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# Impact mapping tool for interdisciplinary research institutes

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ABSTRACT

The identification of societal impacts resulting from interdisciplinary research is a complex task. This complexity is particularly evident for agricultural research, which strives to mitigate trade-offs between agricultural production and multiple societal targets, including food provision, ecosystem services, soil and biodiversity conservation, climate action and rural development, all contributing to the Sustainable Development Goals (SDGs). To address this issue, this article presents an Impact Mapping Framework for systematically assessing such societal impacts. The use case on soil health shows how ZALF, an interdisciplinary agricultural landscape research institute in Germany, uses the framework to map its research activities and their contributions towards the improvement of ecosystem services and biodiversity, and the SDGs. The Impact Mapping Framework is presented in a circular format, with research activities mapped in the outermost circle and their contributions to SDGs in the center. The article provides step-by-step instructions for applying the impact mapping framework and a supplementary Impact Map Table. It concludes by emphasizing the importance of using a systemic approach to formatively assess the societal impact of interdisciplinary research, to visualize it for external communication, to identify research gaps and collaboration opportunities, and to build impact literacy.

**SPECIFICATIONS TABLE**

| | |
|---|---|
| **Subject area** | 1102 Agronomy and Crop Science; 1111 Soil Sciences |
| **More specific subject area** | cropping systems research, integrated in landscape contexts, that combines food security with sustainability to contribute to overcoming global challenges |
| **Category/categories of societal impact** | Environmental<br>Political<br>Societal<br>Technological |
| **Sustainable Development Goals (SDGS) the research contributes to** | *GOAL 2: Zero Hunger*<br>*GOAL 6: Clean Water and Sanitation*<br>*GOAL 13: Climate Action*<br>*GOAL 15: Life on Land* |
| **Resource availability** | Impact Pathways - hub (isometric.site) |
| **Related research article** | The article is linked to the 2021 established research project LeNa Shape. The project develops a systemic research impact assessment (RIA) approach, using established societal goals and indicator systems. It is applied for differing contexts and aims, to test its feasibility to support societal impact of interdisciplinary research. Research articles outlining the theoretical background and analysis of use cases are currently under review and in preparation. |
| **Stage of research** | This paper outlines how research activities, outputs and outcomes of an interdisciplinary structured research institute may improve integration between agricultural production and delivery of ecosystem services and the SDGs. |

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## 1. Societal impact: impacts on soil health through interdisciplinary agricultural research

Conventional agriculture is linked to environmental degradation, resource depletion, biodiversity loss, and climate change. For example, the decline in soil health is a severe consequence of agricultural production across the globe. It diminishes the ability of soil to provide the

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growing global demand for soil-based products and services [1]. The EU defines soil health as "the continued capacity of soils to support ecosystem services, in line with the Sustainable Development Goals and the Green Deal" [2]. In the agricultural context, soil health is characterized by the ability of soils to support five soil functions: biomass production, recycling of nutrients, carbon storage, habitat for biodiversity, water storage and filtering [3]. The achievement of many UN Sustainable Development Goals (SDGs) relies directly or indirectly on these soil functions and on soil health [4] (Fig. 1).

Soil health improvement requires major adaptations of agricultural management, socio-economic activities, policies and consumption patterns. Interdisciplinary agricultural research plays a crucial role in providing the necessary evidence base in support of such adaptations. However, assessing the impact of research on such societal targets is challenging due to the systemic nature of the subject. To address this issue, we developed an impact mapping tool for interdisciplinary research and used soil health research of the agricultural research institute ZALF[1] as a use case. ZALF conducts interdisciplinary and transdisciplinary research in favour of sustainable and resilient agriculture. Its mission is to tackle major societal challenges and current megatrends by using a systems research approach that integrates scientific knowledge with society, practice and policy [5].

ZALF has a strategic interest in the impact assessment of its interdisciplinary research to proactively enable and acknowledge societal impact, recognizing this as a necessary development to align with evolving conditions set by research funders. The development of the impact mapping framework was realized as part of the research project LeNa Shape,[2] which developed and tested a systemic research impact assessment (RIA) approach. The approach utilizes existing societal goals and indicators. It is applied in various contexts, to assess its feasibility for interdisciplinary research.

The article not only showcases the societal impact of soil health research but also holds the potential to make an impact itself through the introduction of a new method.

## 2. Methodology

### 2.1. Development and application of the Impact Mapping Framework

RIA is an approach increasingly used to assess the contributions this interdisciplinary research has to societal change [6,7]. Building on holistic assessment methods, such as impact pathways, so far, the **ASIRPA** approach by INRAE[3] [8] and **ImpresS** approach by CIRAD[4] [9] offer the most appropriate methodology to systemically assess the societal impacts of agricultural research. A comprehensive analysis of existing approaches has been realized within the LeNa Project and is documented in a separate publication [10]. The presented applied model departs from the common practice of using narrative or linear impact pathways found in existing RIA models [e.g. 8, 9], as these approaches, while valuable for assessing impact, have limitations when visualizing the impact of complex, interdisciplinary research or larger scales, such as program or institute levels. Instead, we draw inspiration from innovative visualization structures, such as impact mapping by Fryirs et al. [11], which offer enhanced clarity when dealing with complex and multifaceted connections. Our approach employs a novel circular and multilayer visualization (see Fig. 3 and Fig. 4).

By 2020, initial attempts were made to reflect and visualize the societal impact of ZALF research in workshops. However, it was found that additional guidance and a clear framework were needed to successfully create cross-institutional impact pathways. This process started in June 2021 by the work of the research project LeNa Shape. The research theme "Soil Health" was selected as a first use case. ZALF researchers of this research theme were invited to participate in an **online workshop** (15 participants) and completed separate impact pathways, which were later integrated into a single circular visualization called the "Impact Map". The impact pathway components identified in the workshop were complemented by a **document analysis**. The circular shape of the "Impact Map", unlike the common linear shape of the impact pathway, was found to be the most comprehensible way to integrate the multitude of research activities, outcomes and impacts. Graphic designers were consulted to develop the visualization, which was continuously discussed with ZALF's leadership and researchers to ensure a participatory process. Once consensus was reached on the mapped components, scientists were requested to contribute background information on their research activities. Currently, 27 scientists have contributed to 48 background information sheets.

The *Impact Mapping Framework* is visualized in a circular format, with contributions of cross-institutional interdisciplinary research towards **societal goals (i.e. SDGs)** at its center and **contextual impacts**, such as improvements in ecosystem services and biodiversity, placed around them (Fig. 2). **Outcomes**, which facilitate the application, and implementation of research knowledge are positioned between the impacts and **research activities**, which are mapped in the outermost circle. Research activities linked to specific contextual impacts are placed closer together, allowing for the highlighting of multiple impact pathways within the integrated impact map.

To develop an impact map, the following steps are required (see *Impact Map Table* in supplementary material):

- **Determine research field:** Specify the interdisciplinary research field you would like to assess and visualize within your research institute.
- **Determine impact dimensions:** Identify context-specific impact dimensions that the research anticipates to have an impact on, and formulate guiding questions for these dimensions. Identify the most relevant SDGs the research field contributes to.
- **Record research activities:** Identify research activities through workshops, feedback, and document analysis. Categorize these activities into four clusters: natural processes, natural resource management, societal processes, and methods and infrastructures. Merge the research activities into appropriate groups and record research activities Level 1 (generalized research activity) and Level 2 (more specific sub-activities) in the *Impact Map Table* (sheet 4–7).
- **Collect background information:** Create a list of all research activities and identify contact persons (e.g. from publication, via query in relevant working groups). Create a template file for all research activities (sheet 11) and request contact persons to provide the background information, including research description, projects, outputs, outcome and impacts (see sheet 11 for definitions and examples).
- **Identify research outcomes:** Summarize and categorize research outcomes according to outcome type (contribution to report / policy / strategy, application of new knowledge, co-learning, input for new research) and impact dimension (sheet 8).
- **Record impact:** Record the "main impact dimension" for each Research Activity 2nd Level in the *Impact Map Table* (sheet 4–7).
- **Transfer information to the impact pathway:** Visualize the collected information in the circular format of the *Impact Map* (Fig. 2). Utilize digital tools, such as interactive infographics, to enhance the representation of information, such as background information from the research activities templates and specific impact

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[2] funded by the German Federal Ministry of Education and Research (BMBF): https://www.nachhaltig-forschen.de/startseite/

[3] Institut national de la recherche agronomique (National Institute of Agricultural Research)

[4] Centre de coopération internationale en recherche agronomique pour le développement (French Agricultural Research Centre for International Development)


**Fig. 1.** Soil functions and supported SDGs related to agriculture.

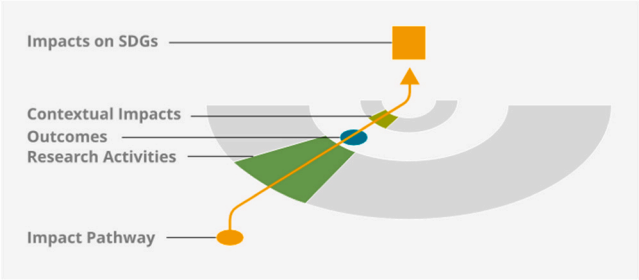


**Fig. 2.** Impact Mapping Framework: Circular visualization.

pathways connected to ecosystem functions and research questions. Alternatively, this additional information can be outlined in an accompanying *Impact Narrative*.

## 3. Results: societal impact of ZALF's soil health research and benefits of the *Impact Mapping Framework*

### 3.1. Impact pathway

The resulting interactive infographic (Fig. 3) illustrates how ZALF's soil health research targets contributions to the SDGs by improving five soil functions. These impacts can only transpire when the knowledge created by ZALF research is transferred, applied and implemented in society, policy and practice, described by different types of outcomes. The 22 mapped research activities are clustered into four categories: 1) Society & Soil, 2) Agricultural Management & Soil, 3) Natural Processes & Soil, and 4) Methods & Infrastructures. Turquoise dots on the white labels mark the number of sub-activities listed in the thematic group.

Clicking on a research question, highlights the corresponding research activities that contribute to the associated soil function and respective SDG (Fig. 4, a)) and their sub-activities become further discoverable (Fig. 4, b) and c)). The most detailed layer of the interactive

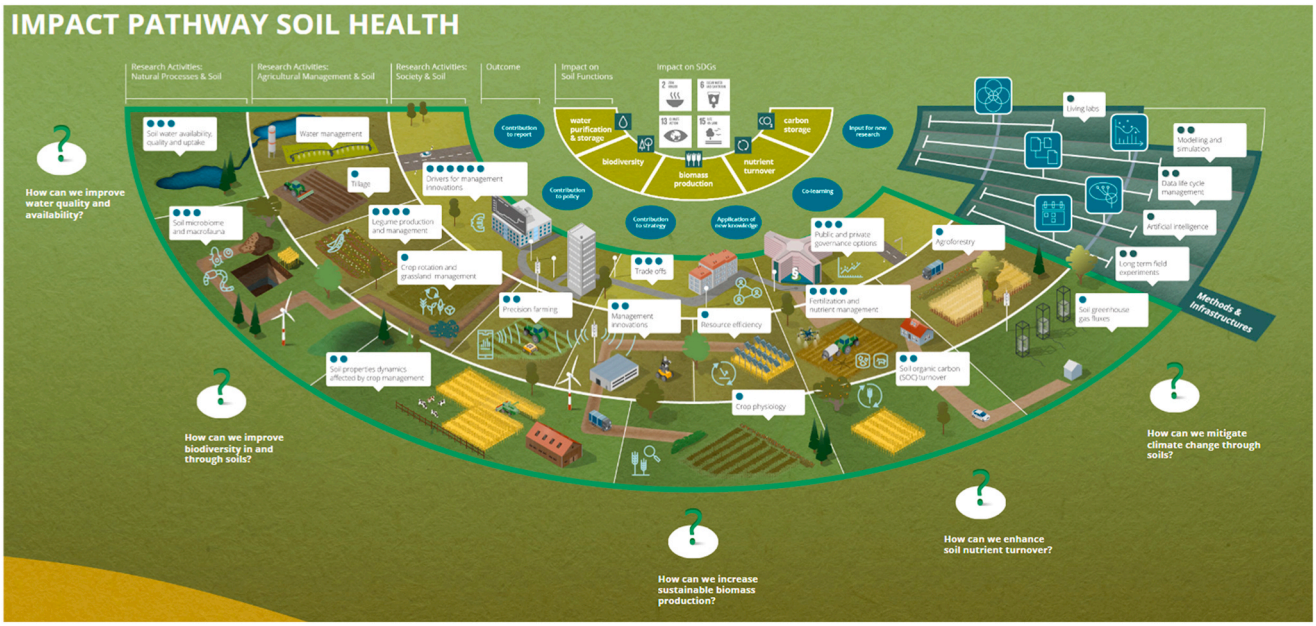


**Fig. 3.** Interactive Infographic for Impact Pathway Soil Health, access at: https://zalf.isometric.site/soil-health?lang=en.

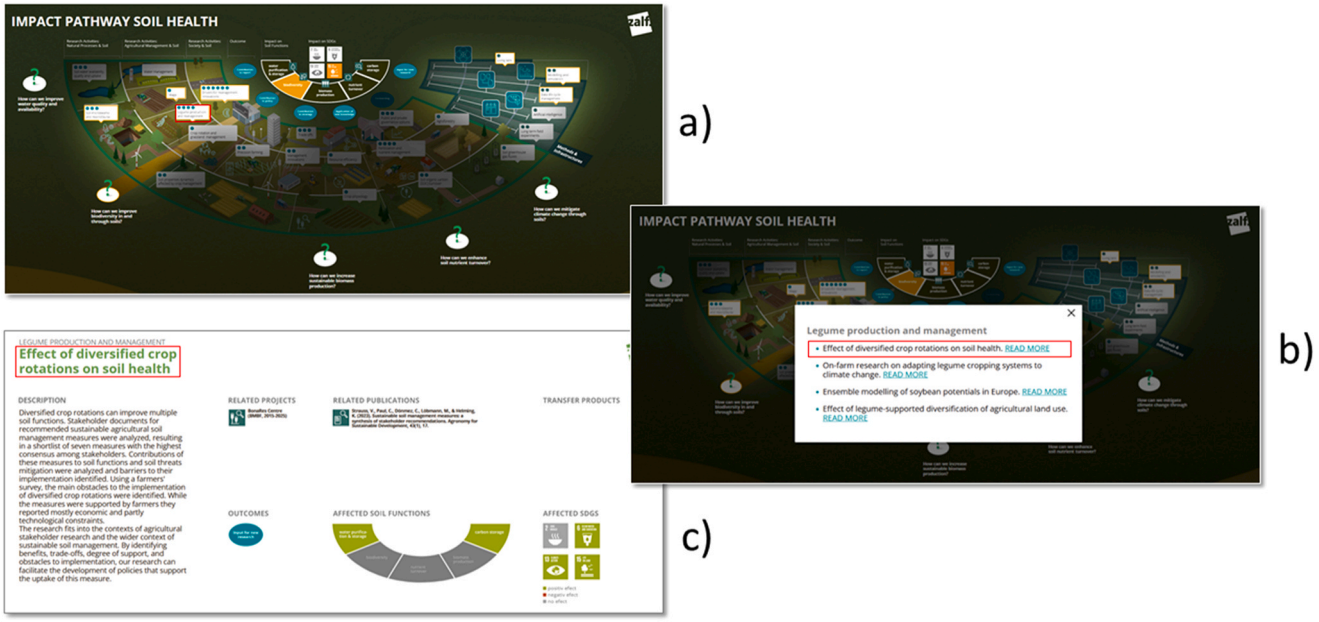


**Fig. 4.** Exploration of interactive infographic, access at: https://zalf.isometric.site/soil-health?lang=en.

infographic (Fig. 4, c)) provides users with a research activity description, linked projects and scientific publications, transfer products, generated outcomes, and its contribution to soil functions and SDGs.

### 3.2. Impact narrative

Since the 1950 s, soil fertility and soil management have been central research areas at ZALF.[5] During times of agricultural intensification, research focused on enhancing soil provisioning services to increase plant production (soil function: biomass production). However, a shift towards (agro-)ecological principles resulted in an increased research interest in soil protection in the 1990 s, followed by efforts to develop solutions that balance production with environmental integration and optimize the five soil functions in combination. ZALF's interdisciplinary structure enables the integration of multiple streams of science and society-driven research.

Currently, there are 55 active or recently concluded (in or after 2018) research projects at ZALF focused on improving soil functions. The scientific expertise provided by ZALF is complemented by scientific partnerships (e.g. BonaRes,[6] DAFA[7]), science-policy interaction (e.g. on soil, agricultural and climate legislation) and practical experience by agricultural practitioners (e.g. on precision agriculture, autonomous machinery, legume cultivation, reduced tillage practices). Physical infrastructures at ZALF, including laboratories, experimental landscape laboratories (e.g. patchCROP[8]) and specialized equipment (e.g. lysimeters, gantry cranes for GHG emission monitoring) make this research possible in the first place. Additionally, ZALF's unique infrastructures, such as AgroScapeLab Quillow,[9] Long-Term Field Experiments (LTE) (running for +20 years), Living Labs and Data Management Services provide very valuable support for the research.

These preconditions allow ZALF to conduct comprehensive research, developing new practices and recommendations, and assessing, analyzing, modelling and monitoring soil processes and management impacts.[10] In the sub-field **Natural Processes & Soil**, research focuses on soil properties and composition, including (1) soil water availability, quality and uptake, (2) soil microbiome and macro-fauna, (3) soil properties dynamics affected by crop management, (4) soil organic carbon turnover, (5) soil greenhouse gas fluxes and (6) crop physiology. Notable contributions of this research include the involvement in the IPCC Special Report on 1.5 C warming,[11] the development of a special fractional deep tillage plow, and advancements in rhizobium inoculation.

In the sub-field **Agricultural Management & Soil**, research focuses on agricultural and soil management practices, including (1) management innovations, (2) crop rotation and grassland management, (3) tillage, (4) legume production and management, (5) resource efficiency, (6) fertilization and nutrient management, (7) agroforestry and (8) precision farming. Notable contributions of this research include involvement in the 6th IPCC Assessment Report,[12] EU's Common Agricultural Policy and policies on soil biodiversity.

In the sub-field **Society & Soil**, research focuses on soil governance and assessing of the sustainability impacts of soil management on society, including (1) tradeoffs, (2) drivers for management innovations and (3) public and private governance options. This research has for example contributed to the implementation of the 2022 EU Soil Mission, the 6th UN Global Environmental Outlook Report[13] and carbon farming strategies.

In the sub-field **Methods & Infrastructures**, research focuses on the development and provision of support for research conducted in the other sub-fields, including (1) long term field experiments, (2) artificial intelligence, (3) data life cycle management, (4) living labs and (5) modelling and simulation. Notable contributions of this research are the development of the models MONICA[14] and ROTOR,[15] and a soil research

[5] previously Akademie der Landwirtschaftswissenschaften of the GDR
[6] BMBF funding initiative "Soil as a sustainable resource for the bioeconomy": Bonares
[7] German Agricultural Research Alliance: DAFA – Deutsche Agrarforschungsallianz
[8] patchCROP - Homepage (zalf.de)
[9] AgroScapeLab Quillow - Home (zalf.de)
[10] see supplementary material for list of key scientific outputs of each sub-field
[11] IPPC SR 1.5°: Faye et al. 2018
[12] IPCC AR6 WG2: F. Ewert, H. Webber contributing authors to Chapt. 13 on "Europe"
[13] Katharina Helming lead author for the Land Policy Chapter of the Global Env. Outlook (GEO6) 2019 (UN Environment report)
[14] MONICA-Model (zalf.de)
[15] Software-Downloads (zalf.de)

data repository.

ZALF's research on soil health contribute to the improvement of the soil functions (1) biomass production, (2) nutrient turnover, (3) carbon storage, (4) biodiversity and (5) water storage, and to achieving the SDGs on food security (SDG 2), life on land (SDG 15), climate action (SDG13) and resource efficiency (SDG 12). ZALF research focuses on all soil functions, with particular emphasis on biomass production and biodiversity, while research related to the interaction between soil and water is least prominent. Although some collaborations exist, researchers have identified further potential for partnerships between organizational bodies and research activities.

### 3.3. Benefits of the impact mapping framework

The *Impact Mapping Framework* is a valuable tool for communicating complex linkages between interdisciplinary research and societal impacts. It supports the identification of research gaps and fosters interdisciplinary cooperation to improve impact, addressing the need for holistic sustainability solutions. It's primarily designed for formative use in impact analysis, as opposed to impact accounting, where the simplicity and directness of linear pathways are often preferred for a clearer and more measurable representation of impacts.

Further and equally important, creating the impact map increases individual and institutional impact literacy [12]. This process enables researchers, including those conducting fundamental scientific research, to reflect on the contribution of their research to societal impact. Engaging with SDG contributions can empower researchers to consciously adopt a transformative role. Following the use case application, ZALF leadership supports the development of impact maps for other research topics and has established internal structures to ensure their regular updating. Conducting impact mapping is a time-consuming process that demands the commitment of participating researchers. The motivation to engage in this process may be enhanced if research evaluations also take into account societal impacts. Supplementary methods are being developed to assess and report research achievements that go beyond traditional academic metrics, taking into account unintended impacts, trade-offs, and synergies.

The Impact Mapping Framework may be especially useful for interdisciplinary research, aiding in visualizing complex interactions. Yet, its applicability extends to less complex research settings. It can be applied in other research fields to make the task of structuring complex research, and anticipating societal impacts more manageable. Institutions can better understand the impact of (interdisciplinary) research on societal goals and improve their contributions towards achieving them by using the framework and following the steps outlined above.

## CRediT authorship contribution statement

**Lena Pfeifer:** Conceptualization; Methodology; Data Curation; Formal analysis; Writing – Original Draft; Review & Editing; Visualization. **Katharina Helming:** Conceptualization; Methodology; Writing – Review & Editing; Visualization. **Hendrik Schneider:** Conceptualization; Visualizations; Writing – Review & Editing. **Frank Ewert:** Conceptualization; Writing – Review & Editing.

## Ethics statements

Not applicable.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.socimp.2024.100048.

## References

[1] M.T. Löbmann, L. Maring, G. Prokop, J. Brils, J. Bender, A. Bispo, K. Helming, Systems knowledge for sustainable soil and land management, Sci. Total Environ. 822 (2022) 153389, https://doi.org/10.1016/j.scitotenv.2022.153389.

[2] C. Veerman, T. Pinto Correia, C. Bastioli, B. Biro, J. Bouma, E. Cienciala, B. Emmett, E. Frison, A. Grand, L. Hristov, Z. Kriaučiūnienė, M. Pogrzeba, J. Soussana, C. Vela, R. Wittkowski, Caring for soil is caring for life: ensure 75% of soils are healthy by 2030 for food, people, nature and climate: report of the Mission board for Soil health and food, European Commission, Brussels, 2020 https://doi.org/doi/10.2777/821504.

[3] R.P.O. Schulte, R.E. Creamer, T. Donnellan, N. Farrelly, R. Fealy, C. O'Donoghue, D. O'hUallachain, Functional land management: a framework for managing soil-based ecosystem services for the sustainable intensification of agriculture, Environ. Sci. Policy 38 (2014) 45–58, https://doi.org/10.1016/j.envsci.2013.10.002.

[4] European Commission, EU Missions in Horizon Europe. EU Missions in Horizon Europe, 2021 (Accessed 27.04.2022 2022).

[5] F.A. Ewert, M. Jank, Imagebrochure - reshaping landscapes by rethinking agriculture, Leibniz Centre for Agricultural Landscape Research (ZALF), Müncheberg, 2021.

[6] N. Chams, B. Guesmi, J.M. Gil, Beyond scientific contribution: assessment of the societal impact of research and innovation to build a sustainable agri-food sector, J. Environ. Manag. 264 (2020) 12, https://doi.org/10.1016/j.jenvman.2020.110455.

[7] P. Weißhuhn, K. Helming, J. Ferretti, Research impact assessment in agriculture—a review of approaches and impact areas, Res. Eval. 27 (1) (2018) 36–42, https://doi.org/10.1093/reseval/rvx034.

[8] P.B. Joly, A. Gaunand, L. Colinet, P. Laredo, S. Lemarie, M. Matt, ASIRPA: a comprehensive theory-based approach to assessing the societal impacts of a research organization, Res. Eval. 24 (4) (2015) 440–453, https://doi.org/10.1093/reseval/rvv015.

[9] G. Faure, G. Blundo-Canto, A. Devaux-Spatarakis, J.L. Le Guerroue, S. Mathe, L. Temple, A. Toillier, B. Triomphe, E. Hainzelin, A participatory method to assess the contribution of agricultural research to societal changes in developing countries, Res. Eval. 29 (2) (2020) 158–170, https://doi.org/10.1093/reseval/rvz036.

[10] L. Pfeifer, K. Helming, Effective mission-oriented research: a new framework for systemic research impact assessment, Res. Eval. 00 (2024) 1–15, https://doi.org/10.1093/reseval/rvae003.

[11] K.A. Fryirs, G.J. Brierley, T. Dixon, Engaging with research impact assessment for an environmental science case study (vol 10, 4542, 2019), Nat. Commun. 10 (2019) 1, https://doi.org/10.1038/s41467-019-13141-1.

[12] J. Bayley, D. Phipps, Extending the concept of research impact literacy: levels of literacy, institutional role and ethical considerations [version 2; peer review: 2 approved], Emerald Open Res. 1 (14) (2019), https://doi.org/10.35241/emeraldopenres.13140.2.