*Chapter 7*

# Making Sense of Climate Science

## From Climate Knowledge to Decision-Making

*Maria Ines Carabajal and Cecilia Hidalgo*

Producing climate information in order to enhance decision-making processes is a long-term challenge faced by academic and operational institutions (i.e. meteorological, hydrological and agricultural organizations). Despite the celebrated advancements of climate science in monitoring and forecasting, there are still gaps between the climate knowledge that is being produced and its social and widespread use (Baethgen, Carriquiry and Ropelewsk 2009; Funtowicz and Hidalgo 2008; McNie 2013; Meinke et al. 2006; WMO 2012). Climate information is under-utilized for various reasons: limitations inherent to the climate system (e.g. in the variables that can be monitored or predicted, temporal and spatial scales of prognostic information – Baethgen, Carriquiry and Ropelewsk (2009)); technical aspects of the information (e.g. the communication of probabilistic information or the timely release of information to meet decision-making needs – Cash, Borck and Patt (2006)); cognitive factors that influence the way users perceive the science-generated information (e.g. in terms of communication, trust, credibility, accessibility and experience – Bowyer, Brasseur and Jacob (2014); Cash and Buizer (2005); Peterson et al. (2010)); institutional arrangements or procedural factors that constrain the use of new knowledge (e.g. rigid operating protocols – Hidalgo (2018); Podesta, Hidalgo and Berbery (2013); Srinivasan, Rafisura and Subbiah (2011); Taddei (2008); Vaughan and Dessai (2014)); or structural factors that shape the capacity and willingness of different decision-makers to use information (e.g. lack of access to knowledge or of choices regarding alternative technologies or policy changes – Rayner, Lach and Ingram (2005)).

Since 2009, in order to overcome this under-utilization, the exploration of channels of communication and of innovative partnerships between scientists, operational institutions and stakeholders has become a priority in South America. In line with the Global Framework for Climate Services (GFCS) (2009) launched by the World Meteorological Organization (WMO), the aim of providing climate services in the region has made apparent the need to build a 'User Interface' to facilitate sustained interaction between producers of climate information and those who need to interpret and make sense of it, be they intermediate users (i.e. academic or operational professionals) who work on climate products (maps, reports, models, etc.) or end users (agricultural producers, farmers, peasants, governmental agents, etc.) who make decisions on the basis of climate information. The GFCS brought together many initiatives that were conceived as part of a 'new paradigm' of meteorologists, hydrologists and agronomists collaborating in academic and operational organizations. However, in this region there was found to be a lack of knowledge concerning who the users were and how they understood climate products. Social scientists were invited to participate in, and facilitate, the monitoring and implementation of the new paradigm. The authors of this chapter became 'embedded anthropologists' within a large research network committed to the provision of climate services in southeastern South America. This chapter is based on this ethnographic research and presents an account of the interinstitutional collaborative process in Argentina, which first targeted the agricultural sector. Our fieldwork, carried out from 2013 to 2017, has provided valuable insights into the challenges and potentialities involved in the creation of workshops, where experiences and knowledge were exchanged by climate-information providers and three different types of users: intermediate users – a wide range of academic, governmental, research and resource-management institutions; end users connected with large farming associations and grain-exchange institutions; and end users who were small goat producers and rural students from vulnerable areas of the country (rural zones in the north of the Santiago del Estero Province).

Disparate and often contested ways of making sense of climate science came into play in these 'user spaces'. In this chapter, we first focus on the global context that framed the actions taken at regional and national levels to promote a deeper involvement of the agricultural sector. We then describe the process of building a user-interface platform, which required diving into the complex world of farms and other organizations from the agricultural sector. This sector involved many potential and existing types of users that need information about the average seasonal conditions to make decisions. As a matter of fact, each type

of user brought to light obstacles to be overcome by academia and the institutions responsible for monitoring and producing seasonal forecasts in Argentina. This forecast is also known as 'Seasonal Outlook', a quarterly forecast of precipitation and average temperature for the next three months, which is issued monthly.

The lack of a preliminary mapping and characterization of the audience to be invited to participate in these workshops was a main difficulty. A proper identification of who the 'users' were and how they used and made sense of climate information emerged as a gradual consequence of face-to-face interactions and interinstitutional engagement. An increasing 'sense of ownership' (Dilling and Lemos 2011) of the problem of the gap between the climate knowledge that was being produced and the social appropriation of such information grew among the participants in the workshops. A reflexive process regarding the link between information providers and end users was triggered. Institutional scientific reflexivity and self-examination became crucial to making knowledge relevant to society (Hidalgo 2006; Rayner and Malone 1998). While the workshops were designed and organized with the stakeholders, the active commitment of the anthropologists involved in the process nurtured reflexivity and awareness of the complex nature of building relationships and ensuring their sustainability over time. Furthermore, collaboration triggered a self-reflexive stance that transcended the issue of the provision of climate services to urge a collective consideration of how to improve the social appropriation of knowledge.

## Methodology

The authors of this chapter are anthropologists who carried out fieldwork within the framework of a five-year project, funded by the Inter-American Institute for Global Change Research (IAI) and entitled 'Towards Usable Climate Science: Information for Decision-Making and the Provision of Climate Services for Agricultural and Water Sectors of Southeastern South America' (2013–18). One of the authors was the Principal Investigator (PI) of the project and the other recently obtained a Ph.D. as a doctoral fellow. Researchers of climate sciences, social sciences and agronomy, as well as a wide range of stakeholders (government agencies and nongovernmental organizations (NGOs)) of Argentina, Brazil, Paraguay and the United States constituted a Collaborative Research Network (CRN3035) to contribute to the provision of climate services in southeastern South America. A major design feature of the project was a close partnership and continuous interaction with the Regional Climate Centre for South

America (RCC-SSA) recently established by the World Meteorological Organization's Regional Association III (WMO-South America). The challenge to coordinate and participate in such a complex, multinational, multi-institutional and interdisciplinary team shaped the expectation that an approach in which social sciences were essential components would make a difference in some way.

Fieldwork involved participant observation during regular interinstitutional meetings, including a monthly meeting held at Argentina's National Weather Service, where institutions that produce and/or use climate information debate and jointly formulate a national quarterly publication, *Climate Outlook* (Barnes et al. 2013; Fiske et al. 2014). The authors also participated in institutional and academic events, conducted personal visits to organizations responsible for producing, managing and communicating hydroclimate information in the region, and carried out more than 50 interviews with institutional representatives, scientists from different backgrounds, technicians and experts.

## The Global Framework for Climate Services

This project was proposed in 2013, when the concept of 'climate services' adopted by the WMO began articulating the agendas of meteorological and hydrological institutions at a global level. The US National Research Council's Board on Atmospheric Sciences and Climate defined climate services as 'the timely production and delivery of useful climate data, information, and knowledge to decision makers' (National Research Council 2001: 2). The interest in climate services was triggered by an increased awareness among policy-makers and the general public about the importance of weather and climate for climate-sensitive sectors and the sustainable development of society. Growing concerns about the direct and indirect socioeconomic impacts of climate variability, climate change and high-impact weather events oriented the attention of WMO members towards the satisfaction of fundamental global societal needs, such as food security. In response to the growing demand for actionable climate information, the WMO developed the GFCS, which promotes the use of relevant science-based climate information and prediction. The main objective of the GFCS is to enable societies, especially those that are deemed most vulnerable to climate-related hazards, to better manage the risks and opportunities arising from climate variability and change (Hewitt, Mason and Walland 2012).

The Framework consists of five components or pillars, which are illustrated in Figure 7.1.

The 'User Interface Platform' (UIP) pillar underlines the centrality assigned to the achievement of a sustained interaction between producers and users of climate information. However, building such a platform, rather than a merely informational device, presupposes at least a preliminary acquaintance with who the users are and how they make sense of climate products. When the GFCS guidelines and the creation of the RCC-SSA prominently figured on public and private agendas in Argentina, the lack of accurate knowledge about differentiated users and their understanding of climate products was recognized as a main limitation. A broad distinction classifies them as 'intermediate' and 'end' users. The former are those who use the climate information that national meteorological and hydrological services (NMHSs) produce to elaborate their own products or services customized for specific recipients – productive, governmental, scientific, technical and operational sectors. The latter are clusters of stakeholders and practitioners who use the climate information produced by NMHSs and other agencies in decision-making processes. Identifying, mapping and reaching these end users was the key to succeeding in the establishment of a proper UIP in Argentina.

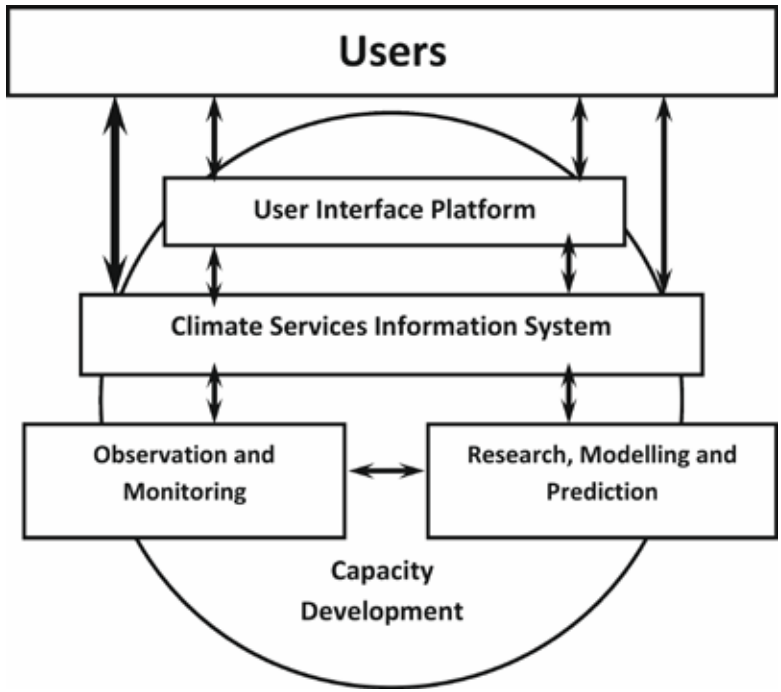


**Figure 7.1.** Climate knowledge for action: a global framework for climate services empowering the most vulnerable (Source: WMO (2012))

## A 'New Paradigm': Networking and Dialogue with Users

The Argentinean National Weather Service (NWS) is a public institution created in 1872. After more than fifty years of military management by the Argentinean Air Force, the NWS was transferred to the civilian sphere at the end of 2006, as a decentralized agency of the Ministry of National Defence. During those years, it was oriented towards the aeronautical activity, with forecasting mainly being aimed at aviation. In the narrative of its agents, the priority was to meet the needs of the air force, as indicated by its former director: 'I worked at the Weather Service for 50 years, 40 of them under military management. The process under the air force shifted the focus of meteorology towards the field of aviation. This happens every time an agency is in the hands of a single user: it gets distorted.'[1] In other words, the service had lost sight of the diversity of users outside the institution. The transference to civilian administration was the landmark that enabled the institution to follow a new pathway. A variety of sectors sensitive to climate information rather than just aviation started to occupy a prominent position among the NWS authorities' concerns, as targets of climate products and services. As part of this new institutional orientation, in 2007 the NWS organized a monthly open meeting to discuss the production of the seasonal climate forecast, the so-called 'consensus meeting', to generate the quarterly climate forecast. This ongoing space involves several academic, technical, operational and governmental institutions, all of them intermediate users of climate information (Figure 7.3). They exchange perspectives in an interdisciplinary mode and contribute to the co-production of climate knowledge (Carabajal 2016). Over time, sustained interaction has allowed many of the institutions participating in these meetings to become involved in the CRN3035 project, with the common goal of establishing a regional climate centre for the provision of climate services in southeastern South America. Given that past collaborations had not included such a strong engagement of anthropologists, many participants found it a novelty to


**Figure 7.2.** The Global framework for climate services: main innovations (data collected by the authors)

work hand in hand with both the 'social' and the 'natural' dimensions of the project.

In Argentina, global initiatives such as those contained in the GFCS aroused collective enthusiasm, not only at the NWS but also among the other institutions. Indeed, these institutions embraced the aim of strengthening collaboration and improving the social relevance and usability of their products and services, but despite the excitement of participants, the interpretation and long-term harmonization of global principles, regional goals and national institutional practices would not be univocal and free of tensions.

In the following pages, we describe the open questions and disparate ways of making sense of the 'new paradigm' endorsed first by authorities and staff of the NWS, and quickly echoed by a wide range of operational and scientific institutions. The new paradigm was presented as an institutional vision that was quite distinct from that prevalent in the era of military management, as an ideological and conceptual transformation in line with global trends, but charged with a sense of ownership and responsibility experienced from an inside-out perspective. At the same time, the need for organizational re-engineering aimed at interinstitutional and interdisciplinary cooperation was stressed. The new paradigm functioned as an 'action guide' depicting the coming of a 'collaborative turn' (Balmer et al. 2015; Hidalgo 2018) that set two main goals. One of the goals was to strengthen collaborative networks between operational, governmental and scientific communities, and the other was to develop new workshops so as to reach out to different types of user. We will now concentrate on the efforts oriented towards the satisfaction of the second goal.

## User-Interface Experiences in Argentina

Since 2013, major efforts have been made by the operational, technical, scientific and academic communities of Argentina to meet the diverse interests, expectations and needs of the many relevant climate-sensitive sectors. These efforts have boosted the implementation of participative spaces of the co-production of knowledge with different types of users. This turning point not only inaugurated an opening-up process, which took climate users into account, but also focused on interdisciplinary efforts to link natural and social scientists in planning and designing these new workshops. To a great extent, the institutions involved in the IAI project realized the complexity of this challenge to 'go beyond the classical dimension of meteorology, i.e. observation,

monitoring and forecasting, to interact with users and create collaborative approaches'.[2] This process will create a pathway for meteorological science to have greater societal impact.

In the cases described below, the meetings began by addressing the agricultural sector of Argentina because of its high sensitivity to climate variation and its key role in the national economy. The main goal of the meetings was to gather information about the sector, its principal features, needs and expectations, and the sociocultural factors involved in the process of interpreting and making decisions using climate information. These 'face-to-face' spaces were expected to foster communication and reconcile users' needs with the information provided by national institutions and agencies. Receiving feedback from users would allow institutions to assess whether the information provided was perceived by them as salient, credible and legitimate (Cash et al. 2003), whether the products were understood and became critical input for decision-makers and/or whether new products should be designed.

### *The Complex World of Users*

The design and implementation of workshops for end users required the exploration and identification of the needs and expectations that many sectors, such as agriculture, energy and health, might have regarding climate information. Proper mapping and characterization of users – actual and potential – were badly needed at both the local and sectoral scales. National and local institutions first had to chart their own set of users. In the case presented in this chapter, the actors to be reached and the priorities to be set were those of the agricultural sector of Argentina, whose users have varied profiles. Among the intermediate users are a large number of academic organizations, governmental organizations and NGOs that develop agroclimate products (models, reports, maps, forecasts, etc.). The end users may be actors directly associated with producers (such as extension agents and/or technicians) or the agricultural producers themselves, be they subsistence producers within the regional economies of the country or medium-sized and large capitalized actors leading the production of commodities for export, like soy, corn and wheat. Each of these end-user profiles has its own particularities, with different levels of access to and understanding of the information regarding, and diverse tools to adapt to, changes in climate.

So far, three main workshops have been held, among other relevant activities (e.g. dissertations, workshops and talks), each of which addressed different agricultural user groups.

### *The First Workshop: Who Are the Users?*

The first workshop was held on 26 November 2014, at the NWS headquarters, and it addressed intermediate users,[3] who represent sectoral, governmental institutions and agencies with extensive knowledge and expertise in agriculture. The participants of this first meeting (Figure 7.3) had already shared common spaces such as the 'consensus meetings', described earlier, and collaborated in research projects in which they exchanged perspectives and supported government decision at the local level. The meeting was organized with the active commitment of anthropologists and involved institutions closely related to the NWS. The process of planning served as an incentive to improve the documentation of the different agroclimatic products available in order to avoid possible discrepancies and/or overlap (e.g. weather and climate forecasts, agroclimatic information, drought alerts, intraseasonal and seasonal predictions and the like). As a result, the anthropologists of the team created 'a map' of the climate products that each institution provides through its website and agreed not only to put communication on

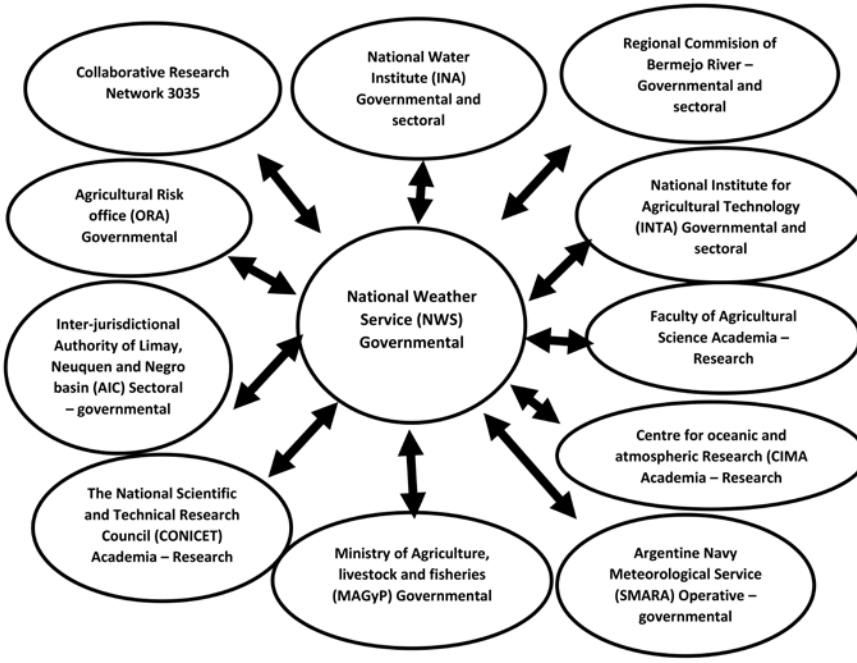


**Figure 7.3.** The first participatory meeting with 'intermediate users' involved in climate services processes, 26 November 2014 (data collected by the authors)

the agenda, but also to address it as a joint endeavour. Interinstitutional and interdisciplinary links already in existence were consolidated in the process, although the networking did not extend far beyond an already well-known group of participants: only a few rural extension workers from the Instituto Nacional de Tecnología Agropecuaria (National Institute of Agricultural Technology (INTA)) and one end user, a cooperative production representative, participated in the meeting.

After the host institution (NWS) was introduced, the three main activities to be held were presented. The first involved forming teams to answer a set of questions about climate information, its production, access and use, and this gave rise to a discussion during a general feedback session. Next was the presentation of the meteorological and climatic situation, as it impacted on the agricultural sector, the so-called 'declaration of emergency and/or agricultural disaster', as a starting point for making visible the crucial role of reliable data and information in supporting public policies. The third activity introduced the representatives of the Agricultural Risk Office (the Ministry of Agriculture) and INTA, who described their products and responsibilities. Finally, the PI of the CRN3035 project outlined plans for joint action and the continuity of linking activities with other user profiles, such as the producers of the Pampean region. The presentations and discussions became a platform for the participants to enunciate the commitment to the goal of providing climate services and at the same time to make visible their essential contribution to that goal.

The NWS took advantage of the meeting to show the monetary costs of collecting the data – in terms of equipment, communications, maintenance and taxes – to generate high-quality and timely products, thus raising awareness of the expenses behind the data. In this regard, they considered it necessary to make the commitment and responsibility that their work entailed visible to these important intermediate users, seeking recognition for the efforts that operational institutions make to generate data in real time and to build various products for the large sectors. One of the strategies to bring to the fore their commitment was to demonstrate the cost-benefit ratio, i.e. the value of the data, and the enormous amount of work involved, in processes ranging from the collection of data at the weather stations to producing finished products, such as the quarterly weather forecast. Incredibly, none of the participants correctly estimated the real monetary cost of collecting meteorological data, except for the members of the NWS. As one meteorologist put it: 'It is costly for the Service to provide data when someone requests it, but the recognition either within the Service or from the other institutions

is important. We would like to receive that recognition.'[4] This narrative shows that the value is not only measured in economic terms, but also in terms of the recognition of the institutional effort to update and make the meteorological information available. The search for recognition implies transcending the task of making data available – the main function of the institution – by making it valuable, visible and relevant to users. Recognition is perceived as a relational term, implying intermediate users' appreciation of the information and the service they receive.

The participants from the universities and the National Scientific and Technical Research Council (CONICET) of Argentina did show their appreciation of the work performed by the NWS, not only in terms of the monetary costs involved, but also regarding its ability to keep and make public its vast historical observational data record. However, they valued these data only as a necessary condition for modelling, because models cannot be created and run without such data. Nor can the numerical models be used for short-term weather forecasting or for making longer-term scenario-based projections of climate change without NWS data. When blamed for setting agendas with no clear articulation with operational applications or without any orientation towards supporting decision-making (governmental or nongovernmental), academics explained that without robust research that complemented observational activities, the implementation of the new paradigm would not be possible. In the meantime, participants from agricultural governmental institutions and agencies appealed to their relative closeness to agricultural users, stressing that the relationship that they had with users was central for a proper assessment of the availability, reliability, understandability, consistency and essential contribution to decision-making of the range of products and services delivered to the different user communities. The anthropologists did exactly the same, showing their key role in understanding the social and political contexts in which information could be used. As the social dimensions of the goal of providing climate services became so prominent on this agenda, the voice of the anthropologists grew stronger. As a result, many issues became evident. The weak articulation of disparate efforts, timid networking and the lack of communication between governmental institutions often resulted in similar products, maps and forecasts, with different interpretations and messages relating to the same agroclimatic conditions, causing confusion among the recipients.

The discussions about interinstitutional collaboration, networking and the need for recognition nurtured a reflexive atmosphere among the participants, and gave rise to a final and most relevant question:

what about the 'end users'? While everyone celebrated the opportunity to inaugurate these meetings and the demonstration of the will to work together, it was clear that further work would need to be done to reach the end users: the decision-makers, representatives of producer associations, individual producers – i.e. those who use the information in their daily activities. The absence of end users in this first meeting caused an uncomfortable awareness of a task yet to be faced, namely, the proper identification of end-user profiles. The institutions attending the meeting were users, but 'just' intermediate ones (see Figure 7.3). For example, by operationalizing the knowledge produced at universities, the NWS was, in fact, a user of the academic sector. However, participants would have to find a way to interact face to face with the 'end users'. When a NWS meteorologist was asked to define their users, he replied: 'We define the user as the producer, the typical farmer, who sows, harvests and works in the field; these are the users that we really work for. We differentiate them from the staff of intermediate institutions that also consult us.'[5] This comment shows that the end users were conceived of as the recipients of their daily efforts – those that give meaning to their work. At the end of the meeting, an agrometeorologist from academia claimed: 'I would have liked to meet the users of smaller agricultural sectors or networks of producers. The voice of the small user was missing.'[6]

A sense of ownership of the problem of the need to reach different types of climate-information users within the agricultural sector (Lemos and Morehouse 2005) had grown among the participants. The awareness that no end user was present at the first meeting led the organizers to recalibrate endeavours towards the second meeting, in which the institutions were able to meet representatives of large farmers' associations and NGO and corporate agents, in order to exchange perspectives and understand how they made sense of climate information. It was clear that workshops enhanced mutual understanding between researchers and end users about specific contexts in which forecast usability could be increased, but that it was through the processes of face-to-face interaction with users and self-reflexivity that institutions with operational responsibility could 'own the problems' of improving the social appropriation of knowledge and of connecting science with society. Furthermore, all the participants in the first meeting became aware that successful interactions would require social scientists' interventions in order to identify different types of users so as to develop suitable profiles and establish effective communications. Otherwise, 'user categorizations' would become homogeneous (Sivakumar 2006) or follow stereotyped patterns. The complexity of knowledge co-production became apparent to all.

### *The Second Workshop: Reaching out to the Big Players in the Agricultural Sector*

The second meeting was held on 26 August 2015 at the National Institute of Agricultural Technology (INTA) and was co-sponsored by the NWS. INTA was selected as the host institution, because the main target of its policies is the agricultural sector; therefore, INTA's broad outreach to various producer groups allowed it to give greater support to the event. This meeting addressed the big players in the agricultural sector of the Pampa region and Mendoza Province (Figure 7.4), a total of forty-seven actors: seventeen representatives from farmers' associations, grain-exchange institutions and rural consultants; twenty-five from the organizing institutions; and five anthropologists from the CRN3035 project.[7] Highly qualified users attended the meeting: technicians, representatives and advisers of agricultural and livestock producers, agronomists and professionals of agricultural meteorology. Most of them often hired private consultants in agrometeorology who offered talks and actively participated in discussions on key planning dates for sowing and harvesting. They also received specialized reports and analyses, and in

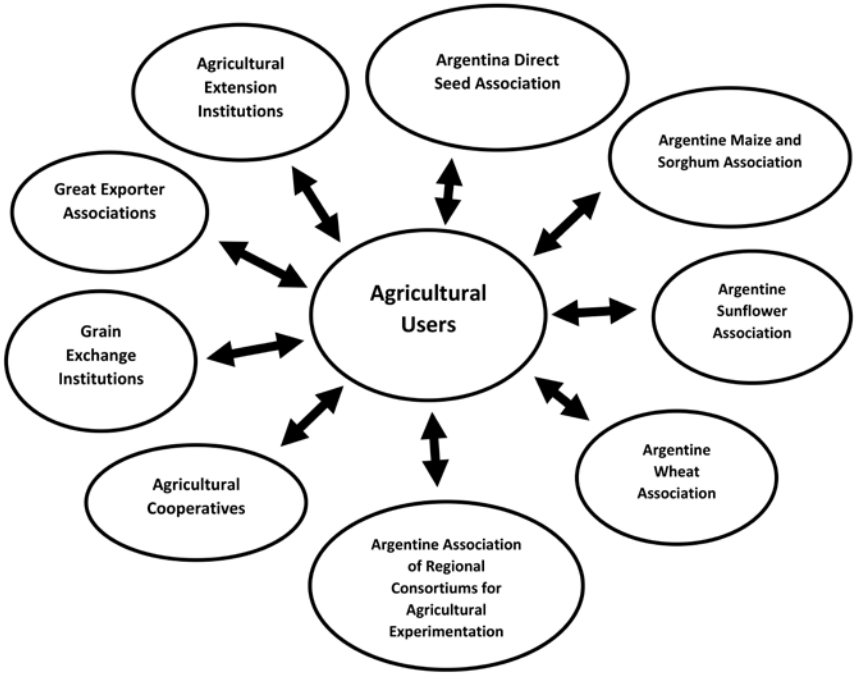


**Figure 7.4.** Interface in action: agricultural institutions and end users participating in interactive spaces, 26 August 2015 (data collected by the authors)

turn disseminated them to groups of associated producers. Therefore, the level of information they managed was high, and their outreach to agricultural producers made them excellent interlocutors to approach this sector for the first time.

The meeting was planned collectively, with all the institutions and agencies in charge of the first meeting joining efforts to organize the second meeting. Participants of the Ministry of Agriculture, the Centre of Oceanic and Atmospheric Research, the Faculty of Agricultural Science, and sectoral institutions such as the National Water Institute and the Regional Commission of Bermejo River together oversaw the strategic coordination of the meeting, such as who would participate, what activities would be conducted and how the end user issue would be addressed. From the beginning, the stated goal was clear: the meeting organizers had agreed not only to deliver presentations on the range of information they produced but also to 'listen' to users' needs and 'to be listened' to as a collective group that had to renew their credentials and gain recognition from a relatively unknown audience. The institutions expected to make their work visible and to be rewarded for their efforts. 'There must be give and take of information and services',[8] claimed one meteorologist.

During the organization of the second meeting, all the institutions decided to highlight the leading role of the NWS, acknowledging the opening-up process that it was going through, after its transfer from military to civilian management. This meeting was identified by the organizers as an excellent opportunity to improve users' views on the image of operational institutions, especially the NWS, and also to (re)gain authority and legitimacy among powerful and demanding stakeholders, such as the users invited to the second meeting. Therefore, they decided to highlight the features of the new paradigm: the collaborative turn that they were experiencing and the level of integration that for the first time the institutions had achieved after the first formal meeting eight months earlier. It was a question not only of building internal awareness of the changes that they were implementing together, but also of communicating the features of this transformation to the end users. The increased interaction and collaboration among institutions would be reflected in the image of the 'new' NWS. All the institutions, especially the NWS, aimed to make a good impression on the participants by emphasizing the goal of rebuilding the relationship with end users.

During the opening address, representatives of INTA and the director of the NWS – through a video created especially for the occasion – announced and celebrated the participation of end users and decision-makers from different agricultural associations of Argentina. The participants were then asked to engage in small group discussions, which lasted

more than four hours. These smaller round tables created an atmosphere in which the participants shared their experiences, needs and opinions about the type, access and availability of the meteorological information they were receiving at the time, and they were able to clarify any queries about forecast services. This meeting rose to the institutions' expectations, as it finally made it possible to explore and map the kind of climate information that these target users needed, as well as the sources of meteorological information that the users considered credible and reliable.

The under-utilization of the climate information was notorious. In the meeting, the agricultural users emphasized that the relevance of the information depended on whether it fit users' needs and whether it was delivered in a timely way, and was comprehensive and appropriate to the context in which the data would be used. Indeed, one of the main user expectations was found to be that climate information should allow them to make decisions at local levels, using what they called 'local field information' so that 'they sow with the forecast'.[9] This expectation showed that participants were not acquainted with the limitations inherent in the available climate knowledge. In their search for information, they consulted with a wide range of private advisers, who felt free to offer nonvalidated opinions and predictions, given that they were not constrained by the mission of providing official figures and forecasts. At present, research and operational climate institutions are unable to provide products with a high level of accuracy at this scale, given limitations that have not yet been overcome concerning the variables that can be monitored or predicted, and the temporal and spatial scale and accuracy of prognostic information. The extent of the Argentine territory adds further difficulties for national institutions in obtaining localized information. This situation is of crucial importance for vulnerable or poor farmers, who do not have proper access to valid information. For large farmers' associations, it is less deleterious, because they have the financial resources to acquire advice from renowned private experts. These private agroclimatic consultants take advantage of the situation regarding national forecasting and build credibility for themselves by providing detailed and daily advice to these users, though with less accountability than is demanded of the public sector.

From this, it would seem that in order for national institutions to build credibility and legitimacy in agricultural sectors, they should recognize the huge differences in legitimacy and accountability between public and private sources, and aim to have a strong presence at key moments when the information is urgent. One meeting participant stated: 'There cannot be missing links in the information chain; someone must link the sources, and it is not the farmers' fault that they do not consult NWS

information.'[10] Indeed, this level of 'place-based' interaction is very demanding and complex for governmental institutions, especially for the NWS after fifty years of military management. Finding ways to strengthen the relationship with end users is one of the main challenges in delivering climate services to local levels. This particular type of user highlighted that the value of information lies not only in the product, but also in the translation and advice that the institutions may offer. When a future climate event is forecast, it is not sufficient to do so in probabilistic terms, as the producers require guidance in their specific decision-making process. For example, the announcement 'El Niño is coming to southern South America' could be translated as 'It is a good opportunity to sow between October and December'.[11] Temporal and spatial scales of information also affected the discussions about the responsibilities of the NWS and the other organizing institutions – for example, a farmer's request: 'When it doesn't rain in November, it gets complicated. Critical periods: December–January. December is crucial. If you could predict November, that is ideal. That defines the most important thing: whether to make sorghum and not corn, hyper-early weaning, you can define the purchase of a forage pasture or not, sell the farm, but well in advance, before the drought, because then everyone would be selling, even the purchase of rolls or of balanced food that gets very expensive.'[12] How far should governmental institutions go to meet local users' requirements for a high level of specificity? They have national commitments, but the challenge is generating actionable climate information that can assist a whole spectrum of end users, not just the big players of the Pampa region.

Last, but not least, during the meeting, users demanded that governmental institutions provide certain types of seasonal and agroclimatic products. Operational institutions were surprised to discover that products fulfilling many of these requirements had already been developed or experimentally trialled, but users were unaware that they existed. Under-utilization was grounded not only in technical aspects of the information, but also in a very basic communication barrier: many existing products were almost unknown and therefore were not used. With regard to the known products, the participants acknowledged some constraints on their full utilization, given their poor accessibility and/or difficult interpretation. Forecasts and products contained useful information, but operational institutions could not decide whether they should 'keep it simple' or add more data to products or maps. The institutions made decisions on a daily basis, but a lack of feedback from users presented a gap they still needed to fill in order to deliver understandable and actionable information. Following the discussions, a plenary session was held, where end users and information providers expressed their commitment

to interacting and building close collaboration that could overcome all the obstacles that prevented the full usability of the available agroclimate products and services.

### *Roving Seminars: Reaching out to Small-Scale Farmers*

Roving seminars were carried out on 7–12 September 2016 and they were aimed at different types of end user: small-scale goat farmers and rural students in three vulnerable areas in the north of Santiago del Estero Province. These activities were funded by the WMO and their main goal was to improve the communication of climate information so as to help small-scale farmers handle climate risk and the use of resources. Moreover, the intention was to increase interaction between the NWS and end users, in this case goat farmers.

Unlike the previous meetings, in which intermediate users (those who use climate information to make their own set of sectoral products) and large farmers' associations were invited to the headquarters of the NWS and INTA, this programme allowed the NWS to travel to remote places and reach another type of end user – those who were more vulnerable to climate variations and less able to respond to these changes. Organizing these workshops required additional efforts, such as greater funding and commitment of time, to organize activities at a distance and move them from one locality to another. Local leaders (teachers and priests) and rural experts (agricultural technicians and extension agents) supported the meteorologists during the organization and implementation of the seminars. Without the participation of these key intermediaries,

| Rovin Seminars | | | |
|---|---|---|---|
| PLACES | (1) Nueva Esperanza | (2) San Jose del Boquerón | (3) Sachayoj |
| TARGET USERS | secondary school students and teachers | primary and secondary school students and beekepers cooperative | subsistence farmers |
| GENERAL ACTIVITIES | Rain Gauges distribution | | |
| | National Weather Services introduction, mission and vision, responsabilities. Forescasts on different time scales | | |
| SPECIFIC ACTIVITIES | Sample of Measuring instruments of weather - Film projection | | THI Temperature - Humidiy Index |

**Figure 7.5.** The NWS in the territory through roving seminars of 7–12 September 2016 (data collected by the authors)

connecting with users would have been impossible. Therefore, cooperation between the NWS and these local stakeholders was key to the success of the activities. The NWS does not have data sources in these towns, as the closest weather station is located in a large city, far from them, and the forecast does not accurately depict local climate conditions. The aim of the seminar was to build capacity among rural communities and to distribute rain gauges for them to make local measurements. It was hoped that the distribution of these devices and the interactions with the beneficiary institutions – those expected to create products based on this local information – would strengthen communication between the NWS and local producers and build relationships for future collaborations.

Three seminars were held for two different types of audience. The first two were delivered to young students from agrotechnical schools, some of them children of local producers or rural teachers. The presentations gave an overall view of the NWS and showed the activities that the institution carried out, by means of slides, a film and meteorological instruments, in the hope of motivating the students. The meteorologists trained these youngsters so that they would be able to pass on the information to their families. The third seminar was aimed at small family enterprises, goat and pig breeders, so the talk was about meteorological and agrometeorological issues as well as preventive measures to mitigate the adverse climatic effects on animals. In general, the meteorologists pointed out the common ground formed in these seminars by the positive predisposition of the participants, and the opportunity of learning from and interacting with NWS technicians and local stakeholders. As stated by a meteorologist: 'They were happy. They told us that they had never done a workshop like this. I expected them to be interested but their enthusiasm went well beyond our expectations.'[13] The meteorologists recognized the impact that this first event, conducted by experts from Buenos Aires, had on the participants, and stressed that the small farmers and students greatly appreciated the seminar; instead of making demands, as had been the case in the previous meeting, they were thankful. Furthermore, the experts agreed that in these territories, communication was the main problem, as the farmers did not have access to the internet or other infrastructures required to access the forecasts. One of the meteorologists reported: 'At a distance and with these communication problems, the interaction must be done face to face.'[14] Because of this, it is difficult for the NWS to provide local information and therefore strong presence is an essential factor to ensure the institution is known. In the previous meeting, given the knowledge and resources available to the big players of the Pampa region, it is easier for these target users to gather climate information through social media channels. However, reaching out to small-scale farmers in

vulnerable areas would require different strategies, such as face-to-face interactions and the identification of local intermediaries who could be the voice of the NWS among these producers and students.

## Conclusions

As embedded anthropologists, we have documented several cases of interaction between scientific and operational institutions, which, led by the NWS, rose to the challenges of generating the participatory spaces required to meet the goal of providing climate services in southeastern South America and the country. The organization of meetings with intermediate and end users allowed us to monitor the ways in which participants made sense of the orientation towards usability of climate science, which was condensed into the motto of a 'new paradigm' for climate services. Disparate and often contested ways of making sense of climate science came into play in these spaces, where the enforcement of the orientation towards users turned out to be more complex than had been expected.

In the first place, the implementation of the new paradigm implied reorganizing the intrainstitutional and interinstitutional relationships, and rethinking the research and operational agendas, in order to create a local 'user platform' in line with state-of-the-art international standards. Achieving this goal depended, to a large extent, on an appropriate characterization of the different types of users that the service aimed to reach, of their particular dynamics and of the sociocultural and political contexts that influence the access and use of information. Hence, the generation of spaces for dialogue became the key to achieving a contextual understanding of the decision-making processes, and thus to producing relevant, timely and useful information. However, before the end users were to be reached, the first dialogue spaces sought to involve the participants from the most important operational and academic institutions linked to the agricultural sector, many of whom already had a history of collaboration, but who hitherto had not articulated their actions with such a clear common goal. It is not surprising, then, that when the first meeting was organized, it was mainly these participants who were convened and that each of them highlighted their own crucial contribution to the common goal. In turn, they recognized themselves as intermediary users for the others, that is, all the institutions needed the data and information that the other ones provided to improve their own sets of products for the agricultural sector. The NWS would claim its central scientific and economic value in the provision of meteorological data, INTA would claim primacy

as a provider of agrometeorological data, scientists would highlight the value of their models, and ministerial agencies would boast of their proximity to decision-makers: each party asserted its essential role. Willing to face institutional re-engineering and having developed new interinstitutional relations, the participants soon noticed that the spectrum of interlocutors needed to be broadened so as to reach the end users of the agroclimatic information. The general recognition that the agricultural producers were under-represented made it evident that many challenges remained to be addressed, among them the lack of tools to identify a wide variety of end users, their needs and expectations in terms of information, and the barriers that prevented their full utilization.

These challenges were taken into account in the organization of the second and third meetings, in which the institutions were increasingly willing to interact and meet the demands of, for example, the large associations of Pampean producers and grain-exchange associations. To the extent that these end users, who were powerful in economic and social terms, already had their own advisers in agrometeorology, the need for recognition of the operational and academic institutions came back into play during the second meeting. All the institutions set out their claims for value, legitimacy and quality, disputing positions against private advisers and consultants from the agricultural sector. The workshops allowed the institutions to specify objectives well beyond the provision of information in order to make visible the value and quality of the service they provided and thus (re)position themselves as the authoritative source for the users, achieving recognition of their work and recovering institutional legitimacy. This challenge increased with the institutional decision of the NWS and its partners to become immersed in the distant reaches of the nation by identifying user profiles in the regional economies located in Santiago del Estero Province.

We have described a process in which institutional recognition of the complexity of the 'user' approach has triggered a reflexive framework that has been crucial in generating socially relevant knowledge and services. We are convinced that this systematic and deep reflexivity was enhanced by the active participation and collaboration of the anthropologists. We believe that success in the construction of a useful climate science will depend on the sustainability of interactions over time. The first and second meetings and the roving seminars allowed us to see that under-utilization of climate information could be overcome by close and frequent interaction, helping to build trust, credibility, legitimacy and the relevance of the climate information. Dialogue helped all types of users understand the main limitations concerning the variables that can be monitored or predicted, and the temporal and spatial scales of forecast information.

However, it is still a challenge for national information-providing institutions to solve the technical aspects involved, namely the timely release of uncertain information suited for decision-making needs. This challenge will be not overcome without the effective participation of users. Increasing the quality and quantity of the information is a necessary but not sufficient condition. Further research will be needed to demonstrate and describe how sustainable participatory spaces reconfigure the knowledge practices of scientific and operational institutions as well as the decision-making contexts of the different users. Reducing the gap between science and society will depend on making the most of the actors' enthusiasm for building collective knowledge, opening up institutions to society and generating frames of long-lasting interaction and commitment.

## Acknowledgements

The authors acknowledge the financial and intellectual support provided by the Interamerican Institute for Global Change Research (IAI-CRN 3035), which is supported by the US National Science Foundation and by the Universidad de Buenos Aires, Argentina (Project UBACyT 593 BA).

**Maria Ines Carabajal** is a postdoctoral fellow of the National Scientific and Technical Research Council (CONICET) of Argentina (micarabajal@gmail.com) and an anthropology lecturer at the University of Buenos Aires. She received her Ph.D. in Anthropology from the University of Buenos Aires. Her research focuses on the sociocultural dimensions of the production, circulation and use of climate information and decision-making processes. She is particularly interested in analysing the diverse barriers to the use of scientific knowledge so as to improve the way in which information is communicated and used. Her work aims at contributing to interdisciplinary and participatory research.

**Cecilia Hidalgo** is Plenary Professor at the University of Buenos Aires (chidalgo@filo.uba.ar). Her research and teaching interests are in the anthropology of science. She is currently studying scientific creativity and innovation in interdisciplinary and transdisciplinary research settings. She has participated in several projects working on complex environmental problems and has served as Project Director of a multinational and multisectoral collaborative research network on the provision of climate services in southeastern South America (2013–18) funded by the Inter-American Institute for Global Change Research.

## Notes

1. Interview with NWS ex-director Hector Ciappesoni, 'One Hand to Meteorology', 29 October 2013. Access date November 2016.
2. Fieldwork notes: NWS institutional event, director's speech, 8 October 2014.
3. In this event, many of the participants visited, for the first time, a new building, updated with modern equipment and with extensive infrastructure facilities in tune with the 'new paradigm'. The attending intermediate institutions were as follows. Governmental sector: Ministry of Agriculture, Livestock and Fisheries (MAGyP); Agricultural Risk Office (ORA); National Institute for Agricultural Technology. Scientific institutions: Center for Oceanic and Atmospheric Research (CIMA)); Faculty of Agricultural Science (FAUBA). Operational institutions: National Weather Service (NWS); Inter-jurisdictional Authority of Limay, Neuquen and Negro Basin (AIC); National Water Institute (INA); Regional Commission of Bermejo River (COREBE); Argentine Navy Meteorological Service (SMARA).
4. Fieldwork notes, first workshop, 27 November 2014.
5. Fieldwork notes first workshop, 27 November 2014.
6. Fieldwork notes first workshop, 27 November 2014.
7. The second workshop attendees: the Argentine Direct Seed Association (Aapresid), the Argentine Maize and Sorghum Association (Maizar), the Argentine Sunflower Association (Asagir), the Argentine Wheat Association (Aaprotrigo), the Argentine Association of Regional Consortiums for Agricultural Experimentation (CREA), agricultural cooperatives (Cooperativa Agrícola Ramallo), grain-exchange institutions (Bolsa de Cereales de Buenos Aires, Córdoba and Rosario), and grain-exporter associations and agricultural-extension institutions.
8. Fieldwork notes, first workshop, 27 November 2014.
9. Fieldwork notes, second workshop, 26 August 2015.
10. Fieldwork notes, second workshop, 26 August 2015.
11. Example proposed by an expert in a plenary discussion of project CRN3035, 12 May 2017
12. Interview with a member of Argentine Association of Regional Consortiums for Agricultural Experimentation (CREA), SOBA Project, 31 October 2018
13. Interview with a meteorologist from the NWS, 4 November 2016.
14. Interview with a meteorologist from the NWS, 4 November 2016.

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