Farmers and scientists in AR4D: Looking at a watershed management project through an STS lens

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\textbf{ABSTRACT}
Agricultural Research for Development (AR4D) provides the interface for the meeting of farmers and scientists. This is a meeting of different social worlds, contesting agendas, cultures of cooperation and networks of actors. Like in other disciplines, scientists in AR4D have developed their own culture of science. However, the role of their culture of science in the negotiations and encounters with farmers’ social worlds is rarely discussed. Analysing AR4D with a theoretical framework based on Science and Technology Studies (STS) helps us to highlight important issues of power and access in AR4D. The goal of this paper is to demonstrate how the introduction of certain technologies has interacted with the lives of people in an AR4D project in Ethiopia, and to highlight the potential and limitations of applying STS to AR4D. We interviewed farmers, scientists, extensionists, policy makers and donors associated with an AR4D project in the Ethiopian Highlands using qualitative social research approaches. Akrich’s theory on scripts provided the theoretical framework for analysis. Our findings provide examples for the re-inscription of technology and access in an AR4D project, leading to trade-offs and shifting of power between different actors. We conclude that understanding AR4D as part of a network of actors with its own culture of science provides an essential learning ground. We recommend STS to be applied more widely in AR4D to explore the nature of these networks to highlight what makes technology work for users in the long term.

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1. Introduction

Agricultural Research for Development (AR4D) carries the burden of solving one of the most fundamental problems of humankind: persistent food insecurity among impoverished rural populations in parts of the developing world (IFAD 2021; CGIAR Consortium Office & Global Forum on Agricultural Research 2011). AR4D is an attempt to respond to the failure of disciplinary research to address the complex challenges of agricultural development. In principle, AR4D focuses on collective rural innovation, it is client-responsive, development-oriented, makes use of participatory and systems approaches and works in teams across disciplines and institutions (Verschoor et al. 2006).

In practice, however, AR4D has faced challenges to fulfil all the above: the diversity of actors involved in agricultural innovation leads to contestant and often divergent agendas among those actors (Hall, Rasheed Sulaiman, Clark, Yoganand 2003). National culture is reflected in the norms of farmers, scientists and the organizations farmers and scientists are working with – and culture influences how they interact and how they learn and use knowledge (Hall, Rasheed Sulaiman, Clark, Yoganand 2003). Beyond the ‘national culture’ of science and the more local culture of cooperation of farmers, AR4D also incorporates another powerful cultural construct:

_Having rarely been explicit focal points of research, the institutions of agricultural science itself have been substantially under-theorized as cultural spaces […] The institutions and practices of biophysical sciences, as cultural spaces, have often been either left invisible or assumed to be purely technical._ (Crane 2014, p. 46)

The authors of this paper thus believe that AR4D will benefit from being analysed from the perspective of Science and Technology Studies (STS), a discipline that aims to understand how scientific facts are construed. Many STS scholars have suggested that the way scientific knowledge is produced is far from being neutral, and that scientific facts indeed are often socially constructed (Callon 1986; Jasanoff 2004; Knorr-Cetina 1981; Latour & Woolgar, 1979). Other authors have extended the STS debate to development studies (Leach, Scoones, Wynne 2005), but until recently this debate has not reached AR4D to a substantial extent. We can however see a trend of an increasing number of authors publishing with an STS lens on science in developing countries (Aalok Khandekar, Koen Beumer, Annapurna Mamidipudi, Pankaj Sekhsaria, and Wiebe E. Bijker 2017; Arvanitis & Chatelin, 2016; Crane 2014; De Roo Andersson, Krupnik 2017; Henke 2016; Shepherd 2006; Shrum 2016; Shrum & Shenhav, 1995). Just like all other disciplines, scientists in AR4D have developed a ‘culture of science’. They use their own symbols, languages, metaphors and epistemologies, that often
constitute barriers in mutual understandings and negotiations with farmers who are not part of this social world (Habermann, Felt, Vogl, Bekele, Mekonnen 2012). In this paper, we use STS as a theoretical framework to understand how AR4D is managing encounters between farmers and scientists.

We start with a premise that many scientists working in AR4D are already aware of the existence of a ‘culture of science’. However, there are obstacles preventing them from responding adequately to its existence. These obstacles are embedded in institutional hierarchies and streamlined evaluations of ‘academic excellence’. This is still largely based on scientific merits measured by the number of publications and their impact factors. Other constraints are imposed by funding systems and the expectations of donors. These leave very little room for scientists to respond to complexity, contextuality and the individual needs of farmers they are working with.

Depending on the culture and politics of the country they are working in, participation may not be as straightforward to implement as theory predicts. Farmers in Ethiopia have rarely experienced participation beyond rhetoric, and participation is mostly used as a term of enrolment. As such, it has become an essential part of rural development in Ethiopia since the 1970s (Harrison 2002), but this was largely through the increasing role of civil society organizations, while the Ethiopian State remained hierarchical and controlling (Habermann 2014). Coercion and control – mobilizing farmers for the implementation of government-selected technologies, like terrace-building – have shaped how farmers and scientists understand ‘participation’ (Habermann 2014).

AR4D takes science out of the laboratory into real life scenarios (Shrum & Shenhav 1995), where scientists are confronted with the needs, expectations and challenges of farmers in complex social and agro-ecological environments. This paper presents research on an AR4D project in the Ethiopian Highlands as a case study of how farmers, scientists and other stakeholders meet, interact and mutually reframe the contents and the scope of their interaction. We use an STS lens to analyse: 1) how the efforts of scientists to introduce technologies in a development context have interacted with the lives of people affected by an AR4D project; 2) what are the potential and limitations of applying STS to AR4D using a theoretical frame for analysis based on Actor Network Theory (ANT) (Callon 1986; Latour, 1987, 1992, 2007; Pinch & Bijker 1987).

To understand how scientists’ efforts to introduce technologies have interacted with the lives of people affected by an AR4D project, it is helpful to look back at work done on laboratory studies (Knorr-Cetina 1981; Latour & Woolgar 1979). Analysing the work life of scientists from an anthropological perspective highlights how scientists ignored contradictory data and that decisions on which data to keep or to discard were highly subjective.
According to Latour and Woolgar, science was constructed as a culture based on beliefs, oral traditions and cultural practices. Though highly controversial, Latour and Woolgar managed to dispute the long-upheld image of science of being supremely unbiased, objective and fact-based (Latour & Woolgar 1979).

STS finds a lot in common with development studies where social anthropological work emphasizes social and local embeddedness of knowledge and beliefs (Leach & Scoones 2005). In development studies, it is the knowledge of people that defines and explains technical problems and which data are relevant or not (Leach & Scoones 2005). Actor Network Theories (ANT) rooted in STS support this by claiming that a divide between technical and social issues is not possible: constructing facts is a collective process (Latour 1987). However, despite its high relevance to AR4D, STS has rarely been applied in this field to date.

The focus of our study is an ‘integrated watershed management project’. We use Akrich’s theory to understand the script-like nature of the integrated watershed management approach (Akrich 1992, 1993). Actors become the users of the technology presented by the designers: ‘like a film script, technical objects define a framework of action together with the actors and the space in which they are supposed to act’. (Akrich 1992, p. 208) Designers define actors with specific attributes, for example, rich/poor, adopters/non-adopters, male/female (Akrich 1992). The problem lies in the assumption that technology works, even if it keeps on failing (Akrich 1993). The technology is rarely seen as the problem; rather, the users and their attitudes are put at the forefront when it comes to seeking blame for the failure of implementing the prescribed technologies. The users act on behalf of their own interests. The original idea of the designers becomes displaced by a new script developed by the users – a technology designed for one purpose may then be used for another purpose the designers had never thought of themselves (Akrich 1992). To test to what extent Akrich’s findings can be applied to our objectives, we used the qualitative social research methods explained below.

2. Materials and methods

We selected the Integrated Watershed Management Approach as a case study in Ethiopia to understand how the efforts of scientists to introduce technologies in a development context interact with the lives of people. We decided on a qualitative research approach using observation, Focus Group Discussions (FGDs) and Semi-Structured Interviews (SSIs) due to the explorative, open-ended nature of these methods (Table 1). Village walks, seasonal calendars and participatory mapping served to better understand the social world of farmers in the case study area. We included:
The study of project documents.

(2) SSIs and FGDs with scientists and extensionists working in the case study area.

(3) SSIs, FGDs, village walks, seasonal calendars and participatory mapping with farmers living in villages inside the case study area and in one village outside the case study area.

The case study presented in this paper was situated about 80 km from Addis Ababa at Galessa Koftu in West Shewa. A watershed is defined as a specific space with topographic boundaries and a water outlet (Lal 2000). Watershed management puts emphasis on the connections between land use, soil and water (Gregersen, Ffolliott, Brooks 2007).

The case study included several consecutive and overlapping projects carried out from 1997 to 2007. It involved local actors (development agents, farmers) as well as a national research organization (Holetta Agricultural Research Center – HARC), a research partner at an Austrian university, the agricultural district administration and an international agricultural research organization. To avoid confusion, the often interlinking and overlapping projects will be called HA-PR, for Holetta Agricultural Projects. HARC was involved as a lead in all the projects that were part of the analysis. Farmers in the project area perceived HARC as their main partner and as responsible for the projects’ activities.

The projects all had their own objectives. They also had a definite time frame, that was extended a few times, but finally all projects ended in 2007. The only sustained activity was the institutional mandate of HARC to continue doing research there.

Galessa Koftu comprises of 526 households. The initial semi-structured interviews were done in all six villages belonging to the watershed (Tiru, Sombo, Gebi, Toma, Kamate, Ameja) and one adjacent village (Abeyi). Based on the results of the initial interviews, the research then focused on the villages of Tiru and Sombo in the watershed, and one village outside the watershed (Abeyi). These villages had 27 households (Tiru, Sombo) and 40 households (Abeyi), respectively. The total number of respondents was 33; six respondents were interviewed repeatedly for clarifications and additional information. The respondents were 20 men and 13 women; of these, eight were female-headed households. Among the respondents, 15 people had

| Table 1. Number of respondents for SSIs and FGDs. |
|--------------------------------------------------|--------|--------|--------|
| Focus Group Discussions                          | Farmers | Scientists | Other |
| Semi-Structured Interviews                       | 18      | 20      | -      |
|                                                  | 33      | 10      | 4      |

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their birthplace outside of Galessa. Almost all were speaking Afaan Oromo, and five spoke Amharic as a first (one person) or second language (four people).

Informed consent was obtained from all individual participants included in the study, either in written form or orally. To avoid bias, the interview guidelines for all interviews were presented to a group of peers, and to the supervisors of the first author who was doing a PhD study within a project funding this research. The supervisors were based at different universities from the university involved in the case study. Thus, the research outlines for this research were scrutinised by researchers at three different universities.

All interviews and FGDs were semi-structured and tape-recorded upon permission and handwritten notes were also taken. Recordings were later transcribed. Interviews in Amharic and Afaan Oromo were translated in the field during the recordings. The transcriptions were then cross-checked again by the original translator. As one of the translators was associated with HARC, a second neutral translator was hired for triangulation.

Observations in the field and during project events such as workshops were documented with video, photographs, observation notes and a reflective diary. Village walks and seasonal calendars were done as well as participatory mapping and FGDs. This took place at different intervals between October 2009 until July 2012 with a total of 3 months spent directly in the villages. These research methods served to understand the social structure of the villages, to learn more about the agricultural year of the farmers and their workload throughout the seasons, and to gain a better understanding of the topography, the land use challenges and the natural resource base of the area the case study was embedded in.

The other stakeholders interviewed in semi-structured interviews were ten scientists and four ‘other’. Out of the scientists, three were Austrian scientists and seven Ethiopians. The category ‘other’ included four stakeholders from the local government administration (district and village level). Initially, the Austrian contact points for the projects were interviewed, then the scientists supervising the Ethiopian PhD student, as well as this PhD student himself. Following a snowball system, this led us to interview other scientists both in Austria and Ethiopia. To better understand the social world of the scientists involved in the case study, project events such as workshops and field days were observed and documented.

To minimize bias in the qualitative analysis, several steps were taken by the research team. Firstly, as mentioned above, the transcriptions were cross-checked several times: the transcripts were sent back to the original translator to cross-check, and the translations were then randomly checked by a second translator. Secondly, the preliminary results were presented to a group of scientists in Ethiopia, many of them involved in the case study themselves.
Similarly, a village level workshop was held to present preliminary results and to obtain feedback from interviewed farmers, as well as other farmers living in the same area. Feedback and comments were considered during final data collection and data analysis. Finally, the results of the research were presented to researchers at three different universities.

Qualitative data analysis was done per ethnographic methods (Bernard 2002) by the first author. To support our analysis with analytical software, partly SPSS and Atlas-ti have been used. The code categories applied were both descriptive (external and internal setting and context) and actor-based (actors, social worlds, epistemologies and narratives). In the final analysis, coding focused on the following five groups: emerging causal links (interfaces, networks, alliances); epistemologies; learning; boundaries and change as to the perceptions of different actors.

We were looking for examples where farmers among the respondents were referring to how technologies were introduced to them in the HA-PR, if and how they were implementing them, what encouraged or discouraged them to do so and what they had learnt from the process. We screened interviews with other respondents, like scientists and development agents, for reference to the design of the intervention, to the entry into the community, the negotiations with the community of Galessa Koftu and reference to how they thought the technology was received by the community.

The results’ section is structured in three parts: the first part explains how the HA-PR was set up and structured, and how the scientists as designers in Akrich’s terminology gained an entry point into the community and started implementing the script of the Integrated Watershed Management in the planning phase. The second part explains which challenges and opportunities scientists and farmers encountered during the implementation stage leading to a partial description of the original approach by farmers using the example of one specific technology, the seed potatoes. Finally, the third part elaborates on the implications of the trade-offs between scientific and development objectives of an AR4D project when farmers re-inscribe different aims into the approach.

3. Results

3.1. Designing the AR4D approach: Learning to listen to farmers

This part of the results section describes the beginning of the HA-PR: this was the time when the scientists came to Galessa Koftu. In the early 1990s, the attention of the Ethiopian government shifted to integrated watershed management following a visit of a delegation to India and China to learn about different development interventions. It then became an important policy framework: a conference organised at Woldeya, Amhara Region, was
instrumental in this process. Following the conference, a committee selected representative sites for Ethiopia’s main agro-ecological zones, and Galessa Koftu was selected to represent the highland and high rainfall areas. The mandate for research at Galessa Koftu was given to HARC. At the same time, an international agricultural research organization was looking for a model site for potential upscaling for integrated natural resource management. They were interested in developing methodologies, and HARC wanted to test technologies in the watershed. This is how their cooperation started. The project of the international agricultural research organization went through four phases with different focus from 1995 until 2007:

The INRM project aimed at contributing towards food security by improving natural resource management and agricultural productivity. It went through four phases, but the first stage (1995–1997) was geographically scattered and did not involve Galessa. The second phase (1999–2000) looked at improving income through farm diversification, intensification, soil conservation, fertility improvement and integrated pest management. The third phase (2002–2004) focused more on social issues and process documentation and used participatory and interdisciplinary approaches. The fourth and final phase (2005–2007) focused on scaling up technologies and knowledge, and strengthening local institutions and by-laws (GWP publication 2008c). (Habermann 2014, p. 95)

Galessa Koftu was only directly involved from 1999, which was the second phase with more of a technological emphasis. The third phase from 2002 until 2004 focused more on social issues and the use of participatory and interdisciplinary methods. The fourth and final phase up until 2007 was about up-scaling and strengthening local institutions (Habermann 2014). However, even after 2007 HARC continued some of the activities introduced earlier by the project.

The way the project script had been designed had not only been influenced by the acting scientists themselves: it was shaped by the institutional context of their organizations as well as by the political context in Ethiopia at the time, which aimed at developing natural resource management and agriculture through the integrate watershed management approach. It was a very common narrative at that time that watershed management would be the best option to contribute to natural resource management and agricultural development, and deeper analyses of these issues can be found elsewhere (Habermann 2014; Habermann, Felt, Vogl, Bekele, Mekonnen 2012).

Many of the original authors and designers of the script were then working for the HA-PR as implementing scientists with changing roles over the years – this ranged from researchers, technical field assistants, PhD students to site coordinators. Most importantly, there were scientists who joined later who had not been involved in the original writing of the script. They followed the design, and to some extent participated in the re-writing of parts of it. However, the HA-PR had different phases with different objectives – so this
re-writing and changing focus was deeply influenced by the donors as well as the changing political focus of the government. During the duration of the HA-PR the strategic focus of the government changed several times forcing the scientists to adapt. In addition, this was influenced by the length of the HA-PR, the high staff turn-over in both research and extension, the diversity of participating institutions and the priorities of several different donors.

In the run of the project, the previously common top-down approaches were seen more critical by the government that was allocating resources to HARC. This change in the political environment led researchers to re-think their approach in Galessa Koftu to increase the level of involvement of farmers to meet these new expectations. Initially, this was met with scepticism by some of the national scientists involved, who at that time were used to a more traditional approach. The traditional approach people were trained in was to provide technologies without major consultations of farmers beforehand. This shift to a more participatory approach took place in Step 4 of the nine steps of building participation in the HA-PR (see Table 2). This epistemological shift was not only mentioned by interviewed scientists, but it has also been documented in publications about the HA-PR (Admassu et al. 2008; Admassu, Mekonnen, Gorfu 2011; German, Mowo, Amede, Masuki 2012; Mekonnen & Admassu 2008; Mekonnen et al. 2006).

This shift was easier for some researchers, but not so much for others who were challenged in their genuine epistemological understandings. The original narratives of the HA-PR were shaped by this more technology-oriented and less user-oriented culture of science. This was a view of ‘how to work with farmers’ that was deeply embedded in the extension system as well. Nevertheless, given the political pressure and with deeper involvement of the international agricultural research organization in the project, the design of the HA-PR increasingly aimed at a higher level of involvement of farmers in decision-making. In the following section, we will elaborate further on how the scientists were confronted with realities in the field. We will explain how farmers and scientists, and to a lesser extent the extension agents, struggled to find a way of working together in a project context where the government, donors and different research organizations represented sometimes conflicting narratives.

During interviews with scientists involved in the project it became clear that there was a learning process for both farmers and scientists working for the HA-PR. The starting point of the HA-PR was when the government allocated Galessa Koftu watershed as a model research site to HARC. There was a high institutional interest on behalf of HARC to pursue this research within a certain policy context that assumed that ‘protecting a watershed by increasing tree cover and by putting soil conservation measures in place will lead to more sustainable land use and a decrease in soil loss, which will eventually also improve agricultural productivity and livelihoods and contribute to the
Table 2. The nine steps of building participation in the case study HA-PR.

| Step | Participating Actors | Participation level |
|------|----------------------|---------------------|
| **Step 1** | Contacting officials | Government organizations (Woreda = District, Kebelle = Municipality Administration) Researchers | Gaining permission, removing potential obstacles |
| **Step 2** | Contacting individual farmers | Farmers (Village leaders and their relatives) Researchers Development Agents | Informing and consulting |
| **Step 3** | Calling village meetings | Farmers (Village leaders and selected village representatives) Researchers Development Agents | Informing and consulting Negotiating consent Information given to farmers by researchers/development agents |
| **Step 4** | Participatory meetings | Farmers (Village leaders and selected village representatives) Researchers Development Agents | Consulting Decision-making |
| **Step 5** | Consensus building | Farmers (Village leaders and selected village representatives) Researchers Development Agents | Informing Consulting Decision-making |
| **Step 6** | Project Implementation | Farmers (Village leaders and selected village representatives) Researchers Development Agents | Participatory Research (on-farm experiments carried out jointly) Labour (SWC constructions, nursery, spring development) Farmer Research Groups (on-farm trials) Experience sharing visits |
| **Step 7** | Field days | Farmers (Village leaders and selected village representatives) Researchers Development Agents Woreda Visitors from abroad or from other organizations (supervisor) | Joint farmer-researcher presentations Consulting Informing Knowledge Sharing |
| **Step 8** | Project workshops | Farmers (Village leaders and selected village representatives) Researchers Development Agents Woreda NGOs Local policy makers Visitors from abroad or from other organizations (supervisor) | Researcher presentations, farmers present (approval by presence) Consulting Informing Knowledge Sharing Consensus / agreement |
| **Step 9** | International conferences | Researchers Selected project partners | Researcher presentations, farmers absent Knowledge Sharing |

Country’s overall development’. (Habermann 2014, p. 109). In addition to this, the HA-PR also included crop varieties and crop management, livestock, feed and forage. This calls for a degree of interdisciplinarity that is not always easy to facilitate, as the different experts may not follow the same goals (German et al. 2007).
Other challenges derived from the tension between different expectations of scientists and farmers. From the perception of Sci-Et-Fed-5 (scientist, interview, 2.11.2009), farmers usually find it hard to accept scientists in the beginning of a project, and only after living and working together for long time will lead to acceptance. According to him, the first year is always a challenge, so he recommended bringing entry points that showed some impact, to show that the technology was working. In the case of the HA-PR he explained that this entry point was the introduction of Farmer Research Groups on potato farming, who were given improved potato varieties. The new potato varieties were demonstrated to farmers together with the government and extension. After this technology was working in the first year, a lot of farmers were asking for the improved varieties in the second year.

Realising that farmers seemingly needed such incentives to engage in the project, the scientists, after initial struggles to develop rapport with the farmers, engaged with farmers in more interdisciplinary and participatory ways. However, it is important to note that there was also the above-mentioned pressure to abide to the changed expectations of donors, the government and partner organizations that forced scientists to think in new directions.

The scientists held consultation meetings as well as individual interviews and informal encounters with the farmers, which helped them to learn more about the farmers’ problems and preferences. This was an important step towards changing the original script of the HA-PR. The following steps in the project process illustrated how the collaborative re-writing of the script by some of the original designers/scientists; other scientists who joined the HA-PR later; actors from the international agricultural research organization; the extensionists; and the farmers themselves shaped the originally unilaterally designed script into a more collective one. The changing political context, and the changing discourse among researchers in and outside of the HA-PR at that time, led to a dismantling and reconstruction of the scientific culture of the project. During the project activities, it became obvious to the researchers that the community had many demands – even if they were embedded in the watershed approach, the administrative and infrastructural issues connected to these demands made it challenging to meet these. While watershed management is an interdisciplinary approach connected to a range of sectors such as the water sector, health sector, education sector, infrastructure and others that does not mean that every watershed management project is able to cover all these aspects.

At this moment in the HA-PR, meetings with farmers in the watershed were organized. During those meetings, a list of 48 different problems was collated, and this list was then condensed by the scientists working for the project at the research centre (Sci-Et-Fed-5, 2.11.2009). The farmers engaged
in the process suggested priorities. Then the priorities were refined by the scientists and again presented to the farmers. The focus of the farmers during problem identification was access to water, but water engineering was not part of the project’s agenda. There was a debate among the scientists, whether they should get involved in this, as they did not consider this as their mandate. However, in the end they decided to construct three water points.

*Water was the first problem for farmers. But water containers and construction of such things is not the mandate of research. So, we were challenged by the farmers on the one hand, because their problem, the first problem is water, but from research, especially from officials, no, this is not our mandate. This is the mandate of water boards or any other NGOs. But since we had support from the project, we tried to really compromise this thing with participation of farmers. So, three water points were identified and constructed. (Sci-Et-Fed-4, scientist, interview, 29.10.2009)*

The original vision of the project as a scientific endeavour was described by the users. This description was then supported by the scientists. The first priorities mentioned by the participating farmers in the problem ranking were water supply and tree seedlings. The scientists agreed to develop three springs and handed over technical objects such as a mini-weather station, a community-based tree nursery, seven diffuse light stores for potato seeds, 12 energy-saving stoves and three cross-bred dairy cows to the farmers in Galessa Koftu (Admassu et al. 2008). This was not without hesitation by some, who considered this as extension and not as scientific activities. It indicates that the narrative of the project changed at this stage in a direction initially not endorsed by everyone involved. A new script emerged that was more participatory but also more development- and less research-oriented. This re-inscription had consequences for the farmers: they were expected to participate in the activities of the HA-PR, to actively contribute labour and to adopt the technologies brought by the HA-PR. But the consequences were largely positive at this stage: farmers living in Galessa Koftu perceived immediate benefits from the project, which made them more supportive. However, it implied that to be able to work with the farmers, a ‘buy-in’ was necessary. This ‘buy-in’ created expectations, that the HA-PR scientists could only partially fulfil. The farmers had described the role of the scientists to the role of an advisor, almost an extensionist, filling a void left by an extension system not able to cover the large number of households within their administrative boundaries. In the next section we explain an example of the implementation of the seed potato technology in the HA-PR that was well received by farmers due its positive impact on their livelihoods.
3.2. The seed potato story

In this section, we explain more about how the gradual introduction of a technology by multiple actors developed its own dynamics. Seed potatoes are the central agents in this story. The seed potatoes are not isolated actors, they are connected to political decisions on which technologies to promote in different agro-ecological zones of the country and their suitability to these agro-ecological zones; they come with instructions in the shape of trainings developed by both scientists and extensionists; they are linked to other technologies like agricultural inputs such as pesticides, diffused light stores for storage. Their fate is tied to diseases such as the late blight on potato, whose agency ultimately decides the fate of the seed potato technology. Seed potatoes are also connected to a network of actors involved in planting, tending and harvesting, as well as actors involved in trading such as the middlemen buying the seed potatoes after they have been harvested, put in bags and carried to the road. But a central question for both farmers and scientists was the one that should come first: how do the seed potatoes initially reach the farmer, where is the source and how do the farmers gain access to it? Initially, the answer to this was clear, however later the distribution developed its own dynamics: in Galessa Koftu and neighbouring areas seed potatoes were promoted both by the HA-PR and the government extension system. We found that according to both HA-PR scientists and farmers in Galessa Koftu and the neighbouring village Abeyi, the most popular new technology provided by the HA-PR was seed potatoes of improved varieties. The advantage of the new varieties was that they were growing both in the short and long rainy season. Furthermore, the new varieties and the improvements in management increased the yields substantially. The seed potatoes could be sold with high profits to middlemen passing through with lorries. A government expert from the district level explained that there was a problem with late blight on potato, hence the new variety of late blight resistant seed potatoes introduced by HARC was popular with farmers (Woreda expert, 44 years, interview, 13.5.2010). In the training provided in farmer field schools, farmers learned about the management of the seed potatoes, and about the real cause of the late blight. Before that, according to a former HARC scientist most farmers believed that the late blight was related to the makings of evil spirits, like the devil.

Interviews in the village outside of the watershed confirmed that new potato varieties introduced by the HA-PR had spread in the entire area – and it was unclear how this had happened. Farmers had received training on potato production from the government as well. But there was a certain level of discord among farmers regarding the accessibility of such trainings, on seed potatoes as well as on other technologies. One female farmer from the village outside of the watershed explained that the productivity of
grains had decreased in recent years due to a decline in soil fertility and occurrence of frost; she confirmed that she had received advice from the government on how to respond to this (Female Farmer, 60 years, village A., interview, 10.5.2010). Some farmers confirmed that they could get this kind of support. But there were others who mentioned that the development agents were not helping them, and that they even went to the District and Zone without getting the answers they were looking for. The development agent on the other hand complained both about the District and the farmers: according to him, the District was not supporting him, and the farmers were not implementing technologies offered to them by the government. However, the seed potatoes were adopted rapidly, in contrast to other technologies. It was striking that rather than critically assessing what the difference was between the different technologies, he blamed the farmers to be ‘laggards’, which they clearly were not when it came to the seed potatoes.

The agency of seed potatoes as actors in a network of technologies, organizations, politics and human actors such as scientists, farmers and extensionists was a powerful one. Seed potatoes changed the lives of many farmers in Galessa Koftu. Galessa Koftu is located along a road leading to the main road to Addis Ababa. This enabled lorries to come and collect the potatoes in a relatively easy way. This system of selling to middlemen provided farmers with immediate benefits of this technology. The other attribute beneficial to the agency of the seed potatoes was the agro-ecology. As a high-altitude area Galessa Koftu, is very suitable for growing potatoes. And finally, there was the advice and technical support given to farmers about potatoes. This was to some extent provided by the government extension, and to some extent by HARC. In the script of the designers, the training and technical support was considered relevant at the introduction phase of the technology. However, the technology evolved, and new challenges emerged – seed potatoes developed their own agency, and the dynamics of this technology went beyond what the project could achieve. After the end of the project, users were facing difficulties in getting answers to emerging challenges. The seed-potato technology had become an important income-generating activity all over the area. For many farmers in the watershed, it became the most tangible benefit brought by the HA-PR, in addition to the watering points. However, when new diseases emerged that affected the potatoes, the farmers who participated in the HA-PR were waiting for the scientists to help them. They expected the same scientists to provide advice to them that had been coming to visit them in previous years. The farmers understood the scientists’ engagement as a permanent one, while for scientists it was temporary and bound to the lifetime of the HA-PR. With the exit of the international agricultural research organization at the end of phase four, the activities of HARC were limited to government funding
3.3. Trade-offs between AR4D science and farmers’ livelihoods

The third step in our analysis served to highlight possible trade-offs in the implementation of AR4D. The trade-offs specifically concerned the compromises the HA-PR scientists had to accept due to the nature of the AR4D project, that had shifted its focus from a science towards a development-oriented vision focusing on farmers’ livelihoods. This also had an impact on how communication between the scientists and the people at the research site was organized. There were two actors playing an important role in this process: their official role was to be ‘local contact farmers’. Their function was to be spokesmen for the farmers of Galessa Koftu who participated in the HA-PR. ‘Farmers of Galessa Koftu Watershed’ were a group not clearly delineated but vaguely described as ‘the beneficiaries’ in the HA-PR’s language. These two actors named local contact farmers were also the entry point for the scientists to communicate with the farmers of Galessa Koftu, thus they became intermediaries between two distinct communities of actors, the scientists as designers of the original project’s script and its further alterations, and the farmers of Galessa Koftu as the users who described the HA-PR and re-inscribed different visions into the technologies promoted by the HA-PR, as explained above in the seed potato story.

At the time of this research, HARC scientists rarely visited Galessa Koftu anymore, as the HA-PR had almost phased out completely. Nevertheless, there were still some activities on-going like training, seed and soil and water conservation trials and the community nursery. Since the decrease of the HARC scientists’ presence, the role of the local contact farmers became increasingly more powerful as spokesmen: The absentee scientists no longer exerted much control over the local contact farmers’ activities. More and more responsibilities were handed over to the two spokesmen. Scientists still directly involved in the activities of the HA-PR at a later stage reported for example, that registration for trainings offered by the HA-PR regularly featured the names of the two spokesmen on top of the list, and these two determined who else was admitted to trainings. An elderly female farmer complained that she did not get access to seeds like others did – as an elderly widow she could not contribute to the communal activities of the community nursery in the same way as others, thus the local contact farmers did not allocate a share of improved seeds to her. This was particularly remarkable as
one of the local contact farmers, her neighbour, persistently tried to prevent the first author from interviewing her. He repeatedly claimed that she was not mentally fit to participate in an interview.

The HARC scientists had accepted that the spokesmen had acquired a disproportionate amount of power in the process of their withdrawal from the site. While the HA-PR was still running, the HARC scientists had to accept that they had lost control over the allocation of access to HA-PR technologies as well as control over the access to HA-PR knowledge by the assumed HA-PR beneficiaries.

To better understand the trade-offs mentioned above, we investigated the delineation of knowledge transmission in and out of the watershed. This presented a challenge for the HA-PR scientists. While it was intended that farmers outside of the watershed should benefit from the project at a later stage, this was not part of the script of the implementation of the HA-PR. The problem occurred in connection with the dissemination of improved seed varieties for different crops grown in the area. In a scientific experiment, scientists were conducting field trials together with farmers inside the watershed to assess amongst others, the yield and performance of these newly introduced seed varieties. The scientists’ concern was that by using the improved seeds in an uncontrolled setting, the seeds would get mixed with local seeds. These mixed seeds could then be transmitted back into the watershed, and the scientists would no longer be sure whether the results of their field trials were valid or not. Thus, their script specifically ruled out the distribution to other villages.

However, farmers quickly described the technology from being a research topic for participatory field trials to a livelihood issue. The local contact farmer who lived outside the project area explained that his neighbours did not understand why they could not get access to the improved seeds provided to farmers living in the watershed. This made his interaction with his neighbours challenging. Eventually they got access to the seeds through bartering.

There is a social problem on me because I am working for that project and I live in this community. This community always asks me why this project is not covering our village. [...] they saw those improved seeds that were distributed to those watershed management communities. Even they asked me for these improved seeds, why don't you give those to us. But I told them that this also is not covered outside of the watershed management, but the people are just bartering. (Farmer, local contact farmer, 42 years, village G., interview, 9.5.2010)

The scientists’ script designed the HA-PR to be confined both spatially and temporarily according to the projects’ documents and agreements with donors. In the case of the HA-PR, this geographical delineation created imbalances between adjacent villages according to the development agent and some farmers interviewed. The imbalances were constituted of different
access to resources like improved seed varieties. Farmers described the spatial limitation of the project that did not correspond to their social world: family ties reached beyond the watershed. The nature of the society in Galessa would not permit farmers to keep a resource like improved seeds to themselves and refuse to share with family members living outside the watershed.

Farmers from outside of the watershed were linking with farmers inside the watershed to gain access to the new seed varieties. The fact that the uncontrolled bartering of seeds led to a pollution of the seed material available in the watershed was pointed out by the development agent during an interview. He explained that he was trying to control the spreading of the seeds out of the watershed, nevertheless he observed that there were still farmers inside the watershed without these improved seeds, but farmers outside of the watershed who got access to the seeds (Development Agent, interview, 11.5.2010).

According to the interviewed farmers, having access to seeds opened new economic opportunities for farmers: the improved varieties for seed potatoes contributed substantially to improving the livelihood situation of many farmers as they provided an additional source of income, according to both farmers in the watershed and the scientists working with them. Scientists in interviews and project documents also pointed out that frost-resistant varieties of wheat and seeds for crops new to the area such as linseed and triticale further assisted to provide food security and economic benefits to formerly food-insecure households. The scale of benefits was narrated in positive light by one of the two local contact farmers, who explained that there was change in the watershed: when they started the project, only a few people had good livelihoods, but now many people have improved their lives (Farmer, local contact farmer, 42 years, village G., interview, 9.5.2010). Some farmers however were less optimistic about the benefits of technologies introduced (other than the seed potatoes): they pointed out that only a limited number among the farmers in the watershed experienced changes in livelihoods due to the project.

The farmer making the statement above personally benefitted more from the project than most other people, as was confirmed by himself and a scientist associated with the project (Sci-Et-Fed-8). He was one of the two ‘spokesmen’ for the farmers of Galessa Koftu, the two local contact farmers. Farmers, in- and outside the project area questioned whether more than a few people associated with these two spokesman really had benefitted from the project. Others seemed to have a different perception of what benefits the HA-PR had brought. A close relative of one of the spokesmen was very clear about the fact she only attended trainings because she got paid for it, as a kind of alternative income source.
She told us that when she got training from Holetta or when she could go to a workshop, she got paid for it, but now she is sitting here with us for nothing. She compared it with the mineral salt that they give to the livestock. Once you start giving it to them, every time they see your hand, they think you will give them the salt. (Fieldnotes about interview with female farmer, 6.5.2010, village T.)

The attempt to control the flow of seeds to other farmers raised ethical questions among the development agent, the scientists and the local contact farmers. Making the bartering of seed material illegal would in theory prevent the spreading of the technology. From the point of view of farmers, this deprives farmers outside of the watershed from a desperately needed source of income. On the other hand, from the point of view of the scientists, it devalued the scientific experiment, that should bring long-term benefits to everyone. The urgency of farmers to obtain these technologies contrasts with how they were portrayed by the development agent (‘laggards’) and by some scientists. The main interest of the scientists even became an obstacle to farmers who were willing to adopt new technologies by themselves.

4. Discussion

In the results section, we presented the findings from our research at Galessa Koftu in Ethiopia. These findings demonstrated 1) how scientists implemented the script of the Integrated Watershed Management at Galessa Koftu in the planning phase; 2) which challenges, and opportunities scientists and farmers encountered during the implementation stage presenting the example of the seed potato story and 3) the implications of trade-offs between scientific and development objectives. These results support us in answering the two main questions we had asked at the outset of this paper: 1) how the efforts of scientists to introduce technologies in a development context have interacted with the lives of people affected by an AR4D project; 2) what the potential and limitations of applying STS to AR4D using Akrich’s theory on scripts are.

Our study found that the introduction of technologies in a development context leads scientists in AR4D projects to enter a complicated web of social, economic and agro-ecological relations as other authors have shown as well for similar kinds of research (Agrawal 2005; Leach & Scoones 2006; Mosse 2005; Scoones & Thompson 2009). As our results show, scientists at the beginning of the HA-PR had a linear vision of what their engagement with farmers in Galessa Koftu would be like – this vision was very much influenced by their own epistemologies, the scientific culture of their institutions and by what donors and politics supported: defining the situation, the problems, selecting solutions. This vision had to change over the course of the first
engagements due to changes in priorities of donors and the government. This had an impact on the scientific cultures of the implementing research organizations. Initially, the change of the project narrative was therefore less a response to the farmers’ needs than a response to changing paradigms among donors and governments regarding AR4D on an international level that reached Ethiopia at that time.

On the ground, in the implementation of the HA-PR, both farmers and scientists had to learn to work with each other. This was a learning process for all of them: at the interface between farmers and scientists, negotiations take place not only about different perspectives, expectations and views, but also about the nature of technologies (Habermann, Felt, Vogl, Bekele, Mekonnen 2012). These negotiations are influenced by their interactions as individuals and groups of actors, but also by the contextual framings of the institutions behind them, as well as the political context they are embedded in. While some versions of these stories remain hidden, are excluded or black-boxed by individuals, institutions, or groups of actors (Jasanoff 2004; Keeley & Scoones 2003), others will be adopted, altered and merged into the scripts that define the interaction between the actors involved at this interface.

Applying Akrich’s lens helped us to understand how users and designers eventually altered the project’s script to a much more intervention-oriented design, compromising some of the more scientifically oriented goals of the script. For this collaboration to work, both parties had to contribute their part: while scientists brought new technologies and facilitated some direct extension-related activities like constructing the improved springs, farmers engaged in Farmer Research Groups and took part in some experiments. However, scientists had to accept that some of the negotiated rules were broken when farmers described the project narratives according to their own social world: social norms did not permit farmers to keep improved seeds to themselves, not sharing with relatives outside of the watershed – a boundary defined by the scientists – was not an option. The technology thus found its own purpose and exerted its own agency independent of the original script of the scientists.

Complying with the ANT literature we understand that ‘watershed’ is used as a boundary object by scientists: ‘Boundary objects are both adaptable to different viewpoints and robust enough to maintain identity across them, (Star & Griesemer 2016, p. 387). The boundary object ‘watershed’ links different scientists working on watershed management all over the world, who share an implicit agreement. However, while this is an identity recognized by scientists, it does not bear meaning to the population of Galessa Koftu, who understands belonging to social and political entities rather than belonging to bio-physical entities.
The new technology brought by the scientists, the seed potatoes, changed the lives of many in bringing more livelihood security. But due to the nature of their social world, sharing the technology with neighbours and family members was non-negotiable. The boundary of ‘the watershed’ defined by the scientists was not socially relevant for them, hence in the end, there were people inside the watershed who did not have access to the technology, but at the same time, people outside the watershed who did. Compromising the scientific experiment that the scientists saw engraved in the script was less relevant than compromising social relations. Thus, neither the local contact farmers nor the development agent was able to prevent farmers from describing the narrative of the project according to their own social world, despite of the fact that it compromised the scientific experiment.

This description of the project narrative and the re-inscription of different, sometimes individualised goals show that the negotiations between farmers and scientists were not closed after the first ‘participatory meetings’. Such an individualised goal was the description of trainings as a substitute income source rather than an input to technology dissemination. Thus, access to incentives like trainings or improved seeds became important tokens of negotiation between the farmers’ spokesmen and the scientists, but also between the spokesmen and their communities. These findings relate to the literature on the sociology of translation (Callon 1986): as in the example of the fishermen of St. Brieuc Bay, not only was there new knowledge created about Galessa Koftu, and about e.g. potato seed production, simultaneously a network of relationships emerged that connected both social and natural entities, who mutually controlled their roles, identities, mandates as well as their goals and aspirations (Callon 1986). As in the example of the scientists, the scallops and the fishermen, the different moments the HA-PR went through over the years are nothing more than a ‘general process called translation, during which the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited’ (Callon 1986, p. 203). Such negotiations are an on-going process when different actors encounter each other at project interfaces, and they are not always without conflict and can lead to considerable frictions between those actors. However, if such frictions existed, which is highly probable, then these stories of conflict remained disguised to us during our research – it seemed that the farmers still had hopes for the HA-PR to continue their activities, a fact also frequently mentioned by them. It was thus not surprising if they were hesitant to openly criticise the scientists. In addition, the political context at that time was not conducive to such open criticism of actors representing a government institution.

Our findings resonate with the literature about interfaces and power relations between different actors (Foucault 1980; Jasanoff 2004; Long 2001, 1989; Mosse 2005): interfaces not only shape personal relations, but are also
where (hidden) transcripts (Scott 1990) are expressed, goods are exchanged, promises are made and (not) kept (Long 2001; Mosse 2005). Networks between actors of different nature emerge, as access and power are negotiated, as scripts change and the role of technologies is re-inscribed in different ways in the overall script of a project. The participatory process in AR4D projects like the HA-PR is an important and crucial step towards developing a better understanding of social worlds and different drivers of change in rural, agricultural communities. However, as the complexity of interactions, the constant negotiation of access and power, the impact of social worlds on scientific experiments, the shifting perception of technologies have shown us in the HA-PR, this process is not over after the first decisions. Moreover, it is a continuous process of shifting and changing power, technologies and access in AR4D projects, often unnoticed by scientists leading such projects. Constructing facts is a collective process (Latour 1987), and through producing and distributing knowledge and technologies power is exercised between different actors (Foucault 1980; Jasanoff 2004). This is central to the literature on STS and resonates also in the work of Akrich and her colleagues on ANT. Actors in an ANT sense are the designers respectively the scientists in the HA-PR. The ‘integrated watershed management approach’ is an actor that emerged during interviews with HA-PR scientists and project documents. Furthermore, the seed potato technology is another important actor in the network constructed by the HA-PR. Part of the network are the farmers who participated in the HA-PR, and actors associated with them like their social rules and institutions.

We found ANT in general, and Akrich’s theory on scripts specifically applicable in describing what happens when farmers and scientists meet in a watershed management project. ANT opens a potential for looking at AR4D from a new angle. It helps us to understand the multitude of actors in a network constituted by AR4D projects, both animate and inanimate, and how they exert power and influence over both farmers and scientists in often subtle but effective ways. We can understand the consequences of these impacts much better if we grasp the complex relations of theories, assumptions, methodologies, technologies, social institutions/norms/rules, experiments and objects, and documents like scientific publications, reports, project documents, etc. (Detel 2001) that constitute the actor-networks our work is embedded in. Moreover, we are then able to understand where power is exercised through producing and distributing knowledge and technologies (Foucault 1980; Jasanoff 2004).

Yet, ANT has frequently been challenged for its legitimacy, even by Latour himself, one of the main founders of ANT (Latour 2007; Tresch & Latour, 2013). Other authors claim that ANT is too symmetrical and horizontalist (Mills 2018), and that it lacks sufficient political critique (Alcadipani & Hassard, 2010). Den
Satz verstehe ich nicht ganz; issues of access and power are not always emerging functions of this interaction, and often have their roots in previous interactions, existing conflicts and marginalization. These can however be negatively reinforced if scientific projects enter societies like the community of Galessa Koftu. Therefore, these aspects need to be considered additionally and warum die should formulierung not be neglected in further analysis.

5. Conclusion

The goal of this paper has been to understand how the introduction of technologies has interacted with the lives of people, and to highlight the potential and limitations of applying STS to AR4D. STS helps us to understand an AR4D culture of science and to recognize its own symbols, metaphors and epistemologies so that they no longer become barriers when negotiating with farmers.

Although there has been a process of re-thinking in AR4D that has led to more people-oriented approaches, scientists are still facing constraints in transforming AR4D to correspond to its definition as client-responsive, contributing to wider development objectives, and being participatory and system-oriented across disciplines and institutions (Verschoor et al. 2006). Unlike other disciplines in other contexts, AR4D needs flexibility to define research goals together with farmers at the beginning of the project rather than starting the project with already defined research goals. The possibility to re-inscribe their own vision into the project is essential for the users (Akrich 1992) – if they are involved in the original design, this re-inscription that usually takes place later on may no longer be necessary, thus making AR4D projects more relevant, more efficient and more successful and sustainable in the end. However, we will fail, as suggested by Akrich, if we assume that the technology works, even if it keeps on failing. A continuous honest and open dialogue between designers and users throughout an AR4D project is required. This dialogue will also test to what extent an AR4D project can balance the needs of research and development: scientists cannot replace extension agents, but in AR4D they can also not detach themselves from the needs of bringing practical benefits to communities. Involving farmers in the design, implementation and further development of an AR4D technology requires close follow-up and building up of expertise among farmers to respond to emerging technological challenges. To enable the repeated interactions and field exposure this requires, it is advisable to lessen the number of technologies introduced in one project, and to focus more on the process of adaptation of the technology to something that fits farmers. At the same time mechanisms to avoid the deliberate exclusion of some community members by powerful actors who hijack project benefits for themselves need to be in place. Applying STS and a more anthropological approach would also assist
to disaggregate farmers from a lumped group to individuals to better understand how to make technologies work for them.

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