



CRIS 2014

## Developing a Documentation System for Evaluating the Societal Impact of Science

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### Abstract

The evaluation of research beyond scientific impact is increasingly required, but has not yet been widely applied. One reason is that data necessary for the evaluation of the societal impact of science are often not available in sufficient quantities or suitable form. This paper describes first results from a research project that develops improved documentation to serve evaluation beyond scientific impact. Firstly, we refer to the need to do this, and to the specific challenges for data assessment in this area. Secondly, we describe the concept for documenting achievements of research beyond scientific impact with a research information system that integrates the relevant parts of research proposals and reports. This enables data to be provided without causing additional effort for scientists, and makes them usable for scientists, research funding agencies and research institutions for different purposes, including evaluation. Compatibility of the system with interoperability standards (e.g. CERIF) is also taken into account. The concept is currently being developed and tested from the user perspectives of scientists, research funding agencies and evaluators.

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Peer review under responsibility of euroCRIS.

*Keywords:* evaluation; societal impact of science; documentation system; research funding; research information system

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## 1. Background

The grand challenges such as global warming, food safety and the loss of ecosystem services<sup>1</sup> require comprehensive effort on the part of society. Science may contribute essentially to that effort, examine the problems and increase awareness regarding the action required. Furthermore, it is argued that science should even take responsibility for side effects of technologies and innovations that have a deep impact on society. Accordingly, ever larger sections of the scientific community and more and more research funders are placing increasing emphasis on interdisciplinary, transdisciplinary and participative research approaches, cooperation between basic and applied research, reflexive concepts for knowledge and innovation transfer, and a stronger ‘science-society-economy-policy’ interface<sup>2, 3, 4, 5, 6, 7</sup>. However, research evaluation still focuses on publications and citation-based performance indicators, and hardly provides any incentives for research contributions to the grand challenges. It rather leads to disadvantages for applied, interdisciplinary and transdisciplinary approaches and increases the bias between the requirements of research funding and reputation consequences which are still determined by scientific impact indicators<sup>8, 4</sup>. Accordingly, research evaluation is increasingly being challenged to consider criteria that go beyond scientific performance indicators<sup>9, 10, 11</sup>.

Criteria and methods for such evaluation are already being developed within social/societal/broader impact assessment and evaluation concepts for interdisciplinary and transdisciplinary research<sup>12</sup>. However, the widespread implementation of such evaluation fails because the required data are hardly available<sup>13, 9, 14, 15</sup> or because gathering those data is time-consuming using methods such as interviews, case studies and documentary analysis<sup>16, 12</sup>.

Remarkably, the evaluation of scientific performance is based on synergies with other research purposes: peer review, publications and citations exist primarily for purposes of communication and assurance of good scientific practice. Their use in evaluation is a by-product, driven by the availability of easy-to-use metrics, and would probably not work if extra documentation were required for the purpose of evaluation only. Thus, metrics for evaluation are available with hardly any additional effort on the part of the scientists.

Accordingly, synergies are crucial to improve data availability for evaluation beyond scientific impact – and we can find them in research funding and institutional research information systems.

In research grants issued for projects which aim explicitly to contribute to solving societal problems, the performance and impact of such projects has until now mainly been documented in unstructured form in reports. Thus, the information might often be insufficient for thorough assessment of the societal impact or cause additional efforts for evaluation. Additionally, most achievements are only attributed to the project level, which prevents them from being used for the evaluation of scientists and research institutions.

At institutional level, on the other hand, it has been shown that data on the transfer of knowledge, social impact or regional engagement are also frequently not available<sup>17, 18</sup>. Currently, research information systems at universities and other research institutions in Germany are often adapted to specific needs. Nevertheless, developers of research information systems and research institutions place particular emphasis on the compliance of their systems with the CERIF standard in order to achieve interoperability between research institutions. Until now, however, research information systems have only partly complied with the requirements of societal impact evaluation, although the measurement of research impact is one of the objectives in the development of the CERIF standard<sup>19</sup>.

The interoperability of research information between research institutions and research funding organisations has not yet developed much in Germany or in EU funding. In Great Britain the Research Councils UK have already implemented the “Research Outcome System” (ROS) with the main objective of demonstrating the output and impact of the research they are funding<sup>20</sup>. As a centrally organised system, it provides interface management with the Higher Education Institutions<sup>21</sup>. A commercial product that serves the ROS, ‘researchfish’, developed additional features, like creating CVs for researchers and report functions for funders<sup>22</sup>. However, the ROS documentation requirements are not integrated in application and project reporting procedures at the individual research councils which issue the specific grants.

Hence, a general extension of research evaluation beyond scientific impact could be supported by advancements in research information systems and the integration of documentation requirements for research funding.

## 2. Objectives

To facilitate evaluation beyond scientific performance without causing considerable additional documentation effort for scientists, synergies in research documentation need to be achieved. Just as peer-reviewed papers serve the documentation of scientific results as well as the evaluation of scientific performance, the substitution of a good many unstructured reports and proposals with documentation in a research information system could also serve multiple purposes:

- data supply for project administration in research funding agencies
- evaluation of societal impact supported by sufficient data that can be attributed to research units, scientists projects and programmes
- provision of information about the research activities of scientists and research institutions (see Fig. 1).

The main advantage of such a system for scientists would be that while they write proposals and reports they are documenting their work for evaluation and other research information purposes at the same time – instead of documenting a given research activity for funding purposes, evaluation and research information separately.

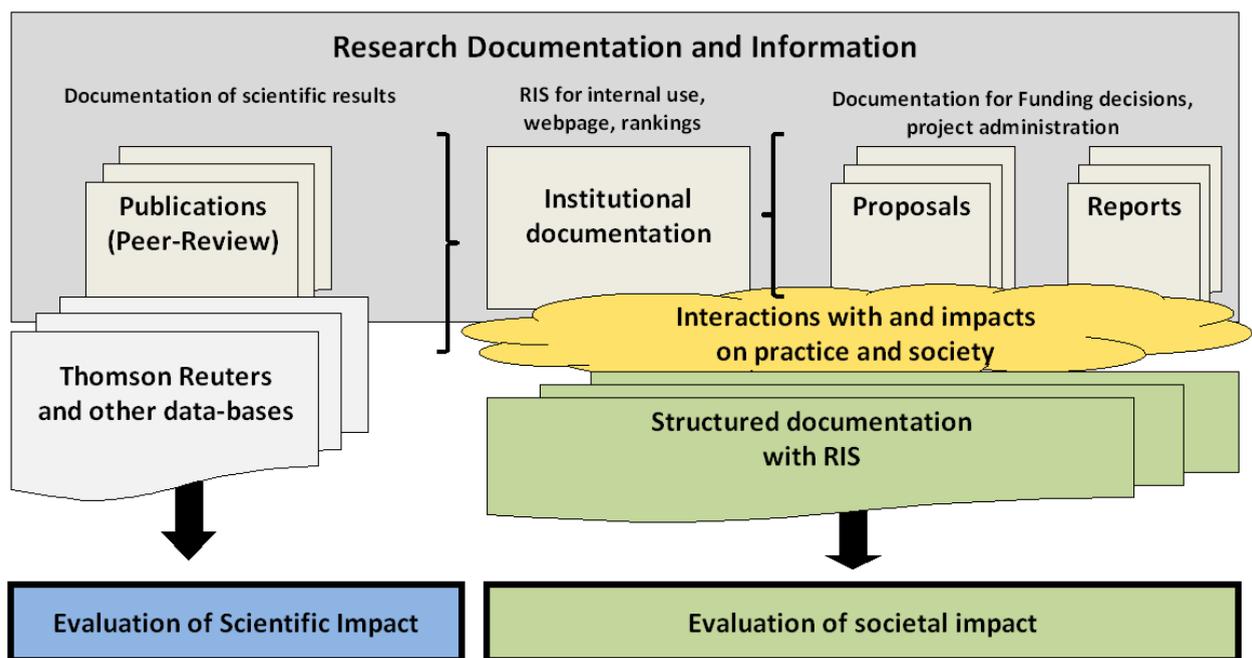


Fig. 1. Synergies in documentation for the evaluation of scientific and societal impact (RIS = research information system)

The development of this documentation concept includes

- a conceptual data model with a comprehensive set of entities required for evaluation and research funding purposes
- a logical and physical data model serving as a prototype for testing purposes and
- the testing of usability for scientists documenting their work, research funding officers for research administration and evaluators for the assessment of societal impact.

To ensure the high quality of the information documented, the concept aims to deal with certain challenges of evaluation beyond scientific impact. These are, for example, the question of the time gap between research and

impact, the inclusion of comprehensive feedback from stakeholders involved or concerned, and the attribution of impact to research, which in complex systems is regarded as contribution rather than attribution<sup>23</sup>.

We intend to achieve connectivity with existing documentation systems and increase the usability of data beyond individual programmes or institutions. Thus, our data model will be compatible with interoperability standards (e.g. CERIF) in terms of its design, main levels and entities. Additionally, structured documentation should facilitate project administration in funding organisations and fulfil the requirements of federal research funding in Germany. On account of the data input in the context of research funding we expect a secondary effect: it should guarantee that data in research information systems are more up to date and of higher quality. On the other hand, we assume that their usability for multiple purposes will ensure that a critical mass of scientists participates and that the diffusion of societal impact evaluation can be boosted. Our results aim to contribute to developing information systems that combine the documentation requirements of research funding agencies and research information systems. For the technical development of such systems, different pathways are possible, and these could perhaps be promoted by funding agencies and commercially developed or open-source products.

### 3. Methods

The background for the aims and content of the documentation structure was gained by

- a literature review of evaluation concepts (social/societal/broader impact assessment, interdisciplinary and transdisciplinary research) from which the content required by the system is derived
- qualitative interviews with researchers from applied and transdisciplinary research in organic agriculture and adjacent research areas, which also contribute to defining content and taking into account the specifics of the research area
- review of existing documentation tools and attempts at standardisation, which provide details and facilitate interoperability with entities and attributes that already exist.

These investigations provided the basis for database design and the first version of the conceptual data model.

The further development of the system follows an iterative process. In the first step, the completeness and usability of the conceptual model were tested with spreadsheets. Subsequently, the conceptual data model was reworked and the first version of the logical and physical data model compiled with a relational database system integrated in a common office software package. After the second test run we are now working on the revision of the data models and preparing the third test run.

Development and testing focus primarily on content required for societal impact evaluation and project administration at research funding organisations. We tested the usability of the system in the first and second runs on the basis of reports, proposals and other documents provided by the scientists conducting the projects. In the third run, researchers not involved in the development will enter the data from their projects themselves. Besides researchers using the tool for documentation, evaluators and research funding agencies are also involved in the development process. The system thus includes three external levels or user interfaces. The first serves scientists for data input. The second provides officers of funding organisations with information for project administration. The third supplies data for the evaluation of societal impact. The testing is carried out, for example, in the field of organic agricultural sciences and adjacent disciplines, but transferability to other research fields is intended.

For easier development of the data model we use full entity and attribute names, which can easily be converted into CERIF entity and attribute names. Formally, our data model follows first order logic, and consists of normalised tables. The main entities of our system comply with the core and second-level entities of the CERIF standard, but include a set of entities for the measurement of the societal impact that exceeds current CERIF entities.

#### 4. Results

##### 4.1. Development of research information system content for the evaluation of the societal impact of science

To replace informal descriptions in proposals and reports, data entry is oriented – besides evaluation purposes – towards the requirements of research funding, and it follows the general logic of proposal development and reporting procedures<sup>24, 25, 26, 27</sup>. Accordingly, the content of the documentation system includes information about projects and research activities that is required for project administration. With regard to high usability for scientists, it is important that data from proposals can be re-used for reporting via editing and supplementation, and that information from pre-projects can easily be implemented in proposals.

Furthermore, the content development is based on documentation tools that are currently in use<sup>25, 20, 28</sup> and concepts for evaluation beyond scientific impact<sup>12</sup>. Additionally, recommendations for standardising research information at institutional level are important in terms of contents and semantics<sup>18, 29</sup> and in terms of the structures of entities like the CERIF standard<sup>19</sup>.

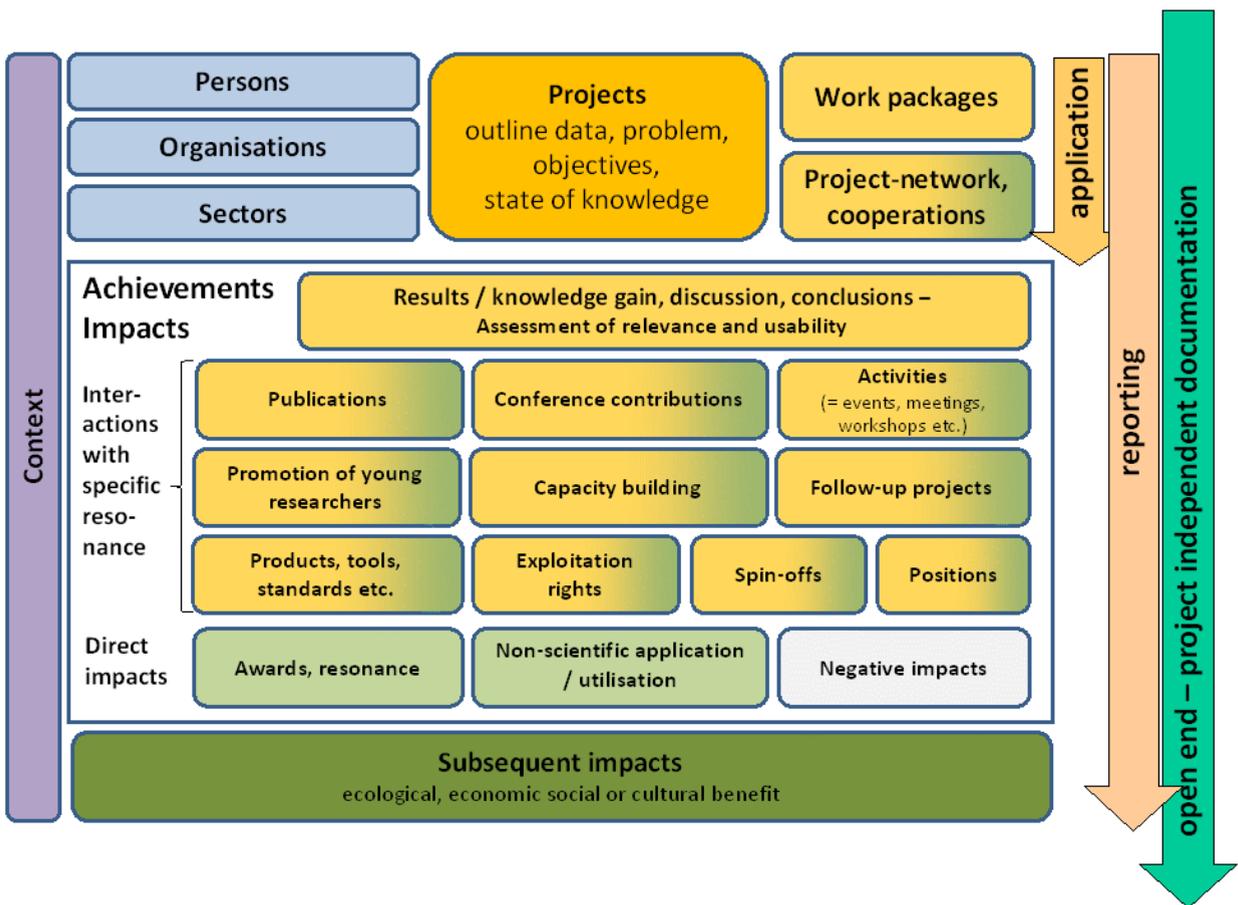


Fig. 2. Entities to be documented for the evaluation of the societal impact and project administration (The vertical arrows on the right-hand side indicate when data should/can be in the system.)

Fig. 2 gives an overview of the entities of our documentation system. The first group of entities, indicated with the arrow ‘application’, is supposed to be documented in research proposals and updated during the course of the project, and if necessary even after it has ended. It includes the base entities of the CERIF standard but with the addition of the definition of sectors, work packages and the possibility to document relevant context influencing the

project and project network; these include formal and informal contacts and cooperation within and beyond science. The system allows researchers to define who was involved, who was reached or who benefited from all interactions, outcomes and impacts. Therefore, it is possible to define the private, civil or public sector to which the stakeholders belong and describe their significance for the project. This enables and encourages evaluators to recognize and value the involvement of non-scientific actors. Furthermore, this might be the starting-point for conducting detailed external impact assessments, if such are intended.

The second cluster of entities in Fig. 2 comprises results, achievements and direct and subsequent impacts of research activities. Alongside scientific publications and conferences, these are classical technology transfer indicators such as patents or spin-off companies, and publications and activities for non-academic stakeholders, which are frequently assessed in evaluation concepts. Concepts for evaluation beyond scientific impact are developed for social/societal/broader impact assessment and the evaluation of interdisciplinary and transdisciplinary research<sup>12</sup>. The data which are necessary to apply these concepts are, firstly, interactions, e.g. the adequate involvement of disciplines, stakeholders and intermediaries, the quality of cooperation and knowledge exchange, and the contribution of these processes to the conducted research – which include different activities within co-design, co-production, co-delivery and co-interpretation of research<sup>5</sup>. Secondly, they relate to the application of knowledge or other research outputs and the subsequent impact on practice and society (see Fig. 2). Attention should be paid to the fact that most achievements include information that is regarded as output (e.g. conducting a workshop, writing a publication) and information about the specific resonance or impact (e.g. number and feedback of participants or downloads and citations of a publication). As already mentioned, the stakeholders involved can be defined for all interactions, outcomes and impacts.

Information from researchers needs to be supplemented with information from practice and society if the aim is a comprehensive evaluation beyond scientific impact. We have therefore implemented the opportunity to define reference persons and document their feedback. Moreover, there is the possibility to record evaluation activities within the project as well as external evaluation results. Generally, the further development of feedback functions might be the focus in subsequent tasks of our project.

Furthermore, impact evaluation needs to consider the time gap between research and impact. Accordingly, documentation should not stop with the end of project funding, but should be possible whenever results are generated or impacts observed. This has, for example, already been realised in the Research Outcomes System from the UK, where outcomes and impacts can continue to be assessed until three years after project completion<sup>20, 21</sup>.

We have given our documentation system this great diversity of content in order to make it appropriate for different research approaches (e.g. from applied to transdisciplinary research), topics and disciplines, and different evaluation objects (scientists, institutions, projects, programmes) and evaluation purposes (e.g. from legitimacy to learning).

To make the broad content of the documentation structure operable for different purposes, certain characteristics of attainments are assigned to categories to enable filtering. The categories are connected and complemented by highly structured information and text description. Additionally, the system allows direct linkage to documents which are available on line. For research funding purposes it is also necessary to include an upload function for documents not available in public repositories or on-line database systems. This supports documentation in alignment with current research activities and ensures that the data are reliable and verifiable.

To sum up, the broad design of the documentation system needs to consider the balance between sufficient comprehensiveness for a broad application on the one hand and the minimisation of additional documentation effort on the other.

#### *4.2. Attribution of Attainments to Evaluation Objects*

As in the CERIF model, our documentation structure allows attainments to be attributed to projects as well as institutions or research units and persons. Such attribution allows use for different evaluation objects, as implemented for example by Research Councils UK with an interface management to the Higher Education

Institutions in the UK. However, in the Research Outcomes system only publications are attributed to the authors, whilst other attainments are attributed solely to the principal investigator<sup>20, 21</sup>. Individual attribution is possible in the ‘researchfish’, which also serves the documentation requirements of RCUK<sup>22</sup>.

In our documentation system outcomes and impacts can be attributed not just to one but to different projects. Furthermore it is possible to connect pre-projects, follow-up projects and cooperation projects. These procedures help to avoid the ‘project fallacy’, in which impacts are only attributed to the last project and not to a project cluster that contributes to the impacts over a longer period of time. Moreover, the assignment of results and research activities to persons, organisations, projects or groups within and beyond science provides insight into ‘systems of innovation’ and regards outcomes and impacts as a multi-causal result<sup>9, 30</sup>. Furthermore the ‘attribution gap’ is reduced, because outcomes and impacts can be assessed in relation to interactions of scientists with stakeholders involved.

However, comprehensive attribution to evaluation objects and the definition of non-scientific actors needs to be designed in a way that incurs no additional effort. This could probably be achieved by interface management or at least by the import of data from existing project databases and institutional data. The German Federal Ministry of Education and Research (BMBF), for example, provides access to institutional data already recorded<sup>31</sup>.

## 5. Conclusions

The widespread implementation of research information and the requirements to extend evaluation systems beyond scientific impact call for an approach that minimises additional documentation effort for scientists. Since research funding organisations are increasingly interested in the clear documentation of funded projects including their societal impact, it seems natural to connect these interests and introduce research information systems in project documentation for funding purposes. The implementation of web-based documentation systems by Research Councils U<sup>20</sup> the BMBF<sup>31, 32</sup> and the EU<sup>25</sup> – with different degrees of structuring, of course – may indicate that more comprehensive systems could be applied. Our project contributes to the development of such applicable and useful systems which explicitly structure and standardise information needed for evaluations beyond scientific impact as well as research administration and funding.

If the testing of the current access database indicates sufficient benefits of the concept, it might contribute to the development of research information systems toward data beyond scientific impact and their conjunction with the drawing up of proposals and reports; it might also help to ensure that data assessment by the funding agencies is more closely oriented toward usability within research information systems. A concrete possibility might be to have a beta version tested by a research funding agency. Therefore a complementary adaptation of an existing research information system might be a successful way to serve interoperability according to CERIF. In this case the information system would be hosted on the servers of the funding agency. Nevertheless, they could also facilitate research evaluation beyond scientific impact at institutional level. If funding agencies provided not only a web interface with forms for data input, but also an interface to exchange data with research information systems hosted at research institutions, this might promote the general adaptation of research information systems closer to the information requirements of funding agencies and evaluation beyond scientific impact. Alternatively funding agencies could provide adequate output functions independent of institutional research information systems.

## Acknowledgements

Our research has been supported by the German Federal Ministry of Food and Agriculture through the Federal Agency of Agriculture and Food within the Federal Programme of Organic Farming and Other Types of Sustainable Agriculture. Project Title: Development and Testing of a Concept for the Documentation and Evaluation of the Societal Impact of Agricultural Research.

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