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BEYOND DISSEMINATION — SCIENCE COMMUNICATION AS IMPACT

Beyond the dissemination of Earth Observation research: stakeholders' and users' involvement in project co-design

Alba L'Astorina, Irene Tomasoni, Anna Basoni and Paola Carrara

Abstract

Modern technology and innovation research needs to analyse and collect users' requirements from the outset of the project's design, according to the Responsible Research and Innovation (RRI) approach. Bringing in new services without involving end-users in the whole research process does not make for optimal results in terms of scientific, technological and economic impact. This commentary reports on research experience of stakeholder involvement and co-production in Italy, implemented in Earth Observation downstream services at regional level. It reports the participative approach and method adopted and the impacts and benefits derived.

Keywords

Participation and science governance; Public engagment with science and technology; Science communication: theory and models

Although activities such as dissemination and exploitation of results are a fundamental task in every research project, they are not always enough to enhance the outcomes and impacts required from modern research. A systematic stakeholders' involvement plan is needed, because it will provide linking mechanisms that increase the potential usefulness of research findings. From a traditional dissemination model, in which end-users play a passive role, we need to move to a more interactive approach, in which stakeholders are active players and the knowledge is co-developed by users and researchers, set in context, problem-focused and demand-driven [European Commission, 2013].

For these reasons, in funded national and international research programmes, scientists are strongly recommended to consider the needs and expectations of stakeholders and potential users and to involve them as research co-actors from the first steps of the project design. This orientation is part of the Responsible Research and Innovation (RRI) approach, a key concept in Horizon 2020 [Hernández and Pintó, 2013], the EU's Framework Programme for Research and Innovation 2014–2020, which brings together different aspects of the relationship between science and innovation and society, including ethics, gender equality, open access, public engagement, and science education. Doing science and innovation "*with society and for society*" as RRI requires, implies a very 'upstream' involvement of the public in the process of research [Owen, Macnaghten and Stilgoe, 2012]. Social and

economic skills are essential to support scientific research, to adapt products to actual markets and better involve end-users throughout the whole research process. However such a socio-economic approach is rarely present in a science and technology research team. This kind of multidisciplinary support should be stable, continuous and efficient, reflecting the different research purposes. In this context, researchers need to include in their activities targeted initiatives for stakeholder engagement analysis of end-user requirements, promoting as much as possible the use of participative methodologies of public involvement.

Moving to the European Space Research sector, space-based services can contribute to the wellbeing of European citizens and support public policies; the main challenge to be faced in the development of these services is the transition from demonstrated applications to real operational systems [Mathieu, 2009], which means offering *real* services to *real* users. Society plays, in fact, a key role in the development of sustainable and operational space services and end-users need to be engaged from the early stages of research and development activities.

In this commentary we specifically refer to Earth Observation (EO) downstream services, such those supported by the Copernicus [Copernicus] programme, the European initiative for earth monitoring, formerly known as Global Monitoring of Environment and Security (GMES). This system collects data from multiple sources: earth observation satellites and *in situ* sensors such as ground stations, air-borne and sea-borne sensors. The data collected are processed and provided to several end-users through a set of services related to environmental and security issues. Some services are already operational, such as land monitoring and emergency management, while others are in a pre-operational mode (atmosphere monitoring and marine monitoring) or in development (climate change monitoring and services for security applications). The end-users of Copernicus's services are mainly policy-makers and public authorities, but also include business enterprises and research centres. Some of the challenges that this specific sector faces nowadays are the lack of co-ordination at European level [Gil et al., 2014] and the over-selling of EO product technologies, linked with the weakness of the interface between the space and user communities and insufficient integration of satellite services within the user community.

Furthermore, suboptimal outcomes from introducing a space innovation can be produced through adopting a top-down, rather than bottom-up, design method[Long, Blok and Coninx, 2015]. To ensure appropriate use of technologies, the concept of 'user-centred innovation' is fundamental and can increase the positive impact of these technological and innovative services [Eurisy, 2010].

User' involvement in Earth Observation research

We report here an Italian experiment in stakeholder engagement, conducted in the field of Earth Observation and led by CNR-IREA, the National Research Council Institute for Remote Sensing of the Environment. The Institute takes part in several Copernicus research projects; the one that we will use as illustration is *Space4Agri* (S4A), "Innovative Methodologies for Earth Observation supporting the Agricultural sector in Lombardy".

In 2004, CNR-IREA set up a skilled multidisciplinary team in charge of managing the processes of stakeholder involvement and user requirements analysis; the group has adopted a social sciences approach for better understanding the relationship between science and society and has experienced new methods both of public communication and public involvement. This team has managed the collection of Space4Agri users' needs and requirements from the very beginning of the research life cycle.

The project, which runs from 2013 to 2015, aims to support the agricultural management of Lombardy and provide new technological and business opportunities both at regional and local level. Lombardy is in the northern part of Italy; its plain, the Po Valley, constitutes 7.7% of the area under agriculture in Italy. In this important district there are more than 50,000 small and medium-sized farms, growing mainly maize, rice, barley and wheat. A sub-set of these farms is part of Space4Agri study: their cultivation is monitored by CNR-IREA researchers for scientific purposes and specific field measurements regularly take place in the area.

S4A aims to find solutions to some specific needs: i) the need to develop a framework of common knowledge to support the agro-food sector of Lombardy and its sustainable management; ii) the need for consistent and updated information from the Lombardy agricultural sector, which has had to deal with unexpected critical situations that caused a decrease in maize production in 2012 (down 20% with respect to 2011) with sensitive impacts on the entire agro-livestock system of the Po Valley; iii) the need to integrate field data and remote observations to provide value added information on a regional scale; and iv) meeting the challenge of Aerospace Earth Observation (EO) for the development of downstream services in order to bring added economic value to business and benefits for local authorities, farmers and citizens. These groups represent the main end-users involved in the project.

As well as recent developments in aerospace technologies for Earth Observation (EO), that make available a large amount of satellite data with different spatial and temporal resolutions, Space4Agri innovatively takes advantage of advances in two more sectors: (i) leading-edge aeronautic technologies, such as Unmanned Airmobile Vehicles (UAV) and (ii) smart app/Web 2.0 technologies and methodologies for acquiring information directly from sensors (i.e. agro-meteorological stations) and in situ observations made by sector specialists (e.g. farmers, associations, consortia) to return information/value-added services to regional decision-makers and agro-business operators. The use of such technologies is guided by the awareness of the heritage of widespread local knowledge in the agricultural sector of Lombardy.

The CNR-IREA team conducted a first consultation on Space4Agri users' needs and requirements during the earliest stage of the project (2013), to better design and identify the possible final products and outcomes. Requirements and demand analysis are fundamental if the service developed by researchers is expected to be commercialised and brought to market. The requirements analysis suggested many interactions with external beneficiaries and the feedback received ensured that the project's objectives and expected results were aligned with end-users' needs.

The data collection approach and the methodology adopted were qualitative: a restricted sample of representative S4A stakeholders was selected for interview and their contributions were analysed. The researchers identified the main public and private S4A target groups belonging to the agro-food supply chain (farmers, agro-food entrepreneurs, agronomists, consultants and technicians and local authorities) as potential user of EO technologies-based services (see Figure 1). The Lombardy regional government partially financed the research project; consultation with some of its members was essential to better understand regional agricultural governance and make predictions based on its future rural development plan.

Ten representatives of stakeholders were interviewed; their needs were investigated through in-depth interviews supported by semi-structured and open-ended questions. IREA researchers belonging to the interdisciplinary team led each interview collectively. The stakeholders were individually interviewed by the group: this procedure avoided external influences, interference by other users and created a friendly discussion atmosphere. All interviews were individually recorded, transcribed and then processed through interpretative grids on which the information collected was entered and, later, analysed and compared. The grids followed the interview structure, which consisted of three lists of questions: explorative, on requirements and on scenarios.

The first part of the interview focused on general information regarding the stakeholders/users and their attitude towards EO technologies: the questions inquired into the social and professional role of the respondent, the position held, their personal level of knowledge and/or professional adoption of EO technologies. The second set of questions addressed the users' general requirements concerning any EO downstream service. The last part of the interview was dedicated to the envisioning of possible future EO services scenarios and on the identification of the impacts derived from the potential Space4Agri services. This step was the most interactive and open to future hypothesis generation. It gave the researchers considerable feedback on which kind of scenarios (still focusing on Earth Observation services) were most appreciated and desired by users in terms of professional and personal preferences and what were the most expected impacts derived from the project outcomes. This experimental part of the interview represented a sort of anticipated analysis of future research developments.

The information provided by the interviews at the early stage of the project's life was fundamental to better designing later research steps.

Figure 1. Interaction and consultation between Space4Agri research staff and Lombardy farmers or agro-consultants (2013).

The expected project results most frequently listed during the interviews by farmers and technicians were detailed and well defined. In particular they concerned the development of methodologies for the creation of maps at the beginning of the cropping season through integration of optical radar satellite data, the production of indicators for crop status on a regional scale through the analysis of satellite data time series, and the evaluation of indicators of crop water stress.

Decision-makers were interested both in such technical results and in the development of smart technologies for the acquisition of and feedback on in-field agricultural observations that could be very useful for regional management and governance.

A second round of interviews and consultations was conducted during the second half of the project's life (2014) to give feedback to the end-users regarding the first round of interviews, the requirements that emerged and also on the main research advances and the first products developed. The methodology implemented was thus recursive. Some scenarios that emerged during the first round of interviews were underestimated and others were fully confirmed.

Throughout the whole research cycle, a second set of 'internal' needs and observations was collected; Space4Agri researchers, experts in remote sensing, image processing and geospatial infrastructures, were interviewed as active stakeholders. The internal observations derived from the interactions between the different project's scientific domains and revealed interesting issues concerning the obstacles that each group of researchers had to cope with when they belong to different disciplinary fields; their diverse languages, the lack of communication within the scientific community and the way in which scientists interacted with the general public [L'Astorina et al., 2013].

Observations and impacts

The project's overall approach combined external (stakeholders/users) and internal (researchers) needs, highlighting critical issues and operational difficulties but also providing interesting ideas for possible applications, impacts and future research developments.

For example, a series of interesting barriers emerged from the interviews conducted with both public and private S4A stakeholders. These barriers mainly referred to the adoption of environmental/agricultural technological innovations such as the Earth Observation downstream services. The barriers that the respondents more frequently named can be divided into three main categories: economic, institutional and behavioural. Among the economic, we registered the problem of the prohibitive costs of many technological innovations and the temporal asymmetry between costs and benefits. The institutional/management barriers included low levels of institutional support and a lack of regulatory frameworks related to innovation and technology services. Finally, behavioural obstacles include the weakness of management support in technology and innovation services, the conflict with traditional agricultural methods and the complexity involved in adopting certain technologies.

This significant collection of information gave S4A researchers the opportunity to understand how to design the project's outcomes taking real users' needs into

account, to realise what the likely benefits are and what is the level of social and economic acceptability of such outcomes. The approach also helped to define how much resources may be concretely invested in the outcomes' development and consequently how to adopt the best research and technology solutions. Moreover, in innovation processes, early stakeholder engagement can make them play the role of intermediaries or project ambassadors and act as multipliers at a regional/national level.

Some critical issues spontaneously emerge from this kind of participative approach. Stakeholders involved from the beginning felt they were part of the research process, however, the interviews were time- and energy-consuming both for researchers and end-users, considered across the project's life. Furthermore, during the second round of interviews the researchers registered a certain decrease in some users' participation, especially the users representing public bodies; this might be connected with their need to manage professional deadlines. In addition, a small group of researchers, involved in different S4A work packages on user need identification perceived the process as too restrictive of researchers' autonomy; this led to an internal discussion the extent to which research has to meet external needs and adapt its methods and times to them.

At the same time, the CNR-IREA team admitted that this experimental approach gave the researchers the opportunity to have a continuous exchange with Space4Agri users, including regional decision-makers, and also with the rest of the research community.

The initiative can be considered a good example of interaction between scientists, the agro-food sector and policy-makers: innovative S4A services and products, available at the end of 2015, will result from this collaboration and evaluation process.

The project will have a significant positive impact in Lombardy, both in terms of direct employment and in terms of the positive effects expected in the medium and long term both for public bodies and the private sector. This activity will allow the development of highly qualified personnel in high-tech sectors such as aerospace Earth Observation, as well as in information, communication and smart technologies. The innovation in the exploitation of Earth Observation data and in the sharing and exchange of information through smart technologies will have a tangible impact in Lombardy both in support of agricultural policies at the regional scale and in opening new market opportunities for agro-consulting in support of agricultural production.

Conclusions

The participative and inclusive approach adopted in the Space4Agri project is *co-production*, that is, *knowledge being co-developed* taking the needs of all actors into account. From the users' perspective this is one of the highest levels of engagement and activism that they can play in a research process, especially one focussed on innovation and technology issues. The S4A stakeholders involved formed a group that influenced and addressed the research outcomes: it is this feature that mainly separates co-creation from pure (innovation) adoption.

The traditional top-down research model, expert- or technology-driven, with a lack of active involvement of the target audience has been by-passed by a model in which knowledge is applied and strongly demand-driven.

This approach, intentionally adopted by the CNR-IREA research team, follows RRI principles that promote transparent and interactive processes through which societal actors and innovators become mutually responsive, co-creating a view on the acceptability, sustainability and societal desirability of the innovation products.

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References

Copernicus. URL: http://copernicus.eu.

Eurisy (2010). *Creating sufficient user pull to secure the benefits of satellite services for society*. Position paper.

European Commission (2013). *Horizon2020 Work Programme 2014–2015 'Science with and for Society'*. URL: http://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation.

Gil, A. J. F., Bosc, C., Basoni, A., Clavée, M., Bacai, H., Pergola, N., Monbet, P., Zolotikova, S., Juárez, J. Z., Antoninetti, M., Tramutoli, V., Wells, A. and Carrara, P. (2014). 'DORIS_NET project: enhancing the regional impact of COPERNICUS program by setting up the European Network of Regional Contact Offices (RCO)'. *European Journal of Remote Sensing* 47, pp. 29–43. DOI: 10.5721/EuJRS20144703.

Hernández, M. I. and Pintó, R. (2013). 'How do funded science education projects disseminate their outcomes to target audiences? Analysis of the current status and recommendations for more effective dissemination'. In: *ESERA Conference*.

L'Astorina, A., Cerbara, L., Valente, A. and Avveduto, S. (2013). 'Practices and images of public communication by Italian scientists over the year'. In: *Critical Perspectives on Making Science Public. Selected papers given at the "Science in Public conference", 22–23 July 2013, University of Nottingham, U.K.* Pp. 75–80. URL: http://scienceinpublicnetwork.files.wordpress.com/2013/12/sip13-proceedings.pdf.

Long, T. B., Blok, V. and Coninx, I. (2015). 'Barriers to the adoption and diffusion of technological innovations for climate-smart agriculture in Europe: evidence from Netherlands, France, Switzerland and Italy'. *Journal of Cleaner Production*. DOI: 10.1016/j.jclepro.2015.06.044.

Mathieu, C. (2009). *Space-based services in Europe, addressing the transition between demonstration and operation*. Vienna, Austria: European Space Policy Institute. URL: http://www.espi.or.at/News-Archive/10-april-2009-espi-report-17-on-the-development-of-space-based-services-in-europe-online.

Owen, R., Macnaghten, P. and Stilgoe, J. (2012). 'Responsible research and innovation: From science in society to science for society, with societ'. *Science and Public Policy* 39 (6), pp. 751–760. DOI: 10.1093/scipol/scs093.

Authors

Alba L'Astorina works at the Institute for Electromagnetic Sensing of the Environment of the Italian National Research Council (CNR-IREA), in Milan. She is responsible for the dissemination of results from national and international projects on the use of Remote Sensing and Earth Observation for Environment Monitoring. Since 2006 she has been part the CNR Research Unit "Science Communication and Education Studies", whose aim is to investigate the major issues concerning the relationship between science and society, such as public communication of science by the scientific community; the relationship between research, policy and decision-making processes; engagement of researchers in public debate; innovative models for involving the public in the production and sharing of knowledge; and innovative models of science education. She co-ordinates a CNR research project on "Models of public communication of science," with a particular focus on public communication by the scientific community. The aim is to investigate models of how researchers communicate and to promote opportunities for public debate about the change in communication within research institutions and the perspective this change gives on the relationship between science and society. E-mail: lastorina.a@irea.cnr.it.

Paola Carrara is researcher of IREA CNR. Her activity focuses on information systems, in particular geographic information on the Web. In RITMARE, the Italian flagship Project on marine research, she coordinates the developing of the interoperable data infrastructure of the Project. In Space4Agri, she is leader of the task regarding the users' requirements collection. She participates in projects related to the integration and sharing of geographic information, also coming from crowdsourcing, with reference to the applications of IREA, such as agriculture, ecology, sea and freshwater. E-mail: carrara.p@irea.cnr.it.

Anna Basoni is an environmental engineer with a background in environmental economics. She holds a Masters in Environmental Management from Bocconi University (Milan) where she worked for five years as a consultant on water management and application of the EU Water Framework Directive. Since May 2010 she has been a researcher in the economics and valorisation of research results in the field of Earth Observation (EO) downstream services of the Copernicus European Programme at the National Research Council Institute for Remote Sensing and Environment (CNR-IREA) - Milan. She is the co-founder and co-ordinator of the regional contact office in Lombardy in the DORIS_Net Project, a cooperation and supporting action funded by EU FP7 aimed at fostering partnerships between providers and users, promoting EO downstream services among regional stakeholders and engaging new potential users of EO products. E-mail: basoni.a@irea.cnr.it.

Irene Tomasoni holds a Masters in Environment and Human Development: Governance, Education, Scientific Knowledge from the School for Environmental Studies, Catholic University of Milan. She has worked on several European research projects within the Alpine Space Programme and the Intelligent Energy Europe (IEE) initiative; in these projects she was responsible for the implementation of social surveys, the adoption of stakeholder involvement techniques and science communication activities. She is now a Research Fellow at the National Research Council Institute for Remote Sensing and Environment, Milan (CNR-IREA). Her main research topics are public communication of science and technology, science

education, stakeholder involvement, and participatory interaction between scientific experts and non-experts. She is also engaged in science education and communication activities in national and international research projects.
E-mail: tomasoni.i@irea.cnr.it.

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