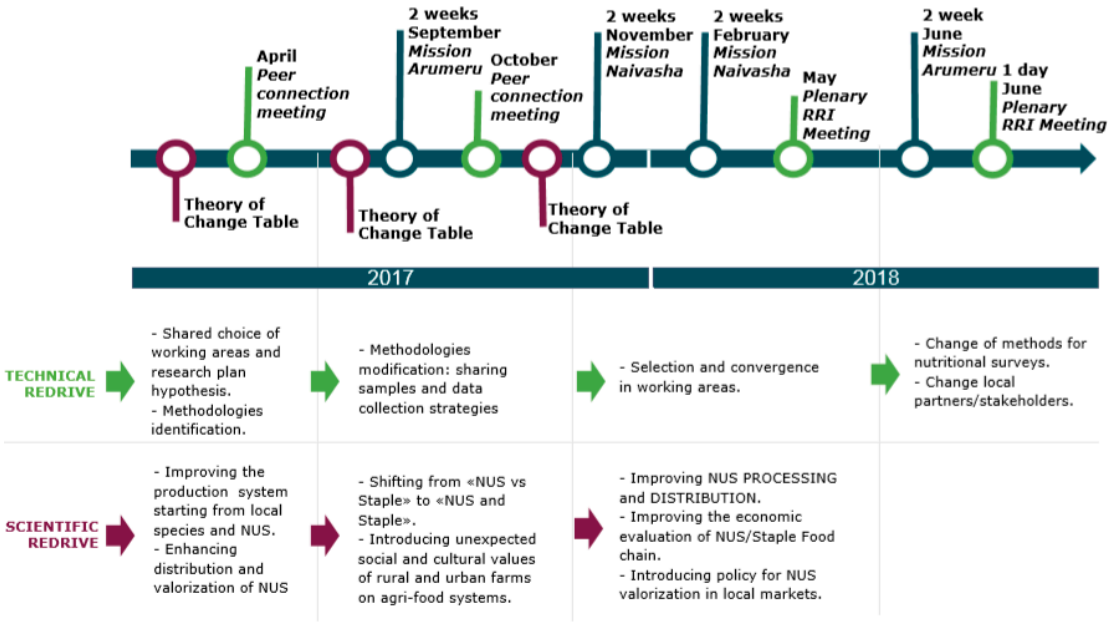


Figure 4. Timeline of the SASS Project and progression of the RRI tools. The resulting technical and scientific redrive issues at each project phase are also reported.

The results suggested that the three adopted RRI tools are complementary. The Peer Connection Meetings are fundamental to underline the workflow of each research team and discipline. The final part of these meetings was focused on merging aims and methodologies and looking for synergies and new shared frameworks to reach the global project goals. Specifically, shared sampling activities and analytic systems in the form of questionnaires were developed by merging the different researchers' workflows. This strategy has been proven essential to reach an incremental innovation approach [65] suitable to address a collaborative and proactive debate and learning process [66].

The Theory of Change Table represented the main convergent and reflexive tool which pushed the researchers to have a common horizon that included objectives and an analysis of the results. The exploitation of this tool defined the practical and scientific sustainability goals for each step of the food supply chain (i.e., production, distribution, and consumption). The first two tools (i.e., Peer Connection Meetings and Theory of Change Table) allowed a partial re-driving of the research hypothesis and experimental plan to re-shape, if necessary, the overall goals of the project. However, only the Field Missions were able to test the technical and scientific hypotheses based on the Theory of Change Table and to evaluate and change the general work plan. For example, during the mission in Kenya in January 2018, it was possible to identify several areas having agronomic, economic, and social characteristics different from what was expected after the previous Peer Connection Meeting. This condition led to a subsequent modification of the area of interest. Similarly, the technical problems, such as administrative difficulties to obtain research permits in Tanzania, also influenced the research agenda in that country. For example, researchers involved in nutritional analysis modified their original research plan, because the time to obtain the permits for medical analysis was longer than initially expected. This strategy largely influenced the scientific results and therefore the re-driving actions in the general project strategy.

Similarly, during the planning of SASS field activities, the researchers based their decisions on a vision of contrast between intensive agriculture of staple crops and the cultivation of local indigenous plants (NUS) [53], but soon after the first field assessments and the successive RRI Peer Connection meeting, the SASS team found that these two systems coexist in African agricultural realities. The project then focused on identifying strategies to enhance local indigenous species together with staples, such as maize. At the production level of the food supply chain, the NUS are widespread in the African rural area, however at the level of the distribution phase, the local cultivars hardly reach the small- and middle-sized city markets. This means that NUS still represent a reality for self-consumption and are not a source of income for the farmers. Finally, with regard to the consumption segment of the food supply chain, many NUS are rich in nutrients [53,59] and therefore represent an important source for local diet diversification. All these considerations were taken into account during the RRI meeting of the project and contributed to redirecting some activities during the first 12–18 months since the project activities began (Figure 4).

On the whole, we found that the Peer Connection Meetings represent a useful tool for presenting the project and also to improve general discussions and to define common goals. The Theory of Change acted as a pivotal element to let all the researchers converge towards shared objectives and to produce relevant changes. Finally, the joint Field Missions represented both an opportunity to verify research hypotheses and a moment of dialogue with the local community. We underline that the internal RRI is only the first part of a correct work path to achieve shared social responsibility. The successive necessary step is the involvement of the local stakeholders (external RRI) that in the context of the SASS project, can really have an impact on the whole agri-food supply chain [67].

6.2. Analytical Evaluation of the Internal RRI Process.

The survey results indicate that at the beginning of SASS, agronomists and policy makers mostly guided group decisions. Considering that the SASS project has two coordinators with policy and bio-agronomical backgrounds, we hypothesize that they largely influenced the initial research plan, especially during the first Peer Connection Meeting event. Moreover, an important role was also played by sociologists and anthropologists due to their long-time experience in the Sub-Saharan area. During the first Peer Connection meeting, they largely contributed to the SASS research plan and to addressing socio-economic impacts in the Theory of Change table tool. However, after the first mission and the first feedback from the interactions with the local stakeholders, other figures contributed to shape the SASS plan. Among these there were social actors such as NGOs, community-based organizations, and local networks. For example the interaction with the seed savers and seed-bank local organizations (e.g., AVRDC) improved the project direction. Moreover, NGOs such as OIKOS and the Naivasha Basin Sustainability Initiative (NBSI) provided useful insights on the territorial state of art, shared their research data related to food systems, and contributed to the

planning of local research activities. This scenario suggests that the SASS team was open to contributions offered by external stakeholders to improve the original project plan. This enhanced even more the need to open the scientific community to the civil society.

The second most important group of stakeholders was the Education and Research community, because during the first missions, the whole SASS research team spent most of the time in bilateral meetings with local colleagues to better define the technical and scientific tools to reach the project goals. On the whole, these interactions influenced the research agenda, as confirmed by the RRI survey.

In addition, the involvement of socio-demographic features in the SASS activities allowed to better clarify the social and agronomical framework of local farmers. For example, the interviews of local farmers contributed to the understanding of the role of NUS for local food security at both the urban and rural levels. Moreover, NUS and staples were found to be not antagonists but synergic crops often occurring in intercropped conditions (e.g., maize and cowpea).

The information derived from survey results about the Anticipatory and Reflective pillar suggested that the SASS team was able to acknowledge criticisms, integrate suggestions, and modify planned experimental actions. This was particularly evident after the first local mission and the development of the second Theory of Change Table, because some scientific targets were largely modified. As highlighted in Figure 4, the areas of intervention changed as well.

Moreover, some issues have been identified and tackled by SASS researchers, such as the distribution of NUS and their valorization both in economic and nutritional terms. Survey results also indicate that the modification of project research agenda was influenced by the three phases of the agri-food supply chain: production (seed quality, agrobiodiversity, biodiversity), distribution (improve local markets), and consumption (food safety).

6.3. Policy Implications and Conclusions

In conclusion, if we consider the relationship between practical means and research ends, in the present paper it is possible to appreciate the relevant role played by RRI tools in producing advantages from interactions and sharing mechanisms to ensure re-drivings and convergence on the research objectives. As the famous epistemologist Donald Scho¨n [68] argued, "Practice can be construed as technical, in this sense, only when certain things are kept clearly separate from one another. Deciding must be kept separate from doing. The rigorous practitioner uses his professional knowledge to decide on the means best suited to his ends, his action serving to implement technically sound decisions. Means must be clearly separated from ends. Technical means are variable, appropriate or inappropriate according to the situation". With respect to this analysis, the present contribution shows how the experimentation of alternative RRI frameworks dealt with the re-driving of research objectives according to reflection in practical experiences. The development of an effective RRI approach means bridging the gap between reasonings developed in a carefully controlled environment of a scientific laboratory and the world of practice, which is notoriously unpredictable and uncontrollable. The RRI tools adopted in the SASS project also helped each member of the consortium to develop an internal 'research responsibility' that permitted to integrate comments, criticisms, and suggestions to reach the project aims and to enhance the impact of the obtained scientific results [69,70]. In this way, researchers can learn from practitioners how to confront a complex situation in which geographic, economic and political factors are usually mixed together.

To date, there are several solutions for improving agricultural systems in developing countries [29,70]. Many of these are only technical proposals, such as the selection of the most productive cultivars and the identification of regulatory systems to enhance the consumption of specific food products. However, modern-day research programs are enlarging food research to include sustainability objectives at environmental, economic, and social levels [71]. To experiment with these approaches, a systematic comparison between scientists with different skills and different areas is needed to tackle common, multidisciplinary problems strongly related to the new 2030 Agenda holistic view on sustainable development [72]. The Horizon 2020 Partnership for Research and Innovation in the Mediterranean Area [73] is a perfect example of this vision, since it is a joint

program focused on the development and application of solutions for food systems and water resources in the Mediterranean basin. We encourage the application of the proposed internal RRI tools to programs like PRIMA and similar initiatives to better integrate any aspect of innovation and responsibility in each project agenda and to transform the project results into value for the society.

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Appendix A

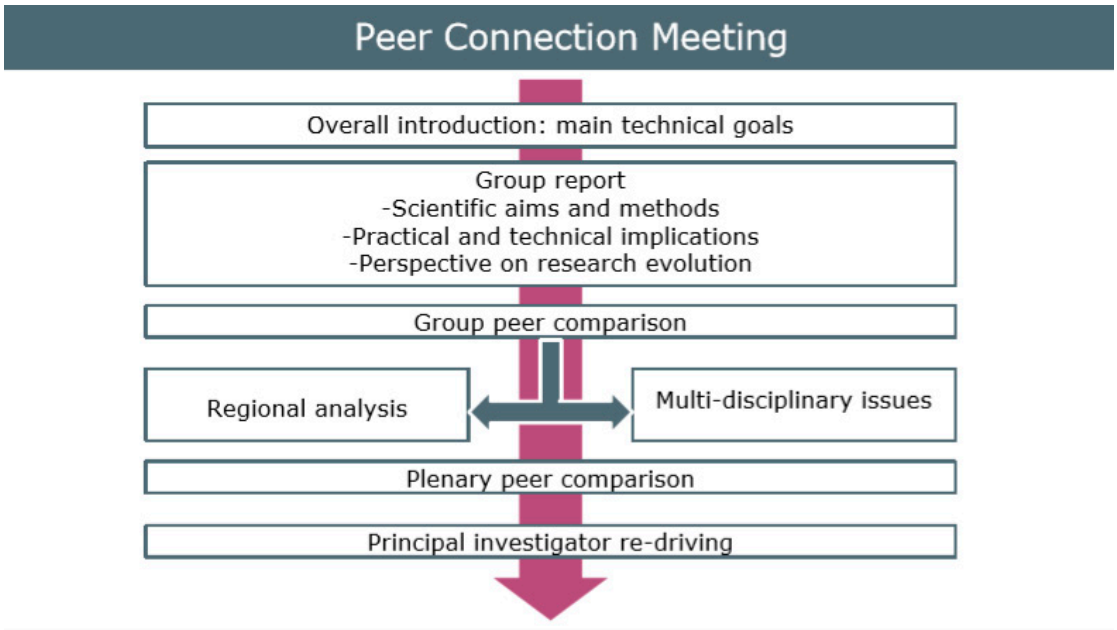

Figure A1. Schematic framework of the *Peer Connection Meeting* RRI tool.

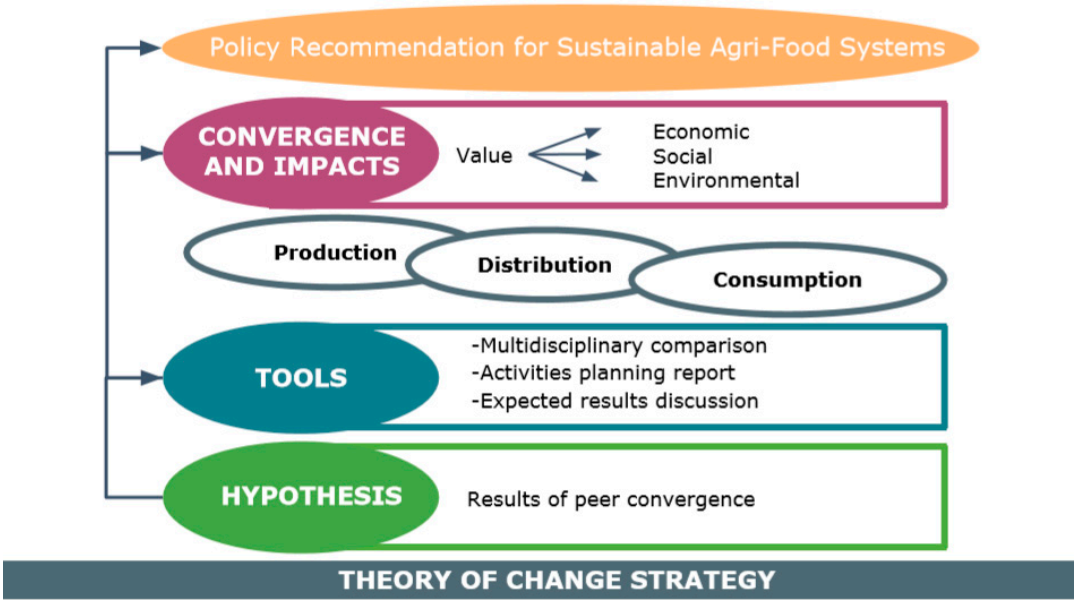

Figure A2. Schematic framework of the *Theory of Change* RRI tool.

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