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What is technography?

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ABSTRACT

Technography has recently been proposed as an interdisciplinary methodology for the detailed study of the use of skills, tools, knowledge and techniques in everyday life. This paper argues that technography is a useful methodological approach for the integrative study of social–technical configurations. Technography focuses on how teams or networks of farmers, technicians and engineers, amongst other actors, solve problems. The key characteristics of the technographic approach are discussed, using examples drawn from agricultural production. The concept of performance helps to distinguish technography from some common agronomic as well as social science approaches to technological change. We conclude that technography, which is basically a methodology, needs to be complemented with a social analysis of concrete political, economic and cultural processes that co-evolve with technological change.

1. Introduction

Farming integrates the technical dimension (such as what kind of soil tillage practices reduce soil erosion) with the social and economic dimension (such as how farmers mobilize and maintain a workforce or select crops according to market conditions). While we know how to research each of these areas separately, there is little consensus about how to design research that integrates biophysical processes and the social determination of technological practices. As a contribution to the discussion on integrative approaches, this article explores one specific approach, namely that of 'technography'. Technography evolved as a compelling methodological framework in the Technology and Agrarian Development research group of Wageningen University (that aims to foster interdisciplinary research in the agricultural, food and environmental sciences). It may be seen as an addition to, and to a certain extent overcomes some of the shortcomings of, other approaches to interdisciplinarity such as system theories [1], participatory approaches [2,3], and action research [4; in this issue].

At its simplest, technography is an ethnography of technology. The term technography is derived from that of 'ethnography', used in the social sciences to account for the detailed description of human × human interaction. Accordingly, technography can be regarded as a descriptive social science of technology that examines human × machine/tool interaction. (We shall qualify this simple formula below by paying more attention to skill and technique). Its principal aim is to facilitate research into the shaping, use and impact of technologies in concrete social situations. We outline the core elements of the technographic approach by using examples drawn from the field of agriculture and food production.

This paper intends to contribute to the discussion about how to design research on technology, broadly defined as the use of skills, tools, knowledge and techniques to accomplish certain ends. In common parlance the term technology generally refers to modern technical objects or artefacts that result from the practical application of scientific discoveries. In the field of technology studies, however, there are many other definitions of technology that are beyond the purpose of this paper to review. From a technographic perspective, we argue that it is primarily the artefact-*in-use* definition that requires explanation and therefore the principal focus of research needs to be on the processes, knowledge and skills that are involved in technology understood as the *human capacity to make* [5].

The paper enters into a discussion with the work of Richards [5–9]. The paper starts by drawing on a case study of technological change in asparagus farming in the Philippines to identify some of the research questions involved in the development of an integrated approach. In a rejoinder to Richards' work, we then discuss three dimensions of technography (Section 3). The paper argues that the notion of 'performance' as introduced by Richards [6,7] should be seen as a key concept that fills an important gap in the study of society and technology. Section 4 presents some unresolved methodological issues. Section 5 discusses the connection between technography and the study of the impact of the wider society on the development and use of technology. We make the point that technography needs to go beyond internalist explana-

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tions in which causal relationships are inferred only from bounded configurations of knowledge, skills and techniques. Finally, Section 6 situates technography within some key debates in the social sciences. We conclude that technography, if integrated with a social analysis of concrete political, economic and cultural processes, enables us to advance causal explanations of the dynamics of technological change.

2. In search of an integrative methodology: the example of asparagus farming

In this section we aim to identify the kind of research questions that an integrative methodology requires. We do so by commenting on a study carried out by Vellema [10,11] who explored the forces and processes underlying the improvement of quality in asparagus (*Asparagus officinalis* L.), The case involved Philippine farmers growing asparagus for export to Japanese markets under contractual conditions set by a global food company. Asparagus is particularly difficult to produce in the humid tropics because the high temperatures tend to result in the tips opening before the spear has reached its required length, and the spear diameter often suffers owing to a shortage of assimilates. The quality of the asparagus spears varies with temperature, with the availability of soil nutrients and soil moisture, and with the hour of harvesting, as the tips easily open in the sun. The variety UC157 that was planted was sensitive to high temperatures, leading to an early opening of the tip and, consequently, was judged to be of lower quality. The agronomic performance of UC157 was held by the company to be satisfactory, although new varieties were being evaluated. The company prescribed how farmers had to apply a rest period between harvests so that the plant can recover. By rotating rest periods between different groups of farmers, a continuous supply of asparagus was guaranteed.

Soil nutrients and water availability depend on the location of the asparagus crown in the bed, which was influenced by how farmers managed weeding. For example, when using a plough for weeding, the crown could end up inside the bed where there are less nutrients and less water. Many growers nevertheless used ploughs rather than weeding manually as the expansion of the asparagus scheme meant that growers had to compete for labour. Some aimed to attract workers by introducing a piece rate system, with additional payments on top of daily wages. Hence, quality and weeding were related through labour management.

Initially, the company delegated all farming tasks, including labour management, to the contracted land owners. However, concern about the quality of the asparagus tip and the marketing strategy in Japan led the company to remove responsibility for some tasks from the contract growers and to implement new practices proposed by its research department. The quality problem meant that a significant number of growers faced a deteriorating financial situation. Growers also faced problems of decreasing productivity and rising production costs. However, specialized company managers and researchers tended to overlook differences between growers when they introduced generic measures, performance assessment in decision-making about terminating contracts, and stronger supervision. It fell to a technician to translate the company's prescriptions to the diverse field practices. Growers did not readily accept the new harvesting practices prescribed (one harvest per day instead of a morning and an afternoon harvest) and discussed the consequences, risks and nature of the quality problem with company technicians.

This article does not aim to provide a detailed description of all the elements and interrelationships that make up this particular case but rather to use this example to highlight an interlinked set of research questions. In his research, Vellema reviewed the social science literature on contract farming from different perspectives, such as political economy, e.g., [12–14], and new institutional economics [15]. These perspectives focus on analysing the effects of contractual arrangements on the decision-making by farmers, whether they considered them to be negative or positive. Overall, Vellema found that the social science literature pays too little attention to actual farming and management practices and to the local capacities to deal with transnational corporations and contractual arrangements. On the other hand, the technical literature, while providing insights into the natural conditions for asparagus growing, fails to explain why farmers, technicians or company managers prefer one set of growing practices above another. In other words, the quality of the asparagus is not the linear result of single agronomic measures but is co-determined by specific labour processes embedded in social relations.

In order to capture these multiple determinations an integrated methodology is needed that combines natural and technical conditions and processes (soil fertility, water supply, and sunlight) with social ones (labour availability, global market strategies, power to control the labour process). Richards considers technography to be basically an eclectic methodology since "no single methodology will provide insight into all the entities and their interactions" [8]. Approaches have to be derived from biosciences and social sciences. In other words, technography is always methodologically plural [77; in this issue]. In the asparagus study a number of questions arise that can be ordered into three groups. Firstly, there are questions about what farmers, workers and technicians actually do to create the best growing conditions for asparagus in a given situation. How do they perform the different tasks and what is the outcome? Secondly, there is the issue of the basis on which decisions are made. What knowledge is being used: the farmer's knowledge of field conditions, the technician's knowledge of cultivating practices and yields on other farms, or the company's expert knowledge about the shelf life of particular varieties in Japan? How does the co-ordination between the different knowledge bearers take place? How are the different goals of workers, farmers, and the company transformed into a single goal? Are alternative views on how asparagus can best be cultivated excluded? Finally, which rules and routines become institutionalized in the contract and the contract farming scheme. How do these rules about how asparagus should be cultivated come into being and how are they enforced? Below we discuss each of these three dimensions.

3. The three dimensions of a technographic study

3.1. Making

In the case study we observe that the quality of the asparagus spears depends on the field practices of contract growers to whom the company had delegated the task of creating optimal growing conditions. On the farm, growers and labourers combined skills, tools, knowledge and techniques to establish quality. In order to understand quality, the research had to integrate material and technical aspects (such as soil fertility, water supply, and sunlight) with social ones (such as labour availability, the selection of technical recipes and the management and control of the labour process). This can be illustrated by the ways farmers managed weeding. As mentioned above, the growing competition for labour meant that many growers used ploughs instead of manual weeding. Ploughing had unintended consequences for quality. First, the high beds imply a mobile soil and the beds eroded quickly after heavy rains. Second, the asparagus crowns began to float in the high beds, and their roots became exposed. Third, the crowns that had little contact with the topsoil found it more difficult to take up nutrients. Fourth, the reduced volume of soil available for the crown became easily heated and the high soil temperatures resulted in thin spears. Quality as an outcome cannot be reduced to component parts, e.g., soil, sun, labour or market. The study of quality requires not only a detailed description of the agronomic features but also of the many different elements, both technical and social, that interact to form a new whole.

We argue that this is the dimension of making or doing. Following Richards, we call the study of this dimension the study of 'performance'. Research within this dimension may start with a description of the material and social circumstances of technological practice and their relationships. This step coincides with approaches to social–technical configurations that describe technology as a configuration and articulation of actors, actions and materiality [16], and to descriptive actor–network theory (e.g., [17,18]). Technography pushes the research frame a little bit wider by drawing attention to performance, situated action, and embodied knowledge.

Richards (P. Richards, personal communication) makes a distinction between his approach to technology studies and approaches that explain the outcomes of technical change from the properties of the artefacts themselves (see also Glover [19]). He also makes a distinction between his approach and approaches that only examine the social and economic effects of artefacts. For example, many studies of the Green Revolution – the introduction of high-yielding varieties responding to higher input levels – measured direct effects like productivity, or more indirect social effects like the impact on livelihoods, social differentiation, and gender relationships [9]. In other words, these studies emphasized the social, economic, political and ideological drivers and effects of technological change [20,21]. Richards has argued that a one-sided emphasis on the social shaping or impact of technology may overlook the role of objectives at the moment of use.[1]

A research focus on objectives is based on the premise that it makes little sense to talk about technology out of context. An axe in the hands of a forester standing before a tree that has to be felled is a different tool from an axe in the hands of a confused lover whose partner wants to break up the relationship. Technography is about how and why the use of technology serves human purposes and shapes everyday life. The *technology-in-use* and the associated objectives co-determine the material and social outcomes rather than the properties of a tool as such or the process of its earlier (scientific) making. This raises the question of how to study objectives.

The study of objectives can take one of two directions. It can either start from plans and intentions or from situated actions [22]. According to Suchman [22] the more common-sense approach is to view plans as a constituent of practical action. Indeed, in many discussions of agrarian technology, machine and input users are considered to work according to clear intentions and plans. Suchman, however, has eloquently argued that plans are "constituent as an artefact of our *reasoning about* action, not as the generative *mechanism of* action" ([22]: p. 39; emphasis as in original). Suchman introduced the term *situated action* to argue that "every course of action depends in essential ways on its material and social circumstances" (p. 50). "(A)n action's course cannot be predicted from knowledge of the actor's intent, nor can the course be inferred from observation of the outcome" (p. 34).

Technography as discussed here concurs with this idea and understands technology as situated action. It is not only the intrinsic characteristics of tools and artefacts that form the basis for explanation but the process of using them to make something. This also applies to the study of the design and making of tools. Hence, technography is in essence a processual approach. Richards' discussion of performance [6,7] corresponds with this notion of situated action. According to Richards, agronomists with an interest in farmers' knowledge of intercropping have been looking for the 'combinatorial logic' in intercropping. "But this is to confuse intention and result, to misunderstand what has *happened*" ([7]: p. 67, emphasis as in original). Instead, farmers in Nigeria compensate for the effects of poor rainfall by subsequent replantings using different seed mixtures, with sometimes more back-up and insurance crops. Crane [78] describes how farmers in Mali plant both millet and sorghum in one field and only decide mid-season, depending on the rainfall, which one to eliminate. It seems more appropriate to conceptualize these practices as 'sequential adjustments' to unpredictable conditions rather than as a combinatorial logic. Rather than thinking about intercropping as a plan, Richards argues that it is better viewed as performance, thus inviting research that studies the performance skills and performance knowledge that underlie farmers' capacity to adjust to unpredictable and shifting conditions. Instead of looking at how social and material circumstances *determine* courses of action, it examines how actors effectively *use* what is available to them [22].

In his discussion of performance and technology-*in-use*, Richards introduces a specific element, namely the field of 'knowing how', which is different from the more commonly adopted approach of 'knowing that' (as when the researcher asks respondents what they know). 'Knowing how' refers to those skills that are often difficult to transmit by theoretical instruction but are a basic constituent of many of our practices, e.g., learning how to repair cars without instructions from a manual [23]. To use a classical example, it is difficult to teach somebody how to ride a bicycle by mere verbal instruction. The co-ordination of the very minor movements needed to ride a bicycle can only be learned in practice. That is also why in many university curricula there is still a lot of room for practicals or learning by doing. For example, virology students need to practise for a long time before they are able to prepare a specimen that can be examined under an electron microscope.[2] The methodological challenge is how to observe and analyse this kind of 'knowledge how' since it is not so easily expressed in words.

This importance of 'knowing how' is one reason why technography does not rely solely on interviewing but reopens the space for observation. Technography as the study of performance and situated action starts with the careful observation of activities such as producing food, navigating a boat, repairing cars, making music or hunting whales. Methods consequently emphasize observation and doing (participation) rather than relying on interviewing. It is the process of making and doing itself that is the starting point for research, rather than the intentions before the act or the rationalizations thereafter.

3.2. *Distributed cognition*

When carrying out a technography it often appears that no single respondent has complete knowledge of all the steps involved in a specific process of making. For example, in the asparagus case study, handling quality problems involves the division and co-ordination of tasks and competences in a corporate structure. Initially, the company delegated all farming tasks, including labour

[1] Richards has labelled this distinction as a difference between *object-oriented* studies of technology and *objective-oriented* studies of technology, with the technographic approach underlining the importance of the latter. We consider this labelling to be unhelpful since it suggests that impact studies never take objectives into consideration, whereas, for example, many political–economic studies have looked at how technological change is driven by the strategic objectives of powerful actor groups. On the other hand, technography itself is interested in the material properties of the object.

[2] Downey [24], in discussion with Bourdieu, introduced in this context the notions of 'embodied knowledge' and 'practice without theory'.

Table 1
Some typical research questions in the three dimensions of technography.

1. Making	What is the use of skills, tools, knowledge and techniques in the process of making? What do the use of skills, tools, knowledge and techniques result in (what is being made)? What human purposes shaping daily life are accomplished in the process of making? What are the responses of actors to unpredictable and shifting conditions? What sequential adjustments and improvisations are visible in situated action? What material/natural elements create conditions for human behaviour and social organization? What shapes the selection of actors involved in (or excluded from) the process of making?
2. Distributed cognition	What task-related knowledge is transmitted in a group or network through time and space? What organizational structure and culture are shaped by the contents of the task? What co-ordinates or orchestrates the skills, tools, knowledge and techniques that are distributed among different actors? What excludes or includes bearers of skills and knowledge from team performance?
3. Construction of rules	What rules, protocols, routines and rituals lead to or follow from task specialization and skill-based association? What modalities of risk management, dispute resolution, and selection shape problem solving and performance? What rules and routines enable organizations to work at distance? What are the conditions under which actors are included in specialized, skill-based association?

management, to the contracted land owners. Later, complaints from the Japanese market concerning the quality of the tip challenged this division of tasks. In the early stages of the contract farming scheme, the farmer/landowner hired workers and together they were responsible for the quality of the spears delivered to the company's processing unit. Technicians, a distinct group within the company, were then charged with the task of translating the company's expert prescriptions to the heterogeneous field conditions. This type of asparagus production can only succeed if the knowledge and skills of all these different actors are mobilized and co-ordinated effectively.

Bringing different types of knowledge together is not necessarily a smooth process. In the asparagus case, growers exchanged views with neighbours on the technological competence of the company. They did not readily accept the new farming practices prescribed by the company's technical management and discussed with technicians the financial consequences, risks and also quality problems they perceived. The growers' associations, initially created to arrange access to credit, formed a platform to exchange ideas and experiences related to production problems. Technicians skilfully mediated between contesting views on good cultivation practices. They developed a brokering role that emphasized the mutual interest of both grower and company in ensuring the quality of the crop.

Bringing different types of knowledge together is often seen in terms of a communication problem between disciplines. Technography, as proposed by Richards, aims to go beyond this position. This is clearly seen in the interest shown in the role of distributed cognition, an interest that is derived from previous research on task groups. The second set of questions in Table 1 concerns the connection between materials, machines and processes on the one hand, and people, task groups, and divisions of labour in organizations on the other. These questions address the tasks performed, their distribution and grouping, and the flows of task-related information. McFeat [25] related the anthropological interest in the structures and cultures of small groups to performance by using the concept of a task group. Task groups are set up to accomplish ends, they are purposive, and they organize and co-operate in order to solve problems [25]. Task groups are particularly innovative shortly after their formation and thereafter maintain a sense of mission and core messages [26]. This makes it possible for new generations entering the group to maintain the group's purpose even when the original members have resigned. Within social science research on large bureaucracies, task groups have received relatively little attention. One aspect of task group studies may be of particular interest to technography. A feature of task groups is that cognition is seen as group work rather than taking place within individual brains. This raises the question of how cognition is distributed in task groups (or among wide networks of task groups) [18].

For many tasks cognitive capacity is distributed among numerous individuals and instruments. Hutchins' study [27] of the 'sea-and-anchor' navigation process aboard a USA warship portrays a team that knows how to accomplish something, even though each member of the team only knows his/her part of the objective. Yet even though no single person has an overall picture in his/her mind, the ship moves forward safely. This notion of distributed cognition can be observed in many social–technical configurations.

Thinking in terms of distributed cognitions raises new challenges for research and practice. Richards et al. [18] discuss the consequences for the learning processes. Classical approaches, such as the Training and Visit system used to expand the Green Revolution in Asia, and also Farming Field School type of IPM training, are predominantly structured around a form of 'supervised learning' in which external expertise shapes the introduction of new technologies. The underlying principle here is that of individual learning. The notion of distributed cognition, however, suggests that unsupervised learning, where there is no central control of what the network learns, may also take place. This defies the conventional idea of individual cognition. "Memory and knowledge (e.g., patterns of categorizations) are distributed properties rather than properties of individual agents" ([18]: p. 202). This implies a shift in focus from learning by individuals to learning by configurations of actors.

Besides these implications for learning processes, distributed cognition also poses tremendous challenges for research methodology. Interviewing is generally biased towards collecting data on the individual knowledge of respondents. Distributed cognition, however, requires a basic shift towards gathering data on emergent knowledge in a network. It follows from the discussion above that distributed cognition cannot simply be seen as an aggregate of people's individual knowledge. The concept of distributed cognition has been introduced above in relation to co-ordinating task groups. The research challenge further increases in situations where there are no clearly defined task groups but only more diffuse networks. We are inclined to think that it is possible to study the presence and importance of distributed cognition in such settings, but research in this field has yet to be developed.

3.3. *The construction of rules*

Asparagus production involves more than the proper watering and fertilizing of plants. The asparagus case study [10,11] describes a period when quality problems led to the deteriorating financial position of a significant number of growers. Growers also faced problems of decreasing productivity and rising labour costs. Another task group, the administrators, were given the task of computing the performance of contracted farmers and became increasingly important in the daily practice on the farm. Their financial figures were used to inform managerial decisions on terminating contracts or taking over responsibilities from individual farmers. This more hierarchical modality of decision-making placed established working relationships in the scheme under pressure. Up to this point, growers and technicians had teamed up in 'trial and error procedures' for achieving quality. Now, company management began to remove tasks and responsibilities from contract growers. In order to secure projected productivity levels and to guarantee quality levels, the company placed more confidence in new practices proposed by its research department. Professional quality managers from Japan devised rules on quality and consistency that were spatially and institutionally remote from farming practices on the ground. In responding to these demands, company managers and researchers increasingly overlooked the existing diversity of performance in cultivation and labour management practices in the asparagus fields. They introduced generic agronomic measures, a financially driven performance assessment in decision-making about terminating contracts, stronger supervision, and the transfer of tasks from farmers to technicians and company managed teams of hired agricultural workers. These shifts, which arose from the search for a high quality asparagus, opened up a whole new series of research questions on the changing rules and routines in the asparagus production process. These questions concern both the introduction of new formal rules set by the company, as well as changes in the existing informal rules that had been developed jointly by the technicians and farmers.

These questions refer, in fact, to the role of institutions. Institutions, or sets of enforceable rules, have attracted an enormous amount of attention over the last two decades, particularly since economics aligned with the continuing anthropological interest in institutions [28] to tackle the problem of co-operation [29] and collective action [30,31]. Technography contributes to the large body of literature studying how sets of rules order social actions and practices [32] and assessing the importance of institutional failures in explaining agrarian conflicts [33]. The contribution of technography may lie not so much in how institutions, seen as rather external sets of rules, impact on actors but more in how groups of actors use, construct or transform sets of rules in the process of making.

Of interest here is that technography goes beyond conventional descriptions of groups, such as kin, class, ethnicity and gender, and pays particular attention to specialized, non-localized organizational forms united by some kind of craft and skill-based specialism. This could be, for example, a group of auditors monitoring and certifying the compliance of farmers with the practices stipulated in codes of conduct. Such organizational forms tend to be governed by professional associations that develop their own internal regulations or guidelines for good practices. These associations tend to determine who can construct a house (architects), cure people (medical practitioners), sell pesticides (agronomists) or certify organic farmers (accredited certifying agencies). A technography explores the role of rules, protocols, routines, and rituals within these professional associations as these affect technology use and innovation. It examines empirically the extent to which professional associations have the ability to transform the world in a way that more closely approximates their abstract models [34]. Such models are found in specialized journals, manuals and trainings, or accreditation procedures. Making a technography includes the description of values, modalities of risk management, modes of dispute resolution, selection of preferred practices, and interpretation of political mandates associated with skill-based organizations [8].

A technography may also study how such professional associations work at a distance by setting and enforcing standards. Such standards impact on technological practices outside the expert settings (e.g., the professional associations) in which they were developed. A body of literature is emerging on how to carry out studies on standards [35–41]. The contribution of standards to social life is often invisible even though they are currently proliferating. In most cases, standards do not become the subject of democratic debate. The general line of argument from technography is that instruments such as standards, rather than being taken as neutral because they are backed up by science and expert networks, can be examined for the way in which they are socially shaped (e.g., why they are designed, whose interests they serve), for their social requirements for use (e.g., what is required for standards to be implemented) as well as for their social effects (e.g., what impact do standards have on people's lives).[3]

3.4. A schematic presentation of the three dimensions

The discussion above is summarized in Table 1 into three sets of research questions that typically inform technography. The rows in this table represent the three issues examined above: (1) making, (2) distributed cognition, and (3) the construction of rules and routines.

4. Unresolved methodological issues

This section discusses some unresolved issues that often recur when discussing this methodology. The first issue concerns how much description of a social–technical configuration and its processes and actions do we need? Presumably, such configurations may be very spatially extended. For example, the asparagus chain discussed earlier ranged from the fields in the Philippines to the shelves of the Japanese supermarket. And do we only record what people do (their activities, tracing prices, counting field visits) or do we also examine what Geertz [43] has called the 'multiplicity of complex conceptual structures' which would involve, for example, noting incoherencies in farmers' views, suspicious evasions by respondents of specific questions, and tendentious commentaries by one actor about another? For Richards the systematic description of technologies and situated action is not necessarily a 'thick description' [44], even though technography builds on approaches such as ethnomethodology [22] and anthropology [45,46]. Rather than lengthy reproduction of narratives and symbols and the reconstruction of meanings in these narratives, Richards considers a 'thin description' of teamwork, documenting the details of performance, to be sufficient in most cases to ground a sociology of teamwork. However, this still does not solve the problem of how detailed the data collection and description have to be.

A second issue that deserves attention concerns the role and kind of logic in respondents' representations of technological practices. Rejecting views that labelled smallholder farming as traditional and backward, anthropologists and agronomists have come to emphasize the inherent rationality underlying farmers' knowledge and activity [47]. This is a very valuable shift as it demystifies the role of scientific experts and increases the common stock of knowledge on farming. The downside is its neglect of the role of performance. Richards' concept of performance coincides with Bourdieu's theory of practice. An example may help to explain Bourdieu's critique of attributing a priori rationality or logic to actors such as farmers. Using ethnographic methods, Jansen [45] investigated farmers' knowledge about the influence of the moon position on the growth of plants in Honduras. Among respondents, Jansen identified at least two different local representations of moon phases and its supposed effect on agricultural activities. The researcher's questions implied a linear, continuous time, in which there is a sequence of moon phases logically connected with agricultural activities and expressed in plant growth. Consequently, the answers of the respondents were, to a certain

[3] This division of the social dimensions of technology into social shaping, social requirements for use, and social effects has been adapted from Mollinga [42].

extent, similarly theoretical, i.e., the farmers made limited reference to practice but answered how (in theory) 'planting with the moon' relates to crop development. Bourdieu [48], in developing a theory of practice, warns against the kind of scholarly approach and mode of reasoning that predominated in Jansen's analysis. In contrast, Bourdieu points to the fuzzy logic that is present when people talk about the agricultural calendar. When reviewing the data on Honduras, such fuzzy logic was clearly present if, at the time, unnoticed. For example, many farmers said that one had to make sure that the moon was in the right position when planting a fruit tree and that this is what they did. But they tended to disagree about what the right position of the moon was. It is precisely this vagueness of responses and these contradictions in people's views that are polished away when building a theoretical model. Jansen had not fully realized that this fuzziness performs a role in, or is even characteristic of, everyday agricultural practice. As Bourdieu argues: "One thus has to acknowledge that practice has a logic that is not that of logic." ([48]: p. 109). Farmers did not need the type of logic emphasized by researchers in the Honduras study to make daily decisions about planting with the moon.[4] But nevertheless, considering moon phases was part of their agricultural practice. One challenge when researching agricultural knowledge is to retain some of this fuzzy logic in the presentation and analysis of data. This fuzzy logic seems to be inherent to situated action but it is difficult to account for its role.

The discussion of fuzzy logic, the discomfort with the anthropological fascination for thick description, and an emphasis on observation relative to interviewing, converge with Richards' position that we should not overly rely on studying symbols and meaning at the expense of the study of organizational data on how groups function [44]. Rather than asking people what they feel and think about something, in order to search for meaning and interpretation, Richards' technographic approach observes what people do within social groups and builds hypotheses about underlying reasons. This approach that social agents "do not act without reason" ([50]: p. 75), does not substitute a rational choice approach or methodological individualism for social and cultural theory. As Bourdieu [50] has argued, the identification of reasons is not based on the assumption that reasons are what direct, guide or orient the actors' actions. "Agents may engage in reasonable forms of behaviour without being rational" ([50]: p. 76, see also [1,51]).

In terms of methods, Richards may expect too much from observation. Observation of doing/making may not cover all aspects of *why* people do something. Answers to this 'why question' may not always be derived from observing the act itself. As we have seen, different people may do the same thing – e.g., use a particular technology – for very different reasons. These reasons are important if the analysis is 'objective oriented'. The skills needed by an asparagus farmer to plant asparagus may not be much different from the ones needed by one of his workers, but the objective of particular choices, such as depth of planting or planting distance, may be very different. The challenge of technography is to balance the study of practice with the study of interpretations without tilting the analysis back to foundational symbols and meanings as conceptualized in more idealist/constructivist approaches. This has practical consequences for methods too; most research situations may benefit from combinations of observing and interviewing. An interview is not simply an instrument to collect factual data or to reconstruct interpretations, perceptions, and meaning. Instead, it is also, or even more so, a method to test hypotheses about reasons or causalities with respondents. Interviewing is, in fact, theory building with respondents [52].

5. From methodology to theory: societal choice and reflexivity

Previous sketches of technography (e.g., [8]) have addressed a delineated field primarily by describing the processes within social–technical configurations. In our view this falls short of detecting specific types of causal mechanisms and processes present in the wider social fabric. Accordingly, technography needs to be complemented with more substantial social theories. It is impossible to review the range of social science theories on offer in a single short paper. Here we do no more than give some hints and leave it up to the researcher of a particular case study to connect technography as a methodology to a more substantive explanatory theory of society × material interaction.

Throughout his work on technology × society interactions Richards has consistently defended and developed a neo-Durkheimian approach in which he traces causes by entering the world of organization and belief [5,9,33,53].[5] Material × society interactions are not simply governed by ends-oriented activities (as studied by engineers and economists) but are, in many instances, regulated by ritual action [53]. Rituals serve to link social commitments to practical activity directed towards material ends. In more rural societies, farmers' agricultural calendars are full of dates marking religious rituals. In so-called 'modern' societies, enthusiasm or 'collective effervescence', for new machines, crops and varieties is generated in ritualized annual fairs, exhibitions and farmer competitions.[6] The theory of ritual agency can be seen as an example of a more substantive theory. The need for coupling technography to substantive social theory can be further illustrated by examining two ways of conceptualizing the links between the wider society and the as yet more narrowly defined technography (the shaping of material transformations, distributed cognition and rules): namely societal choice of technology and societies' reflexivity on the unintended consequences of technology.

Societal choice of technology refers to the intended or unintended selection of technologies by the wider society. The question of how technologies are selected opens up a space for explanations that take into account the economic, political, social and cultural power dynamics of agrarian change [58]. In this perspective, societal choice is not seen as the outcome of aggregate individual preferences but as emerging from many different processes. As a first heuristic step, research may look at which particular parties and interests are mobilized around change or adherence to specific technologies. For example, Kloppenburg's study [59] shows how a tandem of political forces and life science companies was decisive in promoting a hybridization paradigm in plant breeding. However, power can also be analysed at a more structural level than a mere instrumental approach that links political economic

[4] This fuzziness or illogicality is not exclusively a characteristic of illiterate people. Nor are scientists averse to using fuzzy abstractions. One example is the fuzzy use of the concept of sustainability by scientists. In fact, it may often be rather practical *not* to spell out the precise definition of sustainability. In meetings with people from diverse social groups (e.g., other disciplines, or non-scientific social actors) it would otherwise become impossible to reach agreements. It is precisely the pragmatic acceptance of different, contradictory meanings attributed to a term like sustainability that helps to make interdisciplinary activity possible [49].

[5] Richards has built his approach to technography on the French tradition, starting with the work of Marcel Mauss, a student of Emile Durkheim, who developed a descriptive social science of technology [54]. In the French approach a distinction is made between the action and the artefact/machine/tool. Technology is then seen as the study of or knowledge about this action. This action, including the necessary skills, is then labelled as technique [55]. Richards' programme to develop a consistent application of technography stands in contrast with other rather cursory uses of the concept (e.g., [56]).

[6] Richards [53] has pointed out that modernity is blind to its own rituals and considers ritual as marginal without, however, being able to refute recent theory of ritual agency [57].

interests to individual actor groups. The final selection of technologies cannot be reduced to the particular interests of one of the actors, but results from a dynamically shifting balance of powers between ranges of social actors. This can be seen in the construction of powerful narratives about how to regulate pesticides, which cannot be traced back to individual economic interests [60]. In the asparagus case it was relevant to study how the terms of the contract and the company's surveillance procedures affected farmers' ability to perform. Research on the relationship between performance and power raises the question of who controls the labour process and to what extent processes of deskilling are being set in motion [61]. Technography faces the challenge of investigating the continuously shifting micro-politics of local strategies and the institutional architectures in society at large.

The second issue, reflexivity, concerns the way in which society responds to the unintended consequences of technological processes. Climate change has generated intense debate about resource use and technological practices. So there is greater reflexivity about the use of technology and its implications for climate change. Technography style of research has emphasized the need to better understand farmers' responses to seasonal climate forecasts [62]. Another example of reflexivity is the intense debate on transgenic crops. Conflicting parties have created several contrasting imaginaries of the future and developed regulatory frameworks to detect and communicate the potential effects of transgenics that have not been observed as yet [63–66]. The study of societal debates on contested technological developments and the new practices derived from these debates complement the technography approach. In other words, detailed descriptions of processes of making need to be combined with a theory-laden interest in societal choices.[7]

6. Technography and the social sciences

This demarcation of technography has implications for the position of this methodology within the wide spectrum of social science studies of technological change. This is not the place for a lengthy critical review of these approaches. Instead we devote some time to examining how technography relates to a few controversial issues in the social sciences.

Firstly, technography defies the dominant view that the social sciences and natural sciences should be kept separate. In this respect, technography is not radically new. Over the course of the history of science there have been many attempts to integrate natural and social explanations of particular phenomena and to develop a methodology suitable for that purpose. There are many instances, however, where integrative research lines have been split into two as in the division between human and physical geography or in the shifting location of anthropology departments, which today are most commonly situated within the social sciences, but in some parts of the world are still combined with fields like archaeology where more 'technical' research methods prevail. Much of the social and cultural sciences have dissociated themselves from biological explanations of human behaviour, and for some time this dissociation was functional for their development as a social science [54,69]. The general tendency for science to splinter into more and more sub-disciplines has further contributed to the alienation of social science explanations from biophysical explanations. Paradoxically, however, this same process of splitting can lead to sub–sub disciplines from two totally different mother disciplines communicating and developing joint research owing to a shared or overlapping empirical domain. Such interdisciplinary initiatives reclaim many of the concerns of earlier integrative approaches such as human–environment geography or cultural ecology [70; in this issue]. Technography as a methodology fits into these attempts to construct an analysis that crosses disciplinary boundaries and overcomes the shortcomings of a narrow disciplinary focus.

Secondly, with regard to the idealism–materialism binary (or rather spectrum), technography inclines to the materialist side. Rather than assuming that technological practice follows from ideas, it emphasizes that new ideas emerge from changes in technological practice. Materialism may refer here to rather different things such as matter (e.g., soils and their properties, characteristics of plant varieties), to making and doing (sowing, weeding, breeding, meeting), and to institutionalized relations of production (e.g., land tenure systems, division of labour). Technography starts by building explanations that lean towards the material end of the spectrum rather than towards the idealist end of meanings, ideas, and principles, though it certainly includes the latter. It is more a matter of emphasis than a one-sided focus: it first aims to understand why people do what they do before explaining what people think, feel, say or do not say.

Thirdly, technography has developed its own position in the debate on technological versus social determinism. Technological determinism would argue that what asparagus farmers do and think is determined by, for example, the natural conditions they have to work under or the available irrigation technology. Social determinist explanations, in contrast, would explain actions by reference to Philippine culture or to scientists' misrecognition of farmers' knowledge. The research strategy of technography is not to develop any *a priori* statement about whether it is nature, technology, or society that determines specific outcomes. Any of these may matter and historically they interact and co-determine outcomes. Technography considers each of these as quite distinct and they should not be conflated in any investigation. In a technographic approach the effect of soil fertility on asparagus spears and the effect of labour shortages on soil cultivation are seen as different kinds of mechanisms operating at different levels, to form a stratified reality [1]. The notion of stratification implies that material and natural strata create conditions for human behaviour and social organization but do not determine them. This implies that moral agency, social co-ordination, intentionality, normative regulation and symbolic communication are distinctive features of human social life that require distinct conceptual markers [71,72]. Reality is assumed to consist of hierarchically ordered levels where one level creates the conditions for another level but does not determine it. Research questions may remain within one level (e.g., what will be the effect on yield if 100 kg of a nitrogen fertilizer would be applied?) or involve different levels (e.g., why do farmers apply a certain amount of fertilizer?). Most research problems relating to agriculture, however, involve biophysical as well social levels.[8] Technography as defined here seeks an alternative to both

[7] This distinction is not meant to suggest that the initial domain refers to technology and this extension to society. On the contrary, technography intends to re-establish the links between technology generation and use on the one hand and society on the other. Both domains have therefore to be seen as social–technical configurations. But as Ingold ([55]: p. 322) states: "(. . .) in the course of this evolution [objectivication and externalization], technical relations have become progressively disembedded from social relations, leading eventually to the modern institutional separation of technology and society". Recently, any separation of technology and society has become the subject of substantial criticism (in fact, this is the basic premise and object of study of Science and Technology Studies, e.g., [67,32], and important parts of the Philosophy of Technology, e.g., [68]).

[8] Here we do not analyse in detail the differences between actor–network theory (e.g., [17]), which is currently receiving a lot of attention, and technography. While both share a common programme, they differ in their understanding of causality, the notion of power, and the idea of a stratified reality [1,73]. Describing the different elements of a social–technical system, the relationships between material and social actors is not exclusively the field of actor–network theory.

'technological determinist' or 'natural reductionist' views, in which technological changes are represented as exogenous to human society and to 'over-socialized' views that claim that all conceptions of nature and technology are symbolic constructs of one culture or other.

Finally, in the relativism–realism binary, technography adopts a realist position. In explaining the differences between the asparagus farmers' knowledge and the company's expert knowledge, a relativist position would emphasize the construction of meaning in people's minds. In this view, contested meanings cannot be tested by referring to a real world outside knowledge.[9] Realism, on the other hand, without denying that different cultural backgrounds shape the framing of a particular issue, would raise questions about how the background knowledge of asparagus farmers is related to their past experiences with particular cultivation practices, access to land and land tenure arrangements, training and education, the stipulations in the contract, and so on. It would explore to what extent the views of company experts on optimal plant choice are rooted in their scientific training or in the commercial interest of the company. Hence, a realist approach would investigate knowledge in relation to really existing social structures and processes of socialization. The notion that people's knowledge is relative (which a realist technography does indeed assume) does not mean that the world is a figment of the imagination. There is a real world (including a social world) out there even though our knowledge about it is relative and thus fallible [75].[10]

7. Conclusions

This paper has outlined the contours of technography as a methodology. The technographic approach may be particularly useful in integrative studies. The integrative nature of technographic research involves examining material transformation, technology use and performance as a configuration of material and social elements. Technography distances itself from views of technology as single artefacts or as science-based techniques. Instead, it puts the focus of attention on skills and knowledge in the process of making things and transforming the world. It is based on theories of practice that locate creativity, improvisation and innovation in the sphere of situated action rather than in the sphere of plans and intentions. This paper discusses how Richards has enriched the technographic approach by attaching importance to the study of performance as a core element of the methodology. Technography invites researchers to examine how groups relate to the social and natural environment when performing a task, such as regulating the conditions for plant growth or processing food.

Technography, as outlined in this paper, is above all a methodology and not a substantive theory of social processes. Hence, it has to be complemented with substantive social theories, for example, on gender, class, social conflict, inequality or social justice and, in the case of natural mechanisms, with theories relating to evolutionary processes, interdependencies between living organisms, or resilience of ecosystems amongst other things. Both social and natural science are needed to detect underlying causal mechanisms. Although technography is a methodology rather than a social theory it dovetails more readily with some social theories than other. Technography's methodological collectivism as proposed by Richards as well as its materialism and realism may conflict with some contemporary social science approaches as well as common sense beliefs about the social.

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[9] Relativism has caused quite some confusion, including among agronomists. An example may illustrate this. Bouma et al. [74] state: "Different stakeholders usually have quite contrasting ideas about management and development. There is not a single 'truth'!" (p. 263). The idea that there is no single 'truth' (including the exclamation mark) has become a popular statement to characterize diversity in views. On the same page Bouma et al. write: "There is no question as to the relevance of science in this confusing context: 'true' information and an objective evaluation of issues raised are essential in discussions where emotions can run high and where particular interest groups may unduly dominate and monopolize discussions." This can be read as a fast return to objectivity after the initial relativist detour, though leaving the reader in the dark as to what is meant by the quotation marks around 'true'. How can we carry out an objective evaluation if there is no single truth?

[10] This realism does not necessarily imply empiricist realism. It is not about observing regularities in the world and directly deriving causal laws from observed regularities. Instead it is about formulating hypotheses about underlying mechanisms (which are real), but not necessarily observable (though they may be). One has to note that the premise of this kind of non-empiricist realism is that the domain of the real is larger than the domain of the empirical (the latter being that what we experience whereas the real also includes generative mechanisms and their actualization, which may or may not be experienced). A non-empiricist realism would prioritize the investigation of mechanisms and contexts [76]. Natural science creates experiments (through closed systems) in order to find evidence for hypothesized mechanisms. Whether social science can do so is the subject of debate. It is beyond the scope of this paper to discuss the role of experiments in the social sciences. A final comment: a non-empiricist realism does not mean that empirical research is unimportant. To the contrary, it is indispensable for testing the validity of hypotheses about generative mechanisms.

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