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Agricultural Knowledge Networks in Northern Ghana

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Abstract. Farmers, researchers and extension officers in Northern Ghana encounter productivity problems, such as striga, acidity, hardpan and bochaa (a Dagbani word denoting low productivity). We undertook a mainly qualitative study using interviews, focus groups and a workshop to investigate, from a science and technology studies perspective, the intersections between their different ways of understanding these problems. Different actors construct definitions of what productivity problems are during the performance of their occupations, for example through peer association and application of available solutions. Actors with different occupations thus disagree over what productivity problems are, with farmers defining them by their symptoms and researchers by the physical, biological and chemical mechanisms through which they act. Extension services have not trained officers to reconcile these identity-linked understandings, which has hitherto prevented hybrid knowledge about such problems from emerging. Yet actors agree on the utility of certain management practices, such as manuring. These have the potential to act as boundary objects, pointing to the possibility of a composite knowledge network within which different actors retain their occupational identities and discrete knowledges, yet share common solutions. Extension agents and researchers would benefit from training on the use of boundary objects as communication tools.

Introduction

The contested theme of indigenous knowledge (IK) is often referred to in contemporary literature on agricultural knowledge production (Lwoga et al., 2010; Halbrendt et al., 2014; Rushemuka et al., 2014). Although the relevance of the term has been debated, it is still used as a route in to describing farmers' use of agricultural management strategies that do not rely on formal scientific knowledge (Reij et al., 2001; Gray and Morant, 2003; Olango et al., 2014). As researchers and practitioners seek practical answers to agricultural management questions, the concept of 'hybrid' knowledge, a convergence between 'indigenous' and 'scientific' or 'expert' knowledge, has emerged in academia and practice (Vissoh et al., 2004; Reed et al., 2007; Caron et al., 2014).

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Contemporary mainstream African agricultural development is influenced by the Comprehensive African Agricultural Development Plan (CAADP) of the African Union's New Partnership for Africa's Development, within which knowledge generation is conceptualized as an expert, technical activity. Simultaneously, publications such as the World Bank's 'IK notes' have described the interaction of scientific knowledge systems with IK, showing that the concepts of indigenous and hybrid knowledge have entered the lexicon of mainstream development discourse as well as academic literature. Nevertheless, these knowledge forms still maintain complex interrelationships with agricultural research and development. For example, indigenous or hybrid knowledge may develop as a response to resource scarcity (Munyua and Stilwell, 2013), while its implementation may be limited by such scarcity (Dalton et al., 2014) or it may be ineffective for other reasons (Briggs and Moyo, 2012). Meanwhile, agricultural problems such as poor soil productivity and the parasitic weed striga (*Striga hermonthica*) persist (Sillitoe, 1998; Caron et al., 2014).

Thus, a fresh look at the limits of, constraints to and possibilities for hybrid and indigenous knowledge is valid, especially when related to such pressing concerns as striga and low productivity. This article undertakes that task. It uses local West African concepts about productivity as a vantage point from which to examine the interacting ontologies of different agricultural epistemic communities.

A focus on hybrid knowledge entails examining the knowledge construction processes of scientists, alongside other actors, and this is a central theme of science and technology studies (STS). The IK literature has intersected with STS, involving such concepts as 'boundary objects' and 'translation' – to be elucidated shortly – to reflect on the role of hybrid knowledge in agricultural extension (Cash et al., 2003). These literatures interact with questions of identity, and not only in describing how local actors construct knowledge in indigenous cultural contexts: identity is equally connected to an actors' occupation and thus the practice of their everyday professional and livelihood activities (Pickering, 1992). Agricultural extension literature has often lauded the application of hybrid knowledge, co-constructed by scientists and farmers, as best practice (Kristjanson et al., 2009; Newsham and Thomas, 2009). This article similarly connects to the idea of hybrid knowledge by using concepts from STS, such as that of boundary objects, to examine how different actors simultaneously construct knowledge about the same phenomena. What is novel is that it uses grounded data to develop the idea of 'composite' knowledge: this emerges when actors fail to co-construct hybrid knowledge, yet still share common ground.

Studies on West African indigenous agricultural practice and knowledge have described farmers' perceptions of how soil and plants interact, the amelioration techniques they implement and the ways that they come about such knowledge (Millar, 2001; Gray and Morant, 2003; Osbahr and Allan, 2003; Maayiem et al., 2012). This article is in the same vein, but takes a new case study, the northern Ghanaian concept of bochaa, as a starting point. The meanings of this word will be elaborated upon in the results, so it suffices to mention here that it encapsulates a range of states of the soil and constraints upon crop productivity. An emic concept from the Dagbani language of northern Ghana, it is an ideal entry point for this study. In the study situation there are many small-scale farmers and few agricultural extension officers, who receive little training. The extension environment is dominated by project-based approaches, further contributing to gaps in provision. Local ideas such as bochaa thus play a prominent role in the activities and everyday experiences of diverse groups of people involved in northern Ghanaian agriculture.

The article will be useful to people working on productivity problems, including striga, and those thinking more generally about soil management in the West African savanna. Its practical contribution is to show how locating boundary objects can help agricultural actors identify appropriate solutions, even while they maintain their extant occupational identities.

The article is structured as follows: it starts by describing the geographical, policy and extension contexts. An overview of relevant literature on agricultural knowledge production follows, focusing on four key concepts of agriculture as performance, translation, hybrid knowledge, and boundary objects. Following the description of methods, the results explain the formation of two knowledge networks in the study site, and the lack of hybridization between them. Finally, we identify boundary objects that hold potential for composite knowledge construction, and explore their implications for agricultural extension policy and practice.

Context

The work took place around Ghana's northern regional capital, Tamale, a city of about 440 000 people, where over half of the population is involved with agriculture (Gyasi et al., 2014). Farmers here are almost all from the Dagomba ethnic group and speak the Dagbani language. Many households are polygamous, and extended families frequently live together, in urban as well as rural settings. The main staple cereal is maize (Al-Hassan and Poulton, 2009). However, pockets of vegetable production have proliferated, including in irrigated areas close to urban markets (Gyasi et al., 2014).

The sandy savanna soils, low in organic matter (Jones et al., 2013), make agriculture challenging. Productivity is fairly low within the sole rainy season. Localized soil complications include iron concretions, hardpan and isolated patches of low pH. Low fertility contributes to striga in some areas. Around Tamale, rapid urban development exacerbates land scarcity (Naab et al., 2013). Fertilizer has been subsidized since 2009, but late supply, poor availability and transport constraints mean that farmers often struggle to access it. When access to mineral inputs is poor, many farmers try to combine inorganic and organic fertilizers within their soil fertility management strategies, although manure and compost can also be scarce. Labour is often familial and may also be accessed through work parties, compensated with cash or reciprocation.

Ghanaian agricultural policy is influenced by international development discourse and donor country initiatives. The Ministry of Food and Agriculture (MOFA) rarely has the funds to implement policy unassisted at the operational scale, and relies heavily on local and international development partners (DPs), such as NGOs, businesses and donor nations, in the extension sector. The two key guiding documents relating to agricultural policy, the Food and Agriculture Sector Development Plan II (FASDEPII) and the Medium Term Agricultural Sector Investment Plan (METASIP), both outline the public–private partnership (PPP) model preferred for extension service provision.[1] In MOFA's hierarchical extension structure, agricultural extension agents (AEAs) are allocated to large spatial areas, within which they use a transfer of technology (TOT) approach: AEAs teach contact farmers, through whom messages are supposed to reach others. Simultaneously, private sector agencies and NGOs implement their own programmes independently, or incentivize MOFA agents to act as staff, training them in the process. The study area has a reputation for being a

more agrarian, less developed region, so hosts a plethora of local and international DPs carrying out such activities. Governmental decentralization is another factor perpetuating the pluralist extension system, as local assemblies have not yet streamlined funding arrangements for independent local service provision.

Commercialization is an important theme in contemporary agricultural policy. Maize and export crops are emphasized, further encouraging PPPs related to these crops, such as the Ghana Grains Partnership. Vegetable farmers interact more with purely commercial actors such as seed dealers. Technologies, especially improved seed and fertilizer, are central to this model of agricultural development. The fertilizer subsidy to some extent reflects the integrated soil fertility management (ISFM) approach favoured by prominent DPs such as the Alliance for a Green Revolution in Africa (AGRA). ISFM emphasizes improved germplasm and mineral fertilizer, topped up with organic amendments (Vanlauwe et al., 2010). Towards this end, AGRA encourages targeted subsidies. Improved germplasm is trialled by these and other DPs within productivity enhancement and pest – including striga – management programmes. Ghana's Council for Scientific and Industrial Research (CSIR) also develops and releases such improved germplasm. The Savanna Agricultural Research Institute (SARI) is the northern Ghanaian arm of the CSIR. SARI links to MOFA through the Research Extension Linkage Committee (RELC), the coordinator of which, an agronomist at the time of writing, works within both institutions.

The strategy of involving external organizations in agricultural development policy and implementation means that a top-down approach dominates, and local knowledge plays less of a role at the strategic level. Expert knowledge generation is prioritized and externally developed technologies often become available to individual farmers through isolated projects rather than national programmes.

Within this context, the idea of bochaa acted as our entry point into a case study on different types of agricultural knowledge. We collected qualitative data about farmers', AEAs' and researchers' understandings of bochaa and related productivity problems, with the broader aim of investigating how their understandings about and management of productivity interacted. We offer our results as a resource for extension and development.

Ways of Knowing – Performance, Translation and Boundary Objects

Researchers have long moved beyond conceptualizing a dichotomy between indigenous and scientific knowledge (Agrawal, 1995), but such a distinction remains useful as a heuristic device (Gray and Morant, 2003; Ramisch, 2014). Understanding the forms knowledge takes for different actors helps elucidate how it comes into being. Richards (1989) shows how agricultural knowledge in particular can be seen as 'performance', being shaped as actors carry out everyday livelihood activities such as farming. This resounds with characterizations of IK as tacit and transferred through non-linguistic methods (Krige, 2007; Bloch, 2008). Scholars of local knowledge commonly focus on how environmental understanding, particularly of natural environments, is developed through feeling, seeing and other sensory experiences. This is plausible in situations where livelihoods are inextricably connected to ecological contexts – agriculture being one such example. Lauer and Aswani (2009) demonstrate how this is also the case for another livelihood strategy based on natural resource use, fishing in the Solomon Islands. Yet Ingold (2000) poses that, as a social process, the act of verbal demonstration is also an important mode of vernacular

knowledge transfer, even with regard to tangible natural and environmental elements such as soils. As both verbal and experiential construction of local agricultural knowledge are human processes (Munyua and Stilwell, 2012; Curry and Kirwan, 2014), they are embedded in the culture and identity of the actors concerned (Briggs and Moyo, 2012).

In a similar process to the construction of practical agricultural knowledge by farmers, scientific agricultural knowledge is constructed by scientists. The STS authors in Pickering's (1992) collection show that this again happens through the performance of an everyday occupational identity, this time of researchers. Turnbull (2000) thus considers this a process that is 'local' to scientists, making 'scientific knowledge' another vernacular knowledge form. Nevertheless, social scientists and policymakers continue to distinguish between farmer and scientist knowledge generation processes (Halbrendt et al., 2014).

Linked to the exploration of IK, work on hybrid knowledge systems has come to the fore in examinations of agricultural knowledge and extension. These systems combine farmers' and scientists' perceptions to generate solutions to agricultural challenges (Kristjanson et al., 2009; Nguyen et al., 2012). Although knowledge is reproduced in different epistemic communities through activity and performance, both scientists and farmers use words, such as 'bochaa' and 'striga', to describe phenomena, and such common vocabulary allows these different groups to communicate. Comparisons of farmers' and scientists' perceptions are especially common in studies on soil. These move from more abstract, descriptive ethnopedologies (Barrios and Trejo, 2003) to applied works (Gray and Morant, 2003; Osbahr and Allan, 2003; Ramisch, 2014).

The concept of translation, developed in the STS literature, relates to such interactions between knowledge systems. It describes the process through which actors convince each other about their truth claims. Actors 'enrol' other living and non-living 'actants' into their ideas about what is true, aiming to end up with a constellation of such actants that support a particular version of reality. Latour's (1987) development of this idea hinged on a description of how scientists make their particular discoveries real to others, using non-human devices like scientific papers and books to interresse and then enrol other humans in a certain epistemic network. Callon's (1986) classic example involves scientists using data, papers and conferences to convince fishermen and policymakers of a certain model of how scallops cling to rocks. The final step of this translation process involves enrolling enough actors into a network to 'mobilize' it, making it a collective reality. Latour and Callon's examples describe actors being translated from one network of reality to another as they are convinced of new ideas. Palmer (2016) has used the translation concept in a similar way. He describes how a network of Australian indigenous and non-indigenous actors, data, maps and other evidence was mobilized and 'sent' to Paris to convince UNESCO to inaugurate Uluru-Kata Tjuta National Park. As this particular network was itself a hybrid mix of indigenous and scientific actors, the indigenous ideas first had to be made legible to scientific bodies through a process of hybridization, and in order for that to happen they themselves were translated. To describe how this occurred, Palmer involves Latour's idea of centres of calculation (1987), showing how 'indigenous' knowledges were collected and incorporated, in a centre of calculation, into the credible or, to use the STS term, 'durable' actor network that led to the establishment of the national park. Latour introduced this model with reference to the geographical journeys early colonizers made to collect knowledge about new ter-

ritories. Palmer has also related the concept to the process of neocolonial knowledge appropriation over geographical space (Palmer, 2012).

The boundary concept is a schematic more commonly used in descriptions of knowledge hybridization (and a notion maybe more digestible than the notoriously dense work on translation). This idea connects diverse works on how objects and organizations facilitate connections between knowledge systems. Boundary objects are defined as 'plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites' (Star and Griesemer, 1989). The term has been extended to refer to organizations that perform the same role (Carr and Wilkinson, 2005). The boundary concept has been used in agricultural research: Goldberger (2008) portrays Kenyan organic agriculture NGOs as boundary organizations that forge connections between each other to present organic agriculture as a viable alternative to the technologist Agricultural Green Revolution. Within this literature, boundary objects (e.g. maps, concepts, shapes and projects) are conceptualized as being constructed and developed through boundary work that agricultural actors consciously instigate (Carr and Wilkinson, 2005; Klerkx et al., 2012; Tisenkopfs et al., 2015). The objects then go on to successfully enact translation. Less commonly are they conceptualized as pre-existing entities that are re-appropriated by the actors concerned. A question not tackled in the boundary literature relates to what happens when knowledge systems do coexist and overlap, but actors either do not attempt or fail to construct functional hybrid knowledge systems. It is therefore interesting to identify places where boundary objects already exist even though boundary work has not been performed, or where there is incomplete hybridization or only partial connection between coexisting knowledge systems.

This article situates itself within this literature on knowledge construction, using the idea of knowledge as performance to explain the processes of translation encountered in the data. Its conceptual contribution is to extend the application of the boundary object concept, moving beyond the idea of hybrid knowledge to that of composite knowledge.

Research Questions

The overarching question this work tackles is:

- How can agricultural actors reconcile different knowledges about productivity in search of solutions?

In order to answer this question, we ask three sub-questions:

- How do different agricultural actors in the study context conceptualize productivity problems?
- What are the reasons for any differences between them?
- What do their ideas have in common?

Methods

Our main body of primary data comprises 19 purposively and snowball-sampled qualitative interviews. We also collected soil samples and held a workshop. The study location, around the city of Tamale, was advantageous because it gave access

to vegetable as well as staple farmers. We contacted five AEAs through the MOFA Tamale office, purposely seeking those with vegetable farmers in their catchments. This was because we were aware that bochaa was associated with striga but also with other soil problems. Striga is a particular problem for cereal farmers, and we wanted to be able to capture data on the range of its meanings from vegetable farmers too. We asked each MOFA agent to put us in touch with their farmers. The AEAs and seven farmers were interviewed on farm. Some farmers turned their interviews into focus-group discussions, providing opportunities to collect diverse perspectives and data on the social construction of knowledge. There was no such direct link from individual extension agents to researchers, so we contacted researchers at SARI through snowball sampling from the soil science department. Selection criteria for researchers were that they needed to have some understanding of Dagbani and to have encountered the bochaa concept. We met four researchers and one of the MOFA staff attached to the RELC in their work places. We also interviewed two key informant sets, a soap-making group and a Dagbani linguist who was also the retired director of an agricultural NGO. We knew from preliminary investigations that these informants could possibly give us access to relevant data.

It was not intended to make an a priori distinction between the three occupational groups contacted (farmers, AEAs and researchers). Rather, this stratified approach was taken as the most appropriate way to access actors who commonly encounter each other in the everyday context of agricultural practice and extension in northern Ghana. Members of other actor groups who do not necessarily work permanently in the field, such as input suppliers and development workers, are also relevant. The experiences of the actors interviewed were used to elicit the influence of such others on local ways of understanding productivity.

Interview guides focused on:

- understandings of bochaa and associated productivity problems;
- management of bochaa and associated problems;
- how each actor had learnt about these problems and their management.

After the interviews, we revisited six sites in three communities to sample pairs of adjacent soils where farmers indicated bochaa was and was not present. We collected soil to a depth of 20 cm at each sampling point, and sent samples for pH, carbon (C), nitrogen (N) and phosphorous (P) analysis at SARI in Nyankpala, near Tamale. These results acted more as a prompt for discussion between actors than anything else.

Interviews were transcribed in Dagbani and English using the transcription program f4. They were organized into cases, along with photographs and notes on soil samples, in the CAQDAS software QDA Data Miner. Data analysis followed an inductive procedure. All data were coded using thematic codes. Some codes were based on the research questions. Drawing on grounded theory, others were allowed to emerge as the data was coded. These codes were grouped into categories relating to:

- plant productivity and qualities;
- soil productivity and qualities;
- management of productivity problems;
- ways and places of learning;
- non-agricultural uses of the word bochaa;
- actors' self-identity.

Data corresponding to each code were compiled and compared to elicit similarities and differences in representations of productivity problems, their management and the ways different individuals had gained understanding about them.

After this preliminary qualitative analysis and processing of the soil samples, all interviewees were invited to a workshop where the soil and initial qualitative results were disseminated. Two research staff and two farmers who had not been interviewed also attended. After 30 minutes of presentation in Dagbani and English, 75 minutes of heated discussion ensued, which was recorded, transcribed and coded. Earlier data was recoded with new themes emerging from the workshop, before a synthesis was made.

Results and Discussion

In the workshop, the soil results, as seen in Figure 1, were presented first. Productivity is conventionally associated with high soil macronutrient levels and pH values close to neutral, as the AEAs pointed out in the workshop. Yet in Figure 1, N and P levels are not always higher in the plots without bochaa than those with, nor is pH closer to neutral. Workshop participants commented on this, and some AEAs also noted the association of the word bochaa with acidity in the Dagbani language. For example, it can be used to refer to heartburn. This led one AEA to speculate that the bochaa plots should have lower pH, which was not always the case. The consensus conclusion of participants about Figure 1 was that macronutrient and pH levels could not fully explain the productivity problems they were encountering on farmers' fields. Instead, these data acted as an entry point into exploration of actors'

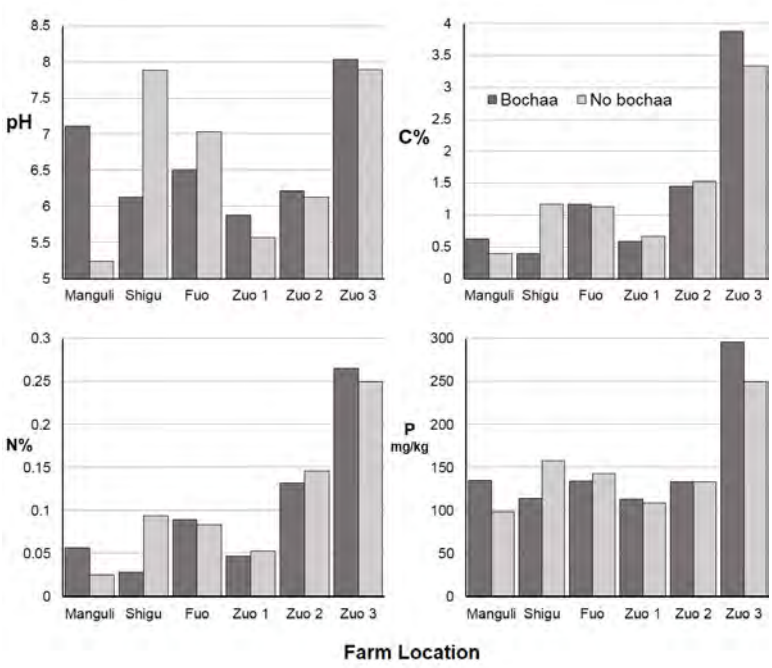

Figure 1. Properties of soils with and without bochaa.

different understandings of the productivity issues they were experiencing.

Networks of Understanding

Among the actors encountered, there were two ways of understanding productivity problems. In this section we explain how they were formed, using the ideas of knowledge as performance and enrolment. Each knowledge network was constructed by a set of actors through the performance of their occupational identity. Actors formed and reinforced those identities through two elements: the way they had learnt about productivity problems and the types of solutions they had seen to function well. Using STS terminology, each of these can be conceptualized as an actant: a non-human network component. These actants became devices, convincing and enrolling the human actors into a particular way of knowing. One knowledge network focused on the symptoms of productivity problems, and the other on the underlying mechanisms for low productivity. We therefore label them the 'symptomatic' and 'mechanistic' networks. We did not set out to align a different network with each occupational actor group, but the data showed that this was largely what happened.

Symptomatic Network

The symptomatic network formed as Dagomba farming elders taught younger practitioners. This happened as part of a more general process of social upbringing called wubsibu. Wubsibu involves teaching people about how to tackle general life issues, of which agricultural problems are one particular type.

> 'When they say bringing up a child it is that they show you things. What we call bringing up a child is not giving you saγim[2] to eat, they tell you "this thing, this is how it works, this particular thing is good, this is not good," that is the bringing up of a child. My grandfather and my father showed me, "this thing, this is how it is," that is the bringing up. If you are in it you will also get to know it. So as you are in it, if someone is doing the same act you can tell him "this is how it is" or "this is how I know it"' (Farmer A).

Wubsibu happened in a tacit fashion as farmers worked together in the farm, but was accompanied by explicit verbal explanation, connecting with the ideas of Bloch (2008) and Ingold (2000) respectively. Farmers described how they had copied their forefathers and also how those ancestors had shown and told them about bochaa, answering their specific questions. For example, farmer D told us how he taught his son how to tackle bochaa as they worked in the farm. As they weeded together, the son asked why certain plants were stunted. D told him this was bochaa and that he should plant the plants further apart to combat it. In an interview, the son corroborated this account, but could not explain why this management practice was effective.

Alongside wubsibu, farmers described how critical observation of their own farms over the course of their farming careers taught them about the causes of certain phenomena. An example given by one group of farmers was the appearance of bochaa around certain trees.

Another way this network was made durable was when farmers used effective low-tech solutions that worked by improving general soil health, specifically manuring and crop rotation. Farmers could not explain the mechanisms through which

these technologies worked. Instead, they described the effects the technologies had on the symptoms of bochaa.

> Farmer D: 'You get cow dung and spread it on your field, plough it all, it will mix with the soil, then when you nurse, you see it doing better.'
> Interviewer: 'Why?'
> Farmer D: 'Bochaa makes plants yellow, and cow manure means its yellowness won't be there again and it'll grow.'

Wubsibu and the technologies farmers use to tackle bochaa act as interressement devices. This is the term Callon and Latour use to describe actants that behave as tools to enrol other actants into a particular network. Here, these devices convince Dagomba farmers to use the symptomatic bochaa concept by relating it to their occupational and cultural identities. Briggs and Moyo (2012) describe a similar process, as do Munyua and Stilwell (2013), who say that, in their Kenyan study, 'farmers shared local knowledge… because it was part of their culture, which was preserved through sharing.' Crane et al. (2011) show how the enactment of specific pastoral and agricultural livelihood strategies and knowledges constructs and is in turn shaped by West African ethnic identities. Like Schareika (2014) and Fraser et al. (2015), they emphasize the importance of the social way in which such knowledge is created, and social learning is indeed part of what happens here, stemming from and reinforcing the farmers' self-perception as Dagombas. That self-perception is tied to the imperative to respect the advice of elders and learn from their teaching. The interlinkage between ethnic and occupational identity is thus central to the performance of agricultural knowledge about bochaa. Together, human Dagombas and low-input non-human technologies comprise a symptomatic knowledge network in which the idea of bochaa is durable.

Mechanistic Network

A similar process of performing occupational identity was part of researchers' knowledge construction. The idea that had enrolled them was not of bochaa. They rather had confidence in the existence of soil acidity, hardpan and striga, the phenomena that they held responsible for low productivity. They had been interressed into the reality of these ideas through formal education, training and digital media. Some of the researchers had in fact come from Dagomba farming backgrounds, and formal education had succeeded in enrolling and translating them into the mechanistic network from the symptomatic one, by showing them the mechanisms through which the phenomena named above worked.

> Interviewer: 'You mentioned you've grown up in a farming community.'
> Researcher H: 'Yes. I had that knowledge too… it was concreted then, but… when I went to school… I was able to establish "so this is why we were doing this, this is why we were doing that." Before that I would just *suggest* that we knew what we were doing but I couldn't actually explain *why* we were doing that.'

This quotation shows how researchers learned mechanistic understandings of how productivity worked from formal education and reinforced these by reinterpreting on-farm solutions. To accept manure and crop rotation as technologies, researchers needed to understand the biological, chemical and physical mechanisms through

which they functioned, rather than merely describing their effects upon plant symptoms as farmers did. This also happened when they were exposed to more high-tech solutions such as liming and striga-tolerant germplasm: they described how tolerant germplasm discouraged striga by referring to maize genetics and striga physiology. These scientific management practices allowed researchers to apply what they had learnt in formal education, speaking to their identities as educated, professional elites. The technical solutions thus became non-human actants enrolling researchers into the mechanistic network, just as wubsibu, crop rotation, and manure had enrolled farmers into the symptomatic way of understanding.

The self-perception that this engendered was reinforced through peer association. Participants in this mechanistic network described communicating with and learning from colleagues as well as actors from other occupational groups, namely volunteers, development NGOs and commercial and non-profit research corporations, reflecting their participation in the pluralist extension environment. Thus, these parties also acted as components of the mechanistic network.

Actors' experiences of training and education reflected the technical focus of mainstream development policy as well as the involvement of external organizations in shaping professional roles and development agendas. The researchers' educations had all focused on technical competencies such as plant breeding or improved cropping systems; they did not refer to research on, for example, knowledge development or dissemination strategies. Few AEAs had experienced formal workplace-based training; most had been from external projects or chance encounters with researchers and volunteers.

In the mechanistic network, because the researchers' identity involved processing data, Latour's 'centres of calculation' concept, as used by Palmer (2012, 2016), is relevant. The centre of calculation here is the place where data about striga, acidity and hardpan are transformed into scientific knowledge. It has multiple nodes: laboratories, classrooms and conference halls. Journeys, analogous to those made by the Latour's explorers, happen as researchers and data travel between these locations and the farmers' or the experimental field. Researchers described how their enrolment into the mechanistic network had begun in the classroom. Later, they perpetuated the cycle of accumulation of scientific knowledge, collecting more information and formulating solutions through their research activities, specifically legume rotation, use of trap crops and development of striga-resistant varieties. These activities related to striga in particular, reinforcing the importance ascribed in professional development circles to this particular problem and technical solutions to it.

Common Actants

Of the technologies that acted as interressement devices, crop rotation and manure are notable because they played this role in both the symptomatic and the mechanistic knowledge networks. Both farmers and researchers saw manure as strengthening crops against threats to productivity. For researchers, the threat could be striga, in which case manure made nutrients available, allowing crops to grow even when the striga parasite was removing nutrients from them.

> 'If the soil is very poor, a weak maize plant cannot support vigorously growing striga plants, because striga will take the nutrients from the plant, not from the soil. So the manure is for the maize to grow, it is not for the striga to grow well. So if the maize plants are growing well, then the striga

> are not able to kill it' (Researcher M).

In contrast, for farmers, the bochaa that threatened the plant was unexplained, but manure gave the crop the strength to fight it.

> Interviewer: 'You seem to be saying that the place where the soil is strong, the bochaa can't come. Do you know how that works?'
> Farmer S: 'The strength [of the soil] is the reason why the crops are strong. The crops are healthy from the soil and the cow manure. Like that maize there, the bochaa is why it's not strong. If cow manure and compost was in it, you would also see it, so it would get fat and dark and that's what we call strong.'

This is because bochaa is not one biological, chemical or physical process, but a description of the symptoms farmers observe and know how to reverse. Similarly, farmers described how bochaa reduced after several years of rotating legumes with cereals. They did not have an explanatory mechanism for this, whereas researchers explained it by referring to the host-specificity of striga. This resounds with Ingram et al.'s (2010) description of researchers' 'know why' and farmers' 'know how': for the same agricultural problem, farmers have practical experience of which solutions work, and scientists a more theoretical explanation for why they do so.

The AEAs are particularly important in illustrating how these two knowledge networks formed. Some fell between the mechanistic and the symptomatic networks, in the sense that they connected to elements of each and were actively struggling to reconcile them. The interressement devices associated with each network resonated with different elements of their identities. They had practical experience of observing low-technology solutions work in the field, particularly manure. Those who were Dagomba identified to some extent with the farmers and their explanations for bochaa. On the other hand, their professional identities meant that they distinguished themselves as more educated than farmers, and their interaction with peers, researchers, corporations and NGOs had familiarized them with technical terms. Thus, some were confused about the relationship between striga, bochaa and acidity, and could not be enrolled into either network.

> 'The bochaa, as we used to know it, was usually attributed to this witchweed, striga hermotica [*sic*]. But of late I have some difficulty, because once it's like what this particular weed do to crops, you have similar effects when we are talking of maybe some high-level acidity in the soil.' (AEA B)

Figure 2 shows the arrangement of actants in the symptomatic and mechanistic networks. It shows how each network is associated with specific concepts. They are made durable when human actants are enrolled into them by interressement devices. These devices are also actants in their own right, comprising functional solutions and elements related to identity. Some human actants, the AEAs, connect to both sets of interressement devices, so are not successfully enrolled into either network.

Translation between Networks

One aim of the human actors in the mechanistic network was to enrol farmers into their way of understanding productivity problems, and thus change their practice to include exclusive monocrop rotation, hand-weeding of striga, and, where possible,

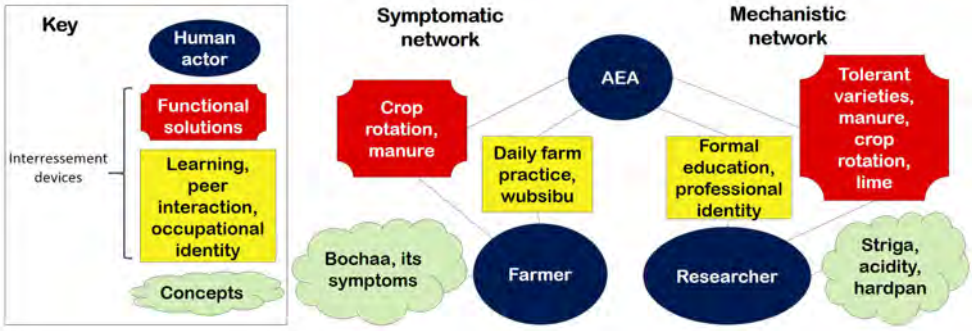

Figure 2. Schematic of the symptomatic and mechanistic networks.

liming and adoption of striga-tolerant germplasm. This resonates with the extension priorities outlines in FASDEPII and METASIP, to improve the low technical knowledge base of farmers and AEAs. However, this section will show why such attempts at translation had failed.

In the workshop, farmers refuted that there was a difference between striga, acidity and hardpan, preferring to group them all under the banner of bochaa. They demonstrated this when a senior scientist stated that 'farmers have the idea that bochaa is the beginning of striga, it is "striga underground", which is wrong' (Researcher E). This scientist asked the farmers as a group if they held to that conceptualization. Farmers collectively stated that they disagreed with distinguishing between bochaa, striga acidity and hardpan. One said 'they all the work the same way' and another added 'they all spoil our crops'.

The actors in the mechanistic network failed to enrol the farmers into this network because the mechanistic interressement devices were not related to the farmers' identity. Those devices worked to reinforce the professional actors' educated status, so were less effective than wubsibu and manure in convincing the farmers. The characteristics of interressement technologies themselves were as important as the identities of the human actors in this. Complex, expensive technologies that had been developed off-farm, such as lime and patented striga-tolerant germplasm, were not available to farmers. Similarly, they had had little contact with AEAs who might explain to them the mechanisms through which those technologies tackled low pH or striga. Low extension capacity is recognized as a problem in METASIP and FASDEPII, but ongoing retrenchment means AEA numbers remain consistently low. Thus, it was impossible for farmers to experience these technologies in the verbal and tacit ways that they had learnt about manure and crop rotation.

This result also helps explain why IK persists as an academic concept and an integral part of farmers' management strategies: Munyua and Stilwell (2013) sum it up well by describing how in their study 'a few farmers used local knowledge when they lacked the funds to implement "scientific" methods.' If the symptomatic network is made durable by farmers' poor access to financial and technological resources, poverty also becomes an actant within it, politicizing the analysis. This is not to suggest that manure and crop rotation are panaceas for poor farmers' productivity constraints. These farmers, as others across West Africa, often had difficulty obtaining manure and mobilizing the labour necessary for its use (Schlecht et al., 2006; Bellwood-Howard, 2013). Nevertheless, in this situation, manure and crop rotation

remained more viable technologies than the expensive, unavailable ones constructing the mechanistic network.

The centre of calculation in the mechanistic network had thus created knowledge that had been successfully mobilized for the AEAs from farming backgrounds, but not for the farmers. This network could not exert any type of influence over actors with less formally educated, professional identities, preventing formation of a hybrid knowledge network. In the TOT model underpinning the Ghanaian agricultural extension system, AEAs are supposed to provide a bridge between researchers and farmers. However, despite the approaches that interressement devices from both networks had made to them, this could not, therefore, happen.

Composite Networks As Solutions

The key to the practical significance of this work lies with these AEAs, and will be explored in this section using the boundary concept. As AEAs could not reject the advances of interressement devices from either network, the solutions they had experienced acted as boundary objects. These solutions allowed both networks to exist for the AEAS, without themselves changing in function (Star and Griesemer, 1989).

Boundary objects are usually conceptualized as being constructed by actors through boundary work (Klerkx et al., 2010). This is the case for Cohen (2012), who describes how the idea of a watershed has become a boundary object for groups of land managers. Although watersheds may be seen as natural landforms, Cohen argues that they are actually deliberately socially constructed by neo-liberal, participatory and scientific actors at scales that fit their diverse political projects. Gieryn (1999) gives another relevant example. He describes how the nineteenth-century English botanist Albert Howard developed and named the 'Indore' method of composting, using it as a boundary object to reconcile Eastern indigenous agricultural knowledge with his training in English agricultural science. He performed boundary work as he attempted to use this composting method to enrol agronomists into a network involving organic agricultural practices. In contrast, the manuring and crop rotation encountered in our case study had not been explicitly or intentionally worked on in such a way by local actors. Other technologies had been worked on to a greater extent in the study context, with varying degrees of success. The fertilizer subsidy and the Ghana Grains Partnership are attempts to make fertilizer relevant to farmers, manufacturers, importers, dealers and donors. An NGO, Opportunities Industrialization Centers International, had instigated a composting training scheme in the area, and researchers had done participatory compost trials (Clottey et al., 2006). In contrast, AEAs simply encountered manuring and crop rotation as they already existed within the different networks. Although they recognized these practices as boundary objects, they were working within a paradigm concerned with knowledge verification, where one network had to supersede the other, and had not had training in amalgamating farmer and 'expert' epistemologies. Similarly, researchers and farmers did not perceive these management practices as points of common understanding, but could only see the roles they already played within their respective networks. Without support for the boundary work that could follow recognition of a boundary object, hybrid knowledge could not form.

Nevertheless, one researcher had a different perspective, being willing to understand how boundary objects could be operationalized in an alternative solution.

> 'We can say that there is a common ground as to what bochaa is. It relates to the general well-being of the plant. So the idea of bochaa is a visual example of what happens when things are not going on well in the soil, when the plants are not having enough nutrients. When the soil is sick in terms of acidity. And you can use that example in so many ways if you want to do extension messages… if you want to talk about fertility issues and they talk about bochaa, you can relate the two, if you see their bochaa is not striga but actually nutrient deficiencies in the soil you can relate the two. If you talk about land preparation and they are talking about hardpans, you can relate the two. If you are talking about striga and they are relating it to striga, you can relate them. So to me, I noted about five definitions of bochaa from what was said, they're related and it becomes very powerful, as to what an extension agent can do with all this information, because you can use it to develop strategies about a lot of issues' (Researcher F).

This is not so much a hybrid as a composite solution: it allows the identities that construct both the mechanistic and the symptomatic network to continue existing, with neither attempting to challenge the other's ontology. There is no suggestion that boundary work be performed to arrive at a common understanding. However, even without such work, common practices can be arrived at through the use of boundary objects: these are the manure and crop rotation that the AEAs had experienced. Researcher F also sees the bochaa idea itself as a boundary object, as it may be used as an explanatory device or communication tool.

Recognizing the role of certain solutions as boundary objects permits consideration of the ecological and socio-economic foundations this agricultural system rests upon. The practices of manure application and crop rotation and the idea of bochaa are relevant to both symptomatic and mechanistic conceptualizations because they relate to fundamental characteristics of this West African environment. The generally low organic matter content of sandy savanna soils, combined with poor access to inorganic fertilizer, implies that sustainable field agriculture involves increasing soil organic matter levels. This fits with both researchers' and farmers' ideas about soil health, and resounds with characterizations of farmer knowledge, as a type of indigenous knowledge, being rooted in ecological understanding and experience (Lauer and Aswani, 2009).

Conclusions

We can now draw towards a conclusion, bearing in mind the overarching research question: How can agricultural actors reconcile different conceptualizations about productivity in search of solutions? Component sub-questions ask how different agricultural actors in the study context conceptualize productivity problems, what the reasons are for differences between their ideas, and what their commonalities are.

Our data show how the different occupations of Northern Ghanaian agricultural actors inform their contrasting symptomatic or mechanistic understandings of productivity problems. These different understandings develop because the performance and reinforcement of people's occupational identities involves different learning styles, implementation of different technical solutions, and peer interaction. Yet, despite their differences, the various occupational groups agree about the relevance of manure and crop rotation, low-input solutions that work to ameliorate

low productivity and can be seen as boundary objects. Such boundary objects can help reconcile differing conceptualizations about productivity. In situations like the study context, actors' performances of their entrenched occupational identities make it difficult to create hybrid knowledge. Yet the discovery of extant boundary objects such as manuring shows there are areas of common ground between occupational groups. The conceptual tool of composite knowledge allows these to act as common practical solutions, as it permits actors' different extant professional identities to coexist.

If boundary objects are themselves solutions, such as manure or crop rotation, they may relate to more general management principles. For example, the use of manure relates to a need to raise soil organic matter content. If, on the other hand, the boundary objects are concepts, they can be allied to solutions – for example, bochaa is a symbol for poor soil health and a need to apply manure or rotate crops.

Some actors in the study situation had unknowingly used boundary objects to perform agricultural extension, for example by advocating manuring. There is a particular need to pay attention to the boundary concept in the contemporary agricultural development and extension landscape of the study setting, which currently focuses more on importing technical expertise than understanding local knowledge and practice. It could be helpful to broaden the national policy focus, widening the market-oriented model encouraged by the CAADP to encompass more human resource development in specific areas. The METASIP emphasizes the need to enhance farmers' and AEAs' knowledge. Indeed, AEAs need more training in general, but specifically on extension and pedagogical techniques as well as technical procedures. They would benefit from learning how to use boundary objects, concepts and technologies to communicate with farmers and researchers. There is also a rationale for sensitizing CSIR scientists, alongside agents from NGOs and other DPs, on these extension techniques. Such technology developers could usefully engage with farmers' ontologies, both in order to identify appropriate technologies and consider how they will be disseminated.

Simultaneously, MOFA needs to address the function of external organizations in the extension environment. They continue to play an important role, and the newly decentralized authorities will have to consider how to support this whilst facilitating AEA's long-term engagement with farmers outside project contexts. Accordingly, the extension approaches of the various DPs need to be streamlined.

We conclude with a further political contextualization. We suggested that poverty could be an actant in the symptomatic network. Currently, a focus on organic amendment application and crop rotation seems more appropriate to poor farmers' needs than emphasis on expensive, exclusive technologies like patented germplasm. Low resource availability is one reason that boundary objects and IK can be important in finding such solutions when the management practices implied by scientific knowledge network cannot be implemented. However, this useful application of boundary objects should not detract from the importance of boundary work to make technological and knowledge resources available to multiple agricultural actors.

Notes

1. These documents were supposed to guide agricultural policy until 2015, but at the time of writing successors are not yet publically available.
2. The Dagomba's staple maize based food.

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Milpa: One Sister Got Climate-sick. The Impact of Climate Change on Traditional Maya Farming Systems

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Abstract. The *milpa* is a traditional Mesoamerican polycropping system involving rain-fed cropping of maize (*Zea mays*), squash (*Cucurbita moschata*) and legumes (*Phaseolus vulgaris*, *Phaseolus lunatus*, *Vigna unguiculata*), crops which in this part of the world are known as the three sisters. Despite alterations due to socio-economic changes during the twentieth century, *milpa* farming still characterizes subsistence production systems of peasants of Maya ethnicity in the central Yucatan Peninsula, Mexico. In Dziuché, a community in the state of Quintana Roo, more 'classical' interpretations of the *milpa*, commonly cultivated by the older generation of peasants, are competing with systems that are essentially hybrids of the *milpa* and conventional maize farming; however, management and output of both variants are affected recently by changing precipitation patterns associated with global climate change. In the present study, implemented in Dziuché in 2012–2014, we recorded and analysed recent changes in *milpa* production systems. Particularly, we compared the *milpas* of two peasants from different generations – one is 30 years old and the other 56 years old. Through a triangulation of participatory and qualitative methodologies, including dialogue between interlocutors, focus groups, and participatory elaboration of an agricultural calendar, we recorded their perceptions of the impacts of climate change on crop management, yield and agrobiodiversity. This information was enriched with economic data related to these production systems. The data was then validated with the entire peasant assembly of Dziuché. It was observed that, regardless of their age, traditional farmers responded to the late arrival or non-arrival of the early summer rainy season by shifting their maize planting dates and by reducing agrobiodiversity, mainly by eliminating beans. The results contribute to the current discussion around the impacts of climate change on traditional production systems. It was shown that despite resilience mechanisms inherent to peasant farming, the magnitude of climate change is challenging farmers to an extent that they respond

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with objectively counterproductive measures, such as decreasing agrobiodiversity. It must be added that in the case of Maya peasants, these reactions are not only caused by altering climatic conditions but also by socio-economic developments like the loss of empirical knowledge transfer, a decreasing number of family members available for unpaid agricultural work, and changes in land tenure.

Climate Change and Traditional Farming

The global average temperature has increased at a rate of 0.5 °C per century in the last 150 years (Ortiz, 2012, p. 2). This rise accounts for changes in precipitation patterns and more frequent extreme weather events (Kotschi, 2006). The phenomenon is principally ascribed to the anthropogenic emission of greenhouse gases (GHG) into the atmosphere, of which CO_2 is the most prominent and CH_4 and N_2O (30 and 300 times more harmful than CO_2, respectively) are the most damaging ones (VCS, 2011, p. 9). Agriculture accounts for approximately one-third of global GHG emission, mainly due to tropical deforestation, CH_4 emitted by cattle and N_2O coming from rice production and fertilization (Ortiz, 2012). Yet, farming is not only an offender but also a victim of climate change: especially regions populated by small-scale farmers will be affected by its consequences (Altieri, 2009). This problem worsens with escalating rates of per capita food consumption: with a world population of up to nine billion by 2050, total food production will have to be increased by 70% (FAO, 2009, p. 2), while the price of crops such as maize will double due to lower yields (Nelson et al., 2009, p. 7). Indeed, with an atmospheric CO_2 concentration of at least 550 ppm forecasted for the end of this century (IPCC, 2007), global agroecosystems will be facing further drastic alterations. Most mathematical models used to forecast the hazards caused by climate change do not consider small-scale agriculture, which makes the real impact of this trend on traditional farming hard to predict (Oreskes et al., 2010).

Latin America with its diverse traditional farming culture has not been exempt from the impacts of climate change. Although representing only 12% of global CO_2 emissions (Verner, 2011, p. 1), the temperature is estimated to rise drastically in the first half of the twenty-first century (Battisti and Naylor, 2009). There is a trend toward dry summers (Neelin et al., 2006, p. 1), which simultaneously causes shorter rainy seasons and more intense precipitations. Climate change is also related to increased night-time temperatures and extreme weather events, such as floods, hurricanes, droughts and landslides (Ortiz, 2012). In Mexico, climate change has already drastically affected its subsistence farmers who depend on rain-fed maize (Altieri, 2009).

Climate Change and Crop Management

An increase of atmospheric CO_2, one of the triggers of climate change, will stimulate the photosynthetic activity and resource-use efficiency of C_3 crops (thus, improving their yield). However, CO_2 combined with the expected rising temperatures will have a preponderant negative impact on productivity (Reich, 2009) due to accelerated vegetative growth and increased water consumption (Ortiz, 2012), which in turn would favour C_4 plants, including weeds. Yet, the indirect effects of GHG on agriculture will be more harmful than CO_2 per se (Führer, 2003, p.1); shifts in nutrient

cycling, crop–weed interactions, ecology of pests and diseases, and the distribution of crop varieties are expected (Dwivedi et al., 2013), going hand in hand with altered biomass accumulation (Ortiz, 2012) and decreasing nutritional potential of relevant crops (Kelly and Goulden, 2008). The impact on agriculture may be as variable as the effects of climate change: it depends on the type and the intensity of the phenomena, on the interactions between them (e.g. drought and heat), cropped soils, agrobiodiversity, surrounding vegetation, land use, crop stage and, of course, management. Among the negative consequences on production and agrobiodiversity (Table 1), soil moisture (altered by less, excessive or irregular precipitation) and the profusion of pests and diseases are the areas more likely to be affected (Dwivedi et al., 2013). Furthermore, loss of biodiversity in the surrounding environment will harm pollination (Garibaldi et al., 2011, p. 2); and natural disasters, the most visible consequence of climate change, cause physical damage to production and infrastructure.

Out of the crops that are associated with milpa,[1] maize (*Zea mays* L.), legumes (*Phaseolus vulgaris* L., *Phaseolus lunatus* L., *Vigna unguiculata* (L.) Walp.) and squash (*Cucurbita moschata* Duchesne), legumes will probably be most affected, particularly by droughts: they require the bean to invest nutrients and energy in non-productive growth;[2] to develop a deep-rooting system to extract soil moisture; and to increase sugar transport to seeds and early maturity (Dwivedi et al., 2013). Regarding quality, elevated heat decreases oil and increases sugar in beans (Thomas et al., 2009, p. 4). Maize yields will diminish due to less rainfall during flowering (Dempewolf et al., 2014, p. 3). Drought stress will affect quality of maize: reducing protein and increasing carbohydrates (Ali and Ashraf, 2011), as well as modifying oil and metal composition (Rastija et al., 2010). For Brassicaceae, it is reported that prolonged drought results in earlier and reduced flowering, as well as in descendants with thinner stems and fewer leaf nodes (Dwivedi et al., 2013, p. 44).

Traditional Farming and Agrobiodiversity

Due to an expansion of industrialized farming, agricultural land now occupies 55% of the Earth's ice-free terrestrial surface (Ellis et al., 2010, p. 5). This development affects biodiversity directly through the use of synthetic pesticides, fertilizers, and through monocropping, where non-native species become competitive invaders in neighbouring ecosystems (Rand et al., 2006); and indirectly, principally through groundwater contamination. As a result, today only 15 crops provide most of the world's food (Motley et al., 2006, p. 7). For the future, climate change is likely to have an equal, if not greater, impact on biodiversity than industrial agriculture (Kotschi, 2007).

In contrast, traditional agroecosystems are characterized by high diversity of (domesticated and wild) crop and animal species. Peasants respond to climate variability by a continuous adaptation of crop management, based on their personal experience and their historical background (Wilken, 1987; Kahneman, 2011; Rogé and Astier, 2013). Their adaptive capacity is determined by a complex interaction of socio-economic and political factors, existing infrastructure, and experience dealing with climate change (Adger et al., 2009). Thus, withstanding external shocks depends not only on the individual peasant but on the social infrastructure he is embedded in (Nicholls et al., 2013). Both agrobiodiversity and empirical knowledge guarantee built-in resilience and robustness that help peasants to cope with disturbances (Altieri and Toledo, 2011; Morales-Hernández, 2014; Altieri et al., 2015).

Table 1. Effects of climate change on crop management and agrobiodiversity.

Parameter	Process	Cause	Consequence	Limiting factor	Impact on agrobiodiversity	Reference
Plant physiology	Increased photosynthetic activity	Altered soil C fluxes induced by CO_2	Accelerated vegetative growth	Soil moisture and nutrient availability	Favours C_3 plants	Führer, 2003; Dwivedi et al., 2013
	Physical damage	Natural disasters	Devastation of agricultural infrastructure; increased risk of soil erosion/leaching and wildfires	Favourable soil structure and intact surrounding ecosystems	Favours fast-growing weeds after perturbations	Morton, 2007
Soil microflora	Increasing reproduction	Higher temperature and elevated CO_2 levels	Increased competition for soil nutrients and water; faster mineralization; increase of soil-borne pathogens; faster decomposition of mulches and dung; increased C:N ratio	Disposability of nutrients; low soil humidity	N/A[a]	Pimentel, 1993; Swaminathan and Kesavan, 2012
Soil organic matter	Augmented decomposition rates					
Nutrient uptake	Reduced nutrient assimilation (decreased soil humidity)	Higher temperature, less rainfall	Increased need of irrigation	Increased mycorrhizal activity due to elevated CO_2	Favours C_3 plants tolerant to drought	Compant et al., 2010
	Increased dry matter production	CO_2 stimulates vegetative growth	Decreased generative development	Heat	Altered polycropping systems	Führer, 2003
	Altered nutrient presence in rhizosphere	Increased N availability due to quicker mineralization and oxidation	Altered soil-fertility management	N/A	N-demanding plants more competitive	Führer, 2003; Hautier et al., 2009

Soil moisture	Increased evaporation	Higher temperature	Harvest losses; need of cooling and covering; negative impact on soil structure and nutrient availability	Mulching	Negative	Pimentel, 1993
Diseases	Shifts in geographical distribution	Changed spread of pathogens;[b] relocation of hosts	Harvest losses; decreased efficacy of established control-strategies	N/A	Disfavours determined pathogens	Dwivedi et al., 2013
	Abundance of pathogen fungi	Increased UV-radiation		Drought (determined species)	N/A	Biggs and Webb 1986
		Heat combined with intense precipitation				Castro et al., 2009
		Increased crop photosynthesis[c]		Heat		Dwivedi et al., 2013
	Decreased mycorrhizal activity	Drought		Heat, increasing soil CO_2	Favours C_4 annuals; disfavours perennials	Augé, 2001
	Abundance of pathogen bacteria	Higher temperature combined with increased CO_2		N/A	N/A	Castro et al., 2009
Pests	Increased reproduction	Droughts or warmer periods (more reproductive cycles)		Shorter cropping cycles		Altieri and Koohafkan, 2008
	Abundance	More food for herbivorous insects		Soil N deficiency		
	Increased food intake	Increasing leaf C:N		Abundance of *Rhizobium* spp.		Coviella and Trumble, 1999; Compant et al., 2010
Virus	Changes in virulence	CO_2 accelerates pathogen-evolution		Changes in host fauna		Dwivedi et al., 2013
	Increased transmission	Abundance of vectors		N/A		Juroszek and Tiedemann, 2012

Table 1 *cont.*

Parameter	Process	Cause	Consequence	Limiting factor	Impact on agrobiodiversity	Reference
Weeds	Abundance	Elevated CO_2 reduces stomatal aperture and increases water-use efficiency	Modified control-strategies; competition for water/nutrients/O_2	Reduced soil moisture; altered respiration	Favours C_3 plants[d]	Patterson, 1995
Harvest quality	Decreased protein content (grains)	Drought, heat	Reduced nutritional quality	N/A	Dwivedi et al., 2013	
	Increased C:N ratio	Elevated CO_2			Hamilton et al., 2005	
Storage	Elevated postharvest losses by pests	Drought	Post-harvest losses	Traditional farming techniques	N/A	Rogé et al., 2014
	Rising mycotoxin contamination	Droughte heat		Non-susceptible species		Whitlow and Hagler, 2005

Notes: [a] Indifferent/not predictable/no evidence found; [b] altered wind patterns; [c] rising carbohydrate content favours sugar-dependent fungi; [d] increased water-use efficiency also favours C_4 plants; d except aflatoxins.

A study by Rogé et al. (2014) offers insight into the ability of traditional farming communities in Oaxaca, Mexico, to respond to climatic variations: since the 1980s, a later beginning of the rainy season causes the peasants there to shift the maize sowing date from May and June, the traditional season, to July. Recently, Oaxacan farmers also learned (or remembered) that biodiverse fields and surroundings, as well as fallows, bring rain, retain groundwater, accumulate soil organic matter and prevent pests. Another common Meso-American adaptation strategy is planting drought-tolerant and precocious local varieties (Altieri et al., 2011, p. 4). Maize landraces show especially high adaptability to diverse climates (Ruiz-Corral, 2008). In this context, Bellon et al. (2011) found that in mountainous central Mexico, germplasm for almost all climate scenarios predicted for 2050 is available locally. Similarly, in the Yucatan Peninsula, the vast majority of communities prefer maize landraces to commercial hybrids, considering them to be more drought resistant, nutritious and tastier, as well as easier and cheaper to obtain (Weiss, 2012). In fact, all over Latin America small-scale farmers cope with climate change by combining traditional and contemporary sustainability practices (Browder, 1989). Their strategies are regionally adapted (Cunningham et al., 2013) or even farm specific (Niles et al., 2014).

Current State of *Milpa* Farming

Milpa, which literally means cornfield, is the most relevant traditional Meso-American production system (Hernández, 1985). Long before and after the conquest, it has sustained large indigenous communities in a relatively secure food situation. Since agriculture has been the dominant economic activity of the Maya people, today, as in the past, there is an intrinsic relationship between Maya culture and the *milpa* (Ebel and Castillo Cocom, 2012). Yet, Yucatec peasants are not limited to the *milpa* but usually manage simultaneously a variety of different production systems, of which home gardens stand out for their agrobiodiversity.

In the *milpa*, usually two varieties of maize (Toledo, 2003) are associated with legumes, squash and a varying number of other crops. Usually, a maize landrace with a shorter cropping cycle is polycropped with a longer-growing one. Farmers maintain this inter- and intraspecific diversity as insurance to meet future environmental change and economic needs. The interaction of these crops creates benefits for all involved plants causing 'overyielding': increased production of each crop compared to when grown alone (Altieri, 2009, pp. 106–108). Gliessman (1998, p. 102) demonstrated in a groundbreaking experiment that 1.73 ha of maize in monoculture produce as much food as 1 ha planted with *milpa*.

Central to the *milpa* is slash-and-burn farming (Gliessman, 2006). In this type of shifting cultivation (Turner et al., 2003), a plot of jungle is cut, allowed to dry, and then burned. After one or two growing seasons it is abandoned to fallow. Since there is always more land under fallow than actually cropped, this land-demanding method (Cowgill, 1962) creates a landscape with patches of secondary vegetation at different ages of succession (Saenz-Pedroza, 2015). Even now, all agricultural activities are done manually in the *milpa*; sporadically applied pesticides and fertilizers depend more on the availability of financial resources rather than on agronomic reasons (Ebel and Castillo Cocom, 2012). Sophisticated tools are rare: for planting, a dibble stick is employed to make holes at regular intervals into which maize and other seeds are dropped without any plugging (Cowgill, 1962).

During the second half of the twentieth century, changes in production and in

the social composition of Maya communities have been observed. Redfield (1970) noted growing frustration among subsistence farmers due to declining maize yields. This statement by the Mayor of an indigenous community reflects the spirit of this era: 'We must modernize our agriculture. It depends on the government to save the fields' (Don Eus, mayor of Chan Com in Redfield, 1970, pp. 171–174).

As history shows, his wish was satisfied in the decades to come. The Mexican government implemented the green revolution, which not only transformed (in the case of richer farmers) or influenced production (peasants), but also initiated a kind of social change: a new class of peasants, known as rich *campesinos*,[3] was born – and became more and more separated from the remaining modernization-resistant ones (Ebel and Castillo Cocom, 2012). They achieved high yields from then intact soils due to the considerable application of synthetic products. Their selection of crops corresponded to the needs of the market, not to the nutrition needs of their families. They became dependent on foreign food, and cash became vital for their economy (Eastmond, 1991).

At the end of the twentieth century, neo-liberal policies in the context of Mexico joining NAFTA (in 1994) served as a further transformer of the social structure. Changes in land tenure were notably momentous: historically, the farmland in Mexico is divided into so-called *ejidos*, a land grant mechanism wherein each peasant family has usufruct rights over a parcel of land, access to common lands, the right to an urban plot and voting rights in the *ejido* assembly (Eastmond, 1991). Following a liberalization policy of landownership in the 1990s, more and more *ejido* land has been converted into private property. Additionally, peasants who in the past had benefited from subsidies and soft credits, now largely had to carry on with farming without considerable public support (Rosset, 2009; Carte et al., 2010). In 1995, *Alianza para el Campo* (Alliance for the Countryside) was introduced, a programme that provided funding for profitable and export-oriented commodities but not for the *milpa*. The government also withdrew from the commercialization process, and middlemen (so called *coyotes*), who capitalize on the vulnerability of small-scale farmers, stepped in (Carte et al., 2010). On top of that, prices for staple crops decreased significantly in this period, a consequence of the World Bank and IMF forcing Mexico to sell off its public-sector grain reserves (making the country dependent on imports) and of price-fixing of the few corporate monopolies that emerged in a widely unregulated market. Even when crop prices recovered after the food crisis in 2008, peasants scarcely benefited, as costs of the synthetic inputs they were now dependent on also rose (Rosset, 2009). Maya peasants are clearly aware of the political and economic causes for the changes in their livelihoods (Carte et al., 2010).

A study by Ebel and Castillo Cocom (2012) gives insight into the impact of these changes on the situation of contemporary Maya farming in X-Pichil, Quintana Roo. There, the children of *campesinos* are being continuously disconnected from farming, resulting in increasing migration and loss of empirical knowledge. Significant is a notable aging of the active agriculturally-employed population: 94% of *ejidatarios*[4] are older than 40 years and only 4% of their children plan to continue working on the farms. According to the youth of X-Pichil, there are three reasons for this tendency: agriculture is seen as too labour intensive; *milpa* output became unstable due to a changing climate; and traditional farming suffers from a poor reputation in society.

An additional factor for the decline of subsistence agriculture on the Yucatan Peninsula is the emergence of mass tourism in the nearby 'Riviera Maya' that has been absorbing workers from indigenous communities (Re Cruz, 2006). Behind this de-

velopment is a national policy to strengthen currency import through tourism, while weakening low-profit sectors such as small-scale farming. This policy has totally shifted the economy and society of Quintana Roo: agriculture contributed to a third of the state's GDP in 1970 and is now under 1%; at the same time, tourism became the biggest economic sector (INEGI, 2011). As the first generation of migrants to the tourism hotspots was widely successful economically, outmigration from the Maya communities rose significantly and the reputation of 'poor' agriculture worsened (Carte et al., 2010).

This development is not alien to older peasants: many of them have the perception that the youth are leaving because their traditional way of farming is no longer competitive with a globalized and continually intensified production. Ironically, most peasants want a 'prosperous' future for their children out of the field, but lament the consequent loss of empirical knowledge about *milpa* and perceive increased consumerism among young farmers: 'Every father who loves his children wants them to get out of the field… Young people have no idea about *milpa*. They have nothing to do but they want a lot of stuff' (Emilio Tuk Aké, *campesino*, in Ebel and Castillo Cocom, 2012, p. 8)

Study Area

The study was caried out from 2012 to 2014 in the community of Dziuché, Quintana Roo, in the central Yucatan Peninsula (19°53′52″N, 88°48′25″O), 37 metres above sea level, a town that historically was built during the *chicle*-boom.[5] Dziuché has 2,870 inhabitants. The total extension of communal land is 27,000 ha; of these, in 2013, 14,000 ha were cultivated with citrus fruits and *milpa* or used for cattle farming (INEGI, 2011; Green-Chi, 2014). There is tropical savanna on the limits between Köppen climate classes Aw1 and Aw2. The raining season is from May to October, characterized by less rainfall in August than in July and September (Giddings et al., 2005). The annual precipitation is 1,195 mm and the temperature 25.4 °C (CNA, 2015). Comparing the mean monthly temperature and annual precipitation of the years 1980 to 2010 and 1950 to 2010,[6] both variables have decreased with time: –0.6 °C (with maximums +0.6 °C and minimums –1.8 °C) and –100.1 mm respectively (Figures 1 and 2). During the same period, maximum temperatures as well as total evaporation augmented, while night temperatures fell notably.

Methodology

The study focused on the members of the *ejido* assembly of Dziuché. Data were collected using a triangulation of participatory action research (PAR), qualitative social research methods, and a quantitative survey tool. Given their wide use in studies of ethnic minority groups, special importance was attached to focus group discussions (Morgan, 2008), which were applied in an initial stage of the study (in order to specify research questions) and in the follow-up (for validating data). Additionally, dialogue between interlocutors, selected PAR tools (workshops, in-depth case studies, participant observation, farmer-generated seasonal calendars), and multisite ethnography were used. The study was carried out in four stages (Table 2).

Stage I consisted of stakeholder identification, which included a meeting with community members (after an *ejido* assembly), in which the purpose of the study

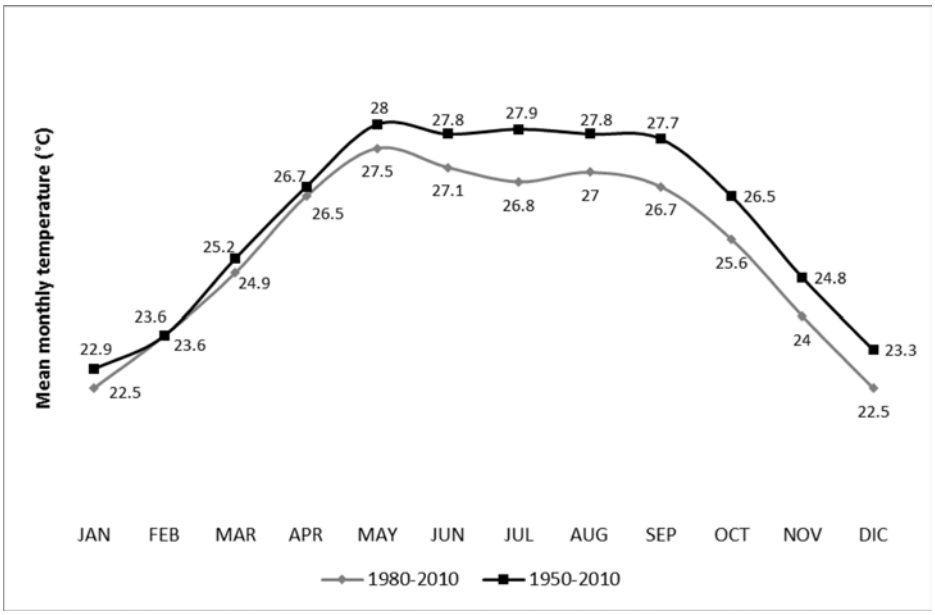

Figure 1. Monthly temperature (°C) in Felipe Carrillo Puerto (100 km from Dziuché). Comparison of the years 1980–2010 and 1950–2010.

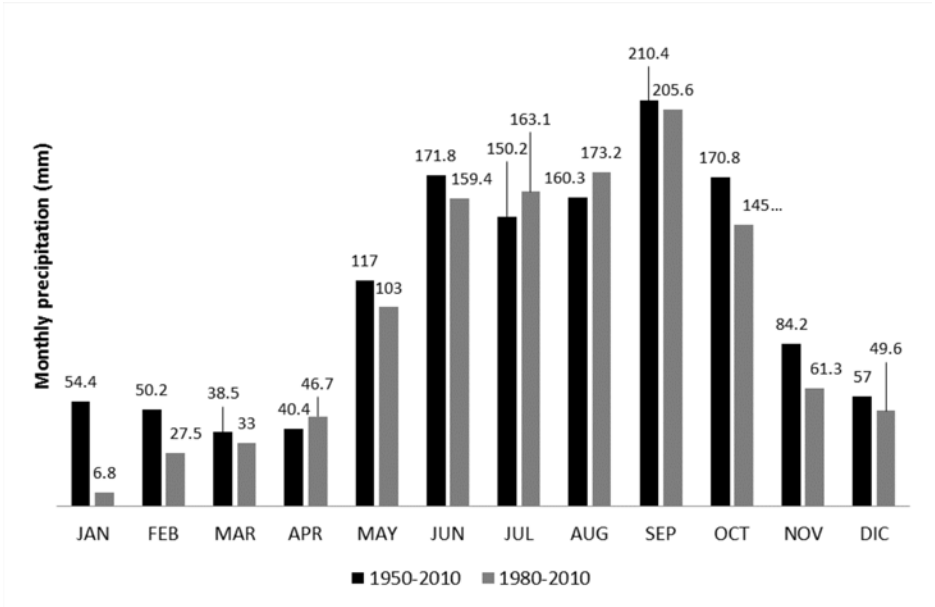

Figure 2. Monthly precipitation (mm) in Felipe Carrillo Puerto. Comparison of the years 1980–2010 and 1950–2010.

was presented. Participating farmers were also asked about their crop management (traditional/conventional), the size of their production areas and current threats for

Table 2. Methodology, main stages and temporal development.

Stage		Participants	Date
I	Stakeholder identification	*Ejido* assembly	July 2012
II	Fact-finding and listening	1. Focus group (5 peasants) 2. Two selected peasants	July 2012–June 2013
III	Analysis	Focus group	July 2014
IV	Sharing of information and validating	*Ejido* assembly	August 2014

agriculture in their region. A co-researcher served as moderator. In order to bring together farmers with a similar background and interest in the topic (Morgan, 2008), we identified volunteers for the focus group using the criteria that they must be active farmers with minimum 15 years of *milpa*-management experience. Applying a stakeholder rainbow (Chevalier and Buckles, 2013), other selection criteria were enthusiasm and age. Finally, a focus group of five farmers was recruited and a respondent moderator was appointed (Hennink, 2007).

Stage II focused on fact-finding and listening. In a workshop, the focus group conversed about recent changes in farming techniques and in environmental conditions. Data was obtained by recording the group discussion, which was guided by a co-researcher. One outcome was the agreement of a seasonal calendar (Chambers, 1994) regarding actual crop management in the *milpas* of Dziuché. Then, the *milpa* of each peasant was visited and adaptation strategies to changing climatic conditions were discussed. There, field notes were taken to record the statements of the peasants, as well as any other important events.

After becoming familiar with the views of the five participants of the focus group, we compiled the information and then processed for structuring the subsequent in-depth case studies (Table 3). Two members of the focus group of different ages (Table 4) were then selected for follow-up interviews (Morgan, 2008). At this stage, the research team had developed a trusting relationship with the peasants, and interactions became more personal. This circumstance facilitated the next step, which were narrative life-story interviews of each selected peasant. These interviews were largely unstructured; we only occasionally guided interviewees using structuring questions as suggested by Atkinson (1998). Interviews lasted 90 minutes and were audio recorded.

We then discussed changes in the peasants' *milpas* and causes for these changes in semi-structured interviews, facilitated by a student from Dziuché, who served as research co-facilitator.[7] The structure was based on questions that emerged during the focus-group discussion. Each of a total of five interviews per farmer was based on a main research question (Table 3), which was open-ended. It was combined with more specific and close-ended questions, which (in the case of unconsidered information) were slightly modified during the interview (Chambers, 1992). Each interview lasted 30 to 60 minutes and was audio recorded.

Finally, economic aspects related to *milpa* were highlighted in a structured survey. The survey instrument was based on information gathered through the agricultural calendar and the semi-structured interviews with both peasants. It was answered

Table 3. PAR tools applied in Stage II.

Participatory technique	Target community	Date	Location	Procedure
Seasonal calendar	Focus group	July 2012	*Ejido* assembly	Peasants completed a monthly arranged matrix with their drawings considering the following parameters: precipitation, temperature, extreme weather events, seeding and harvesting, other activities in *milpa*, hazards (e.g. pests and diseases), other agricultural activities, off-farm activities, farm and off-farm income (subsidies), disposability of food from *milpa*, cash disposability.
Field visits		September 2012	Peasants' *milpa*	Unstructured interviews following the *tsikbal** methodology
Interview		November 2012	Peasants' home	Narrative interview about life story
Semi-structured, in-depth interviews	Two selected peasants	January–March 2013	Public places in Dziuché	Research question 1 (RQ1): How did your father do *milpa*? RQ2: How do you do *milpa*? RQ3: Since you became responsible for it, what has changed in your *milpa*? RQ4: Since you became responsible for it, what have you changed in your *milpa*? RQ5: Since you became responsible for your *milpa*, what has changed in your community?
Survey		June 2013	Peasants' home	Closed ended questions requiring numeric data

Note: * Multi-site ethnography, effective in fieldwork among Maya people. It promotes intimate conversations by generating confidence and empathy, constructing knowledge in a collaborative way (Ebel and Castillo Cocom, 2012).

Table 4. Peasants selected for the in-depth fact-finding process and characteristics of their production systems.

	Age	Cultivated area (ha)	Agricultural activities	Off-farm activities
Farmer I*	30	1.0	*Milpa*	Taxi driver, mason
Farmer II	56	1.0	*Milpa*, apiculture (15 hives)	Tricycle driver, farmworker

Note: *Farmers demanded explicitly not to be mentioned by name.

in approximately 30 minutes and involved questions regarding farm and off-farm income, yield in *milpa*, as well as the duration and costs of diverse crop management activities.

Stage III consisted of data analysis. The data gathered in Stage II were summarized, structured and discussed with the entire focus group. There, the most sig-

nificant findings were identified and their validity for the entire community was assessed. Validating findings communicatively in the focus group ensured that different perspectives entered into the analysis process (Bergold and Thomas, 2012, p. 18) and gave participants ownership of the research (Russo, 2012, p. 10).

Stage IV focused on the sharing and validation of the research results. In an open participant group, accessible for all *ejidatarios* of Dziuché, a co-researcher presented the resumed and synthetized findings to the peasant community. On a scale from 0 to 10, the farmers evaluated both the sufficiency and validity of evidence of the study, as well as their consensus on the findings (Chevalier and Buckles, 2013). Values superior to 6 in both categories were agreed as requirements for the validation of the findings, while inferior values would initiate a reopening of the fact-finding process. Any value inferior to 8 would open a critical evaluation of the methodology.

Findings

Through stakeholder identification it was confirmed that the *milpa* is still the predominant production system in Dziuché; its *ejidatarios* cultivate areas from 1 to 4 ha; however, the number of traditional farmers is continuously decreasing and crop management techniques are changing, especially among younger farmers. Particularly, polycultures are being simplified. As a consequence, considerable sources of energy formerly obtained in the *milpa*, such as diverse legumes, cassava (*Manihot esculenta* Crantz), jicama (*Pachyrhizus erosus* (L.) Urb.), yam (*Dioscorea alata* L.), habanero pepper (*Capsicum chinense* Jacq.), tomato (*Solanum lycopersicum* L.), and honey, now have to be bought. Moreover, low yields due to unpredictable rainfall and high production costs are forcing peasants to earn money off-farm in order to buy maize for family consumption.

The focus group stated that there is decreasing use of landraces and a growing dependency on synthetic products in the *milpas*. Summer drought, shifting precipitation, higher exposure to natural disasters (hurricanes) and excessive weed-growth were cited as the causes of these changes. The term 'climate change' was mentioned explicitly in this context. Furthermore, peasants claimed a loss of empirical knowledge about traditional farm management due to fewer youngsters involved in *milpa*. They also revealed that the improvement of infrastructure in rural Mexico (which they principally favour) and relatives that work in urban regions or abroad brought the spirit of a consumer society to Maya communities.

Comparing two peasants of different ages, the younger peasant (Farmer I) inherited the responsibility of the *milpa* when he was 12 years old and his father died. Back then, synthetic products were not used, as they were difficult to obtain and costly. Now, he applies fertilizers and herbicides, with the aim of controlling tree shoots. Another technique that has changed is that slashing was formerly done by axe; now he uses a chainsaw as this implies less work. He intercrops maize and squash: 4–5 seeds are sown at once in one hole, adding 15 plants of sweet potato (*Ipomoea batatas* (L.) Lam.) in an area of 20x20 m inside the *milpa* (Tables 5 and 6). Likewise, the farmer now hires farmworkers during the crop cycle. Formerly, family members did the fieldwork. This is possible because he has funds to invest in the *milpa* thanks to off-farm activities and support from PROCAMPO[8] (Tables 7 and 8).

Farmer II assisted his father since he was 10 years old, and assumed charge of his *ejido* at 28 years old. At first, he worked alone; now, his two children occasionally, and his brother regularly help him. In his *milpa*, squash is planted in June (3,000

Table 5. Characteristics of *milpas* of a younger (I) and an older (II) peasant in Dziuché.

Farmer, age (years)	Maize planting density (plants per ha)	Distance between maize seeds (cm)	Distance between maize rows (cm)	Intercrops
I, 30	10,375	80	120	Squash, white sweet potato
II, 56	5,000	100	200	Squash, white sweet potato, cucumber, *coyol* palm*

Note: * *Acrocomia aculeata* (Jacq.) Lodd. ex Mart.

Table 6. Management of *milpas* of a younger (I) and an older (II) peasant in Dziuché.

Farmer, age (years)	Weed management	Pesticides	Synthetic fertilizers	Slash-and-burn farming
I, 30	Manual	Systemic herbicide (2, 4-D),[a] 3 weeks after planting	N-P fertilizer applied immediately after planting (40 g per plant)	2 cropping seasons after burning[b]
II, 56	Manual			1 season

Notes: [a] 2,4-Dichlorophenoxyacetic acid used for controlling broadleaf weeds; [b] first cropping season: new *milpa*, second cycle: *cañada*.

Table 7. Cropping cycle and main tools used 2013 in a *milpa* of Farmer II (56 years old) in Dziuché, compared to the routine of a Farmer I (30 years).

Month	Period	Activity (Farmer II)	Used tools (Farmer II)	Difference between Farmer I and II
December/ January[a]	Preparation	Selection of production area: Flat lots with soil depth > 30 cm, few stones and without 'problematic'[b] flora; after a fallow > 10 years[c]		2 crop cycles per area; minimum fallow > 15 years
January	Cleaning, *Rosa*	Cleaning beneath large trees, *Socoleo*	Machete	
January–March		Cleaning of herbs, *Chapeo*	Machete, *coa*[d]	
March/ April	Slashing, *Tumba*	Cutting off all large trees, *Bota*	Machete, axe	Uses chainsaw
		Breaking off trunks and branches in order to accelerate the drying process, *Desgaja*	Axe	
April		Total cleaning at an equidistance of 2 m around the field, done 1–2 days prior to burning, in order to prevent that the fire escapes, *Guardarraya*	Machete, rake	

April	Burning, *Quema*	Slashed vegetation must be completely dry or decomposed. Done at noon, at midday or twilight (moments with few wind); fire starts on two opposite borders and evolves to the centre[e]	With dry timber	
June/July	Seeding, *Siembra*	First squash (end of June), then maize after first intense rainfall in July[f] followed by other intercrops; seeding distances measured by steps[g]	Wood stock	All crops (except sweet potato) are seeded after 2–3 intense rainfalls; uses woody trellises for squash; measures with tape and uses a string for determining seeding lines; does not crop cucumber
July/August	Application of herbicide and fertilizer			Uses 20 litre knapsack sprayer for herbicides; fertilizer granules applied manually
July–September	Weed removal, *Chapeo*	Selective, focusing on perennials; minimum every 2 weeks	Machete, *coa*	Only sporadically
September/October	*Dobla*	Breaking of the stems for reducing vegetative growth, drying husks and improving soil moisture	Manually	Realizes *dobla* in November to prepare for *cañada*
September–November	Harvesting	Cobs are bent down for drying and harvested when dry		
September–December	Selection of seeds	Selection due to plant height, size and quality of ears, providing multiple seed lots; all seeds for the next season come from own collection		Occasionally buys seeds; has experimented with government -donated hybrids
September–December	Storage	Stored with husks in *cabañas*[h]		

Notes: [a] '/' depending on climatic conditions; [b] principally *Mimosa bahamensis* (Benth.) Britton and *Pithecellobium albicans* (Kunth) Benth.; [c] guarantees convenient soil depth, moisture, and fertility; [d] curved machete, similar to a sickle; [e] burning lasts approximately 1 hour, 3–4 fellow peasants assist observing and stay minimum 1 additional hour on the field; [f] the requisition is that soil is sufficiently humid and soft, otherwise they wait for 1–2 additional intense precipitations; [g] 1 step between plants, 2 steps between rows; [h] rustic granaries with thatch made of palm leaves.

plants per ha), followed by maize in July. The next full moon, sweet potato (10 plants per ha) and creole cucumber (*Cucumis sativus* L., 15 plants per ha) are planted in determined areas of the field. He stated that 'twenty years ago, the rains were more predictable', which is why he used to cultivate coriander (*Coriandrum sativum* L.), beans, and watermelon (*Citrullus lanatus* (Thunb.) Matsum. and Nakai). His only regular financial support is from PROCAMPO; an additional quarterly revenue is earned from field measuring and clearing activities for the *ejido*. Occasionally, he sells burned trunks as timber. He does not use synthetic products because of a lack of resources, but also because he considers them not essential. Similar to Farmer I, around 2005 he eliminated beans from his *milpa* due to their dependence on summer rain.

Table 8. Changes regarding crop management, comparing the years 2013 and 1998.

Period	Farmer I	Farmer II
Slashing	As now done by Farmer II; less wages	Less wages
Burning		Less people involved (less risk of wildfires)
Seeding	Arrangement and seeding of grains similar to Farmer II; intercropped bean, cowpea, watermelon, cilantro, yam, and radish	Seeded different maize landraces with varying production cycles and used a complex, cyclic crop arrangement; intercropped cilantro, bean (different landraces), pepper, and watermelon
Synthetic products	Without synthetic products	
Weed removal	As now done by Farmer II	No wages
Harvesting	Harvested approx. 50% more maize	No wages
Storage		Less storage loss

Farmer II yearly invests up to MXN1,500 more than Farmer I in his *milpa*, especially due to wages for weed management, which do not compensate for the costs of applying herbicides (Table 9). The production system of Farmer II is more labour intensive (+32 hours per cycle, Table 10) and also includes his brother's labour (who is paid with harvested maize). His family only helps during the harvest. In a new *milpa*, Farmer I is more productive than Farmer II (3 versus 2,500 kg per ha). Yet, each new *milpa* of Farmer II yields more than a *cañada* of Farmer I (2,000 kg per ha). Comparing a two-year-cycle of a new *milpa* and a *cañada* (as typical for Farmer I) and of two new *milpas* (Farmer II), both farmers harvest a yearly mean of 2,500 kg per ha maize. Although the older farmer sells 40% of his maize harvest, and the younger farmer sells 80%, both are far from being economically sustainable: summing two years, the younger peasant earns a profit of MXN1,720 and the older one loses MXN8,020 (Table 11).

Despite different management practices, the yield of both peasants is above the average *milpa* yield in Yucatan of 1,500 kg per ha (Castillo-Caamal and Caamal-Maldonado, 2011). Regardless of this remarkably high output, both farmers (each one with a family of five people) only obtain sufficient maize to feed their families for five months;[9] in the case of Farmer I, who sells most of the harvested maize, his poultry is fed with corn too. In turn, Farmer II, who sells less, gives two-thirds of his unsold yield to his brother; he also feeds his chickens and turkeys with maize and saves seeds for the next year. According to both farmers, they obtain 80% of their family's annual squash, and 50% of their sweet potato consumption from their *milpa*; Farmer II additionally harvests cucumber and honey[10] and gathers timber. Both farmers must purchase beans (an essential element of the Yucatec diet), and other food.

The peasants of Dziuché rated the sufficiency and validity of these findings with a value of 9 on a scale from 0 (low) to 10 (high). They appreciated our 'willingness to listen to their problems'. Regarding our conclusions, their ranking was 8.

Table 9. Comparison of monetary investment in wages and materials in two *milpa*-cycles of different-aged peasants (in MXN).

		Farmer I, 30 years old						Farmer II, 56 years old					
Year, production cycle		2012, new *milpa* (MXN)			2013, *cañada* (MXN)			2012, new *milpa* (MXN)			2013 new *milpa* (MXN)		
Parameter		Units	Cost/ Unit	Cost	Units	Cost/ Unit	Cost	Units	Cost/ Unit	Cost	Units	Cost/ Unit	Cost
Wages*	Slashing	25	80	2,000	25	50	1,250	25	80	2,000	25	80	2,000
	Burning	3	50	150	3	30	90	3	50	150	3	50	150
	Sowing	25	40	1,000	20	40	800	25	40	1,000	25	40	1,000
	Application of herbicides	12	50	600	12	50	600	0	–	0	0	–	0
	Weed control	0	–	0	0	–	0	25	80	2,000	25	80	2,000
	Harvesting	75	20	1,500	50	20	1,000	64	30	1,920	60	30	1,800
Materials	Fertilizer (1 unit = 1 kg)	1	570	570	1	570	570	0	–	0	0	–	0
	Herbicide (1 unit = 1 litre)	1	75	75	1	75	75	0	–	0	0	–	0
Total 1 year (MXN)		5,895			4,385			7,070			6,950		
Total 2 years (MXN)		10,280						14,020					

Note: *Wages per hour vary depending on the activity and on whether it is about a new *milpa* or a *cañada*; harvesting is paid per yield.

Table 10. Comparison of working hours of a younger (I) and an older (II) peasant for an entire production cycle of 1 ha *milpa* in hours.

Activity	Parameter	Farmer I, 30 years	Farmer II, 56 years
Slashing and burning	Hours per day	9	10
	Persons involved	3	4
	Days	5	11
	Subtotal	135	154
Sowing	Hours per day	5	4
	Persons involved	3	4
	Days	1	1
	Subtotal	15	16
Application of fertilizer/ herbicides	Hours per day	8	–
	Persons involved	4	–
	Days	2	–
	Subtotal	64	0
Weed control	Hours per day	2	4
	Persons involved	2	3
	Days	1	6
	Subtotal	4	72
Harvesting	Hours per day	4	4
	Persons involved	3	4
	Days	2	4
	Subtotal	24	32
Total	242	274	

Note: 'Temporal investment in new milpa and cañada is the same' (Farmer I).

Discussion

In Latin America, (mostly indigenous) small-scale, traditional production delivers at least half of the food produced for domestic consumption (Altieri, 2004; ETC Group, 2009). It persists due to complex ecological interactions in biodiverse environments, which provide yield advantages of at minimum 20% per crop compared to monocropping. Additionally, low disease and pest pressure, and high efficiency in the use of water, light and nutrients (Altieri, 2009) guarantee independence from commercial inputs. Since output in subsistence farming is based on the nutrition needs of the peasant's family, not on the maximum resource exploitation (Rosset, 1999), yields per area tend to be lower than in conventional farming.

As for Maya peasants, this indifference to output may be changing. This is motivated by political and social pressure to 'modernize' farming communities; additionally, although adapting crop management to changing conditions has been an essential part of the historic evolution of Maya farming (García-Frapolli et al., 2008), the current climatic change is more complex, extensive and prejudicial than what was experienced by former generations (Table 1). Consequently, stakeholder identification confirmed that all over Dziuché production systems are being modified. Two climate-related driving forces for this tendency were mentioned. First, a generally uncertain climate; this perception agrees with the actual meteorological

Table 11. Costs, benefits, maize harvest and its use of the *milpas* of two different-aged peasants (two production cycles).

Year, cropping cycle	Parameter	Farmer I	Farmer II
2012, new *milpa*	Expenses (MXN)	5,895	7,070
	Harvest auto-consumed (kg)*	500	1,500
	Harvest sold (kg)	2,500	1,100
	Income (MXN)	7,500	3,300
	Profit (MXN)	1,605	–3,770
2013, *cañada* (Farmer I)/ new *milpa* (Farmer II)	Expenses	4,385	6,950
	Harvest auto-consumed (kg)	500	1500
	Harvest sold (kg)	1,500	900
	Income (MXN)	4,500	2,700
	Profit (MXN)	115	–4,250
Total	Expenses (MXN)	10,280	14,020
	Harvest auto-consumed (kg)	1,000	3,000
	Harvest sold (kg)	4,000	2,000
	Income (MXN)	12,000	6,000
	Profit (MXN)	1,720	–8,020
	Subsistence consumption (%)	20.8	60.1

Note: Farmer II gives about 1,000 kg harvested maize to his brother (not considered as wages).

data for central Yucatan, where rainfall decreased drastically in June, the key month for seeding maize in this region (CNA, 2015).[11] The second trigger is reduced soil humidity due to accelerated evaporation attributed to deforestation (as a consequence of expanding cattle farming, urbanization and wildfires).

Through the comparison of two farmers, it was found that younger peasants tend to respond more strongly to these alterations than older ones. Both took charge of their *ejido* as young men, which at that time had a classical *milpa* management, and changed it within the last 15 years:

- While maintaining maize, squash and sweet potato, both reduced agrobiodiversity by eliminating legumes, watermelon and coriander. Yam, cowpea (*Vigna unguiculata* (L.) Walp.), and radish (*Raphanus sativus* L.) were excluded only by the younger farmer, while the older farmer no longer cultivates pepper.
- In terms of interspecific variety, they now seed one particular maize landrace; formerly, they established at least two different ones.
- Seeding of maize was usually done after the first intense rainfall of the cropping season, at the end of June or beginning of July. Now, they wait for up to three intense rains before seeding.
- Both simplified their seeding procedure. This change is more drastic in the case of the younger farmer (Table 7).
- Since family members have become less involved in their *milpas*, the peasants now have to pay more wages to farmworkers, especially for slashing and burning (Table 10).

Besides age, three particularities distinguish the younger farmer from the older one: the younger sells approximately 80% of his maize harvest, which gives him a more

market-orientated approach to farming. Due to his diverse off-farm activities, he also has to be more time efficient in the field. Finally, he became the only one responsible for his *ejido* at a very young age; thus, he missed a considerable part of the usual empirical introduction to *milpa* by experienced peasants. Bellon et al. (2011) state that farmers respond to climate change by intensification, crop diversification, or agriculture retirement. The young peasant chose intensification of his *milpa* by using synthetic products, a common tendency in contemporary slash-and-burn farming (Toledo, 2003). Under these circumstances, five change responses were made only by the younger peasant:

- he experiments with foreign seeds;
- he seeds two crop cycles on the same field before abandoning it for fallow in order to spend less on wages for slashing-and-burning;
- instead of the traditional cyclical field design, this farmer prefers a linear arrangement;
- he uses more diversified and contemporary agricultural tools;
- he now applies herbicides and, therefore, invests less time in weed control.

Evaluating the magnitude of the responses, the most outstanding is undoubtedly the decision of both peasants to exclude beans from their *milpa*s. Apart from their relevance as food, beans have an essential agroecological function, endowing the polyculture with N-fixing bacteria (Altieri, 2009). Especially in poor fertile soils (as in Dziuché), NO_3 uptake and biomass production are up to 7% greater in polycultures with legumes than in maize monocultures (Postma and Lynch, 2012, p. 1). Both farmers mentioned poor rainfall as the reason for this response; beans are more susceptible to changing rainfall patterns than maize. This decision can be attributed to the limiting factor theory of Niles et al. (2014), whereby immediate limiting factors (in this case decreasing rainfall) are likely the most urgent issue for an agroecosystem and result in short-term responses (eliminating beans).

However, it was also found that the responses of the peasants of Dziuché are not only due to changing atmospheric conditions but are also related to personal experience and technical questions. Finally, there are political, historic, cultural and social reasons that force changes in peasants' production and livelihood styles. In Dziuché, six such non-environmental triggers could be identified.

- The strategies for adaptation to climatic change, inherent to traditional agriculture, are empirically transmitted from one generation to the next. Now, this knowledge transfer is affected by an aging peasant population, whose children tend to more conventional production, influenced by what they learn at school, or abandon agriculture.
- In the Yucatan Peninsula, a trend towards increasing consumption of industrialized food is observed. Changing nutrition habits also apply to other indigenous communities, where demand for *milpa* products is steadily decreasing (Pérez Izquierdo et al., 2012). As for Dziuché, squash especially is becoming a less popular food under younger peasants.
- Across the Yucatan Peninsula, fallow periods in slash-and-burn farming formerly lasted over 30 years, but now last 12–16 years (Castillo-Caamal et al., 1998), which is related to the ongoing debilitation of the *ejido* system (Eastmond, 1991). In Dziuché, most farmers took advantage of the recent possibility to sell *ejido* land and consequently reduced the fallow time per parcel.
- Since peasants count on a decreasing number of family members available for

unpaid work on the fields, they have to pay external workers; this requires cash. Ergo, peasants appeal for subventions, sell a considerable part of their harvest, focus on maize varieties with market potential, sell land, or seek out off-farm income. This increases the need for time-efficient crop management, which for many means the use of synthetic products – a vicious cycle, which demands additional cash.

- Traditional agriculture suffers from a poor social reputation in Maya communities (Ebel and Castillo Cocom, 2012). This point of view is not only shared by the (formerly young) rural residents but also by local and national decision makers, who promote 'successful' livelihoods and desirable lifestyles in tourism (Carte et al., 2010) or in commercial agriculture (or cattle breeding), even if this eventually means cropping (breeding) high-input crops (races), which are not adapted to the local environment.
- The 'modernization' of indigenous communities, mainly driven by their contact with ongoing neo-liberal tourism development (Carte et al., 2010) and the consequences of the restructuring of Mexican agriculture (Re Cruz, 2006), has also encouraged plausible demands like better education or higher mobility, which require additional spending power – money that cannot be gained in the *milpa*.

Conclusion

Traditional farming systems, such as *milpa* polycropping, typical in the central Yucatan Peninsula, are currently facing multiple developments that do not favour traditional farming: economic, socio-cultural, environmental and technical. But the most challenging threat combines all three of these: climate change. In this context, the ability of peasants – key actors in agroecosystems – to find answers to this threat is at least as important as finding technical solutions to predicted atmospheric developments. As shown in this study, even experienced peasants do not only adapt to climate change (shifting the maize seeding date), but also react to it by eliminating beans from their *milpas*. This means that despite the potential of traditional farming to resist and adapt to climate change, the magnitude of it is apparently challenging peasants to an extent that they respond with measures like decreasing agrobiodiversity, which actually harms resilience instead of improving it. In this context, it was also observed that a younger peasant disconnects easier from traditional strategies than an older one. Thus, our findings underline the need to update *milpa* in a way that corresponds to the perceptions and the needs of its future protagonists, the rural youth. As the study demonstrates, this update must involve technical solutions (such as finding ways to maintain the agrobiodiversiy of *milpa* by simultaneously reducing its labour intensity) but cannot be limited to them; *milpa* is also seriously jeopardized by the consequences of neo-liberal politics that complicate its traditional implementation and lure away youngsters from Maya communities.

Across the Americas, the maize-bean-squash polyculture is commonly referred to as the 'three sisters' (Lewandowski, 1987). Now, one of the sisters (beans) has become sick. It is time science and politics provided concrete suggestions for confronting the threats sustainable farming is facing. Time is short. *Milpas* without beans are a serious warning signal, since they become a simple cornfield.

Notes

1. Prognostics correlated to conventional monocrop systems; few information is available for polycrop-

ping.
2. Except varieties with enhanced drought adaptation (Beebe et al., 2008, p. 1).
3. Spanish for peasants.
4. Members of the *ejido* assembly.
5. Natural gum used for chewing gum production generating an important export industry during the first half of the twentieth century.
6. There is no historic meteorological data available for Dziuché. This information is from Felipe Carrillo Puerto, 17 metres above sea level, 100 km from Dziuché.
7. Thus, the procedure can also be considered as participant observation.
8. The federal 'Farmers Direct Support Program', created 1993 in order to compensate peasants for expected declining prices after the initiation of NAFTA.
9. The annual maize consumption in Mexico is 115 kg per capita (SAGARPA, 2011).
10. Principally for familiar consumption; if there remains honey, he sells it.
11. Following this trend, the Yucatan Peninsula is forecasted to transform from mainly wet to exclusively dry lowland by the year 2050 (Bellon et al., 2011).

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Foraged, Trapped and Hunted Foods in Valappur Nadu of Kolli Hills, Tamil Nadu

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Abstract. Wild foods found in and around farms, fallows and forests supplement foods and incomes of rural households and have co-evolved with other wild biodiversity. The present study was carried out using a structured questionnaire during February and March 2013 in two villages of Valappur Nadu in the Kolli Hills, Tamil Nadu, southern India, lying between 900 and 1100 m above mean sea level, covering a total sample of 40 tribal households. The diversity of wild food species across different food groups – greens, fruits, mushrooms, roots, tubers, birds, bats, rats and their seasonal availability and household consumption pattern were recorded. Greens are available predominantly during the rainy season and fruits mostly during the dry season. Women are mostly involved in foraging greens, mushrooms, vegetables, fruits, while men contribute to the food basket through trapping, fishing and hunting, and children are involved in both. Some of the surveyed households reported that they strongly believe that wild foods are nutritious and contribute to overall health and well-being apart from supplementing food security. The article concludes by viewing wild foods through the lens of food security in its four dimensions – access, availability, absorption and stability – and briefly touches upon some sociological aspects related to wild foods.

Introduction

Food security has come to depend on a small handful of widely cultivated species. About half of the world's daily requirement of proteins and calories comes from wheat, maize and rice (Jaenicke and Höschle-Zeledon, 2006); twelve species contribute to 80% of total dietary intake. In contrast, wild foods provide greater dietary diversity to those who rely on them. Ethnobotanical surveys of wild plants indicate

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that more than 7,000 species have been used as food at some stage in human history (Grivetti and Ogle, 2000; Hassan et al., 2005). Several of wild foods have co-evolved with other (wild) biodiversity in and around farms supplementing foods and earnings (Harris and Hillman, 1989; Scoones et al., 1992; Heywood, 1999; Grivetti and Ogle, 2000). It has been estimated by the Food and Agriculture Organization (FAO) that about 'one billion people use wild foods in their diet' (FAO, 2009a; Aberoumand, 2009). Some indigenous communities in India are known to use 600 plant species having food value (Rathore, 2009). Several of the wild food species are found within the fields themselves. Farmers in Thailand harvest wild herbs, insects, trees and vines from paddy fields, (Price, 1997; Halwart, 2008); in Bangladesh, people gather 102 species of greens and 69 species of fish; in the rainfed Deccan in south India, 79 species of uncultivated greens are used as foods along with uncultivated plants, including roots, tubers and fruits (Mazhar et al., 2007).

The recognition that nutritional security and biodiversity are linked is fundamental for enlisting policy support to secure wild food use and preserve habitats of wild edible species as one of the pathways for dealing with malnutrition among poor tribal communities. This is especially important for communities most vulnerable to malnutrition (Misra et al., 2008; Afolayan and Jimoh, 2009). Literature on vulnerability, food security and ecosystem services has tended to emphasize cultivated foods (Hassan et al., 2005; Ericksen et al., 2009). There is an underestimation of wild foods, neglecting the provisioning by ecosystems and the supportive role local knowledge systems play in sustaining food chains (Grivetti and Ogle, 2000; Mazhar et al., 2007; Pilgrim et al., 2008). Sourcing food from non-agricultural lands (uncultivated systems such as forests, wetlands, pastures, etc.) enables a systemic approach to food consumption; it allows rural and tribal communities to sustain for a whole year and steer clear of natural disasters and seasonal induced shortfalls of agricultural foods and act as a safety net (Choudhury and Sindhi, 2017).

Changes in land use, loss of forests, shrinking water resources, water pollution, expansion and intensification of agriculture, have significant implications for the availability of wild foods. Land-use change triggered by the commercialization of agriculture is leading to the decline of wild foods from many agricultural landscapes (Hassan et al., 2005) and implies a decreased reliance on wild foods (Treweek et al., 2006). The spread of agriculture and the homogenization of agricultural landscapes increasingly limit availability and use of wild foods of nutritional importance among agricultural communities and in particular the landless poor and other vulnerable groups (Scoones et al., 1992; Pretty, 2002). Current trends in land use, including expansion of intensive agriculture, limit the capacity of ecosystems to sustain food production and maintain habitats of wild food species (Foley et al., 2005).

The present study was developed as a part of the research project' Alleviating Poverty and Malnutrition (APM) in Agro-biodiversity Hotspots', being implemented in three states of India, Tamil Nadu, Kerala and Odisha, and aimed at addressing malnutrition through agronomic interventions and expanding the food basket of tribal and rural households by promoting kitchen gardens. To enhance understanding of current patterns in the Kolli Hills, Tamil Nadu, two villages from Valappur Nadu – Manjalpatti and Keelsengadu – were chosen for the study with the following research objectives:

- To explore the diversity of wild food species used – greens, vegetables, fruits and animals (including birds and fishes) – and the locations in which they are foraged, gathered, hunted or trapped; their seasonal availability and season-

wise household level consumption patterns.
- To ascertain the roles played by women, men and children in wild food foraging, trapping and hunting and some sociological aspects of wild foods.

Methodology

Background

Kolli Hills is part of the Eastern Ghats, located in Namakkal District of Tamil Nadu in southern India (Figure 1). The elevation of the central region of the hills ranges from 1,000 to 1,300 m above mean sea level and covers an area of approximately 280 km². The maximum temperature ranges from 20ºC to 30ºC, while the minimum lies between 10ºC and 20ºC. Average annual precipitation in the region is about 1,440 mm, which also exceeds the state average (Rengalakshmi and Balasubramanian, 2002, pp. 19–45; Kumaran, 2004) and 41% of this is received during the southwest monsoon. Kolli Hills itself can be divided into two main physical components: the periphery and the central part. The periphery is covered with uninhabited reserve forests lying on more or less steep slopes and it largely contributes to the rich biological diversity of the region. Four types of forests can be found in the Kolli Hills: semi-evergreen forests on top, deciduous forest at the middle elevation, southern thorn and *Euphorbia* scrub forests at the foothill (Jaya Kumar et al., 2002). The central region of the Kolli Hills is inhabited and the predominant land use is either agriculture or agro-forestry. More than 95% of the inhabitants belong to a single tribal community known as the Malayalis or the people inhabiting the hills (Rengalakshmi and

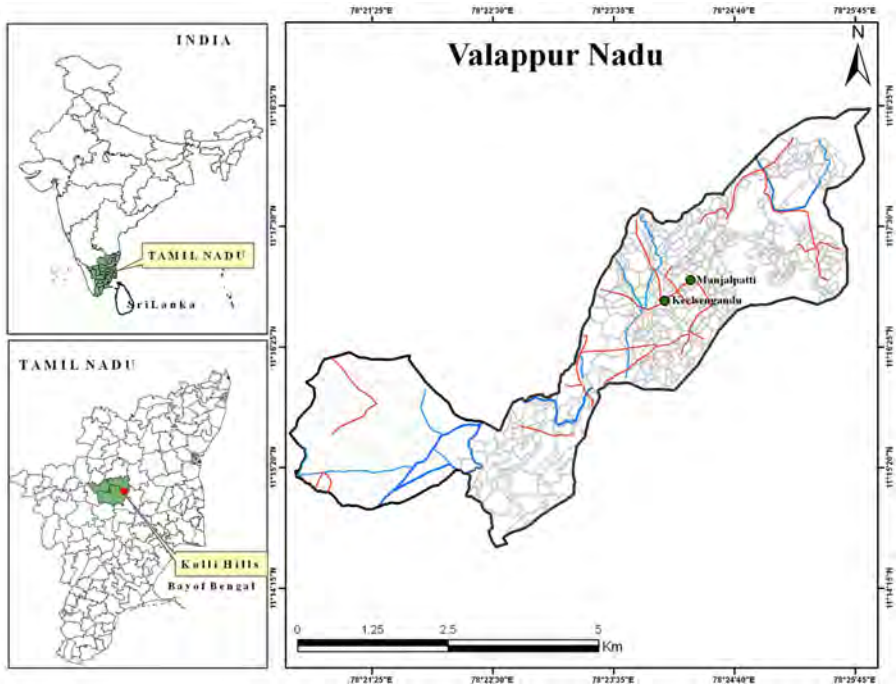

Figure 1. Map of Valappur Nadu (highlighting the two villages).

Balasubramanian, 2002, pp. 19–45). The total population of the Kolli Hills is 40479 (male: 20862 and female: 19617) consisting of 10910 households and the average density is 119 persons per km^2. The Kolli hills are spread over an area of 26600 ha, of which forests constitute 5,168 ha (19.4%), area under non-agricultural uses is 4,176 ha (15.7%), barren and uncultivable lands 945 ha (3.6%), permanent pastures and other grazing lands 945 ha (3.6%), land under miscellaneous tree crops 603 ha (2.3%), and culturable wasteland 1,405 ha (5.3%). Fallow lands cover an area of 2,031 ha (7.6%) and current fallows spread over an area of 1,924 ha (7.2%). The net sown area is 9,669 ha (36.6%) of which 807 ha is irrigated (3%) and 8,863 ha unirrigated (33%) (RGOffice, 2017). The tribal population is mostly dependent on rainfed agriculture, consisting chiefly of tubers, cereals including millets, pulses, oil seeds, fruits and vegetables. The cropping systems includes monocropping, a range of mixed-cropping systems coupled with relay and sequential cropping systems suited to different family and labour conditions and land types (Rengalakshmi and Balasubramanian, 2002, pp. 19–45; Anil Kumar et al., 2015). The study site is known for its rich agro-biodiversity, which has been declining since 1980s due to the introduction of commercial crop cassava and is estimated to represent about 75% of the total dry lands in the Kolli Hills (Pradeep and Rajasekeran, 2006), resulting in the shrinkage of acreage under minor millets (King et al., 2009). Food security / dietary diversity issues in the Kolli Hills are connected with at least two factors: changing rainfall patterns and a shift away from subsistence agriculture to cash cropping, understood in terms of changes in the physical and the social or cultural environments, and the manner in which preferences, priorities and practices change over time within households and communities and on larger scales (Elizabeth Finnis, personal communication, 30 March 2004). Over the last two decades, the tribal population in the Kolli Hills has experienced a decrease in dietary variety and an increased reliance on market systems linked to cassava cash cropping (Huang et al., 2017).

Data Collection

A survey questionnaire consisting of general household information, farming information, collection and consumption of wild food across different seasons (rainy, cool and dry), and knowledge and other information associated with wild foods was prepared, pretested and modified before the commencement of the actual survey.

The term ‘wild food’ as described in this article comprises all plant and animal resources that are foraged, harvested, trapped and hunted from forests, cultivated agricultural lands, field bunds, roadside storm-water drains, edges of stream banks and other common lands in the village. The surveyed households were initially briefed about the study before gathering information. A postgraduate student from the Department of Life Sciences was trained to collect data, sent to the field and consistently monitored by the investigators of the project. The survey was carried out during February and March 2013, covering approximately 70.1% of both Manjalpatti (20 of 20 households) and Keelsengadu (20 of 37 households).

Results and Discussions

Wild Food Species Diversity and Seasonal Household Consumption Patterns

This section describes different groups of wild foods foraged, trapped and hunted

in the study area across three seasons: (i) rainy season (June–October), (ii) cool season (November–February) and (iii) dry season (March–May). The total number of species and percentage of households consuming different wild food groups is presented in Figure 2 (rainy season) and Figure 3 (cool and dry seasons). The consumption of wild food in this section refers to households consuming at least one species belonging to a particular food group. During the rainy season, 28 species of greens (leaf vegetables) are reported to be available. Greens (leafy vegetables), mushrooms, vegetables, fruits, roots and tubers are collected or foraged either from farm lands or from forest lands. All the surveyed households consume at least one green. In contrast, during the dry season, only five species of greens are available and 68% of households consume those during the season. During the cool season, eight species are available and 73% of households consume them. Six species of vegetable are available during the rainy season and 85% household consume them; four species of vegetables are available during the dry and cool seasons, but only 3% of households consume them during this season. Mushrooms (seven species consumed by 58% households) and roots and tubers (five species consumed by 43% households) are available only during the rainy season, while fruits (12 species) are available only during the dry season and 80% of households consume them. Men and children are mostly involved in trapping and hunting only during the rainy season. With regard to trapped and hunted animals, the respondents listed a total of 12 species of birds, four species each of fish and rats and one species each of crab, squirrel and mongoose.

Responding to a question on the periodicity of consumption of wild foods by the household over the previous 12 months, only 4% reported that they consumed wild foods regularly, while close to 20% of households reported consumption to a moderate extent, about once a month, and 55% of them consumed little, about once in three months.

Patterns during the Rainy Season

The diversity of wild food species available during the rainy season, the percentage of households consuming them, the source of collection, the part used, method of cooking and the frequency of consumption are presented in Table A1. It is evident from the survey that the rainy season is significant in terms of the number of foraged wild food species belonging to different food groups such as greens, vegetables, mushrooms, roots and tubers, as well as hunted and trapped wild foods such as birds, fish, rats, crabs, etc.

There are 28 greens available during the rainy season; the major source of greens is farm land followed by forest. The surveyed households consume the leafy part of the greens either in boiled or roasted form, regularly during the rainy season. The major greens consumed by the surveyed households are *Manathakali* (*Solanum nigrum*), *Vallarai* (*Centella asiatica*), *Pannakkeerai* (*Celosia argentea*), *Kuppakkeerai* (*Amaranthus viridis*), *Pulachaikkeerai* (*Hidiscus sabdariffa*) and *Ponnanganni* (*Alternanthera sessilis*). Of the households sampled, 25–68% consumed nine species of greens and less than 10% of households consumed 13 other species of greens. Six species of vegetables are consumed occasionally during the rainy season, foraged from nearby farm land, forest, ponds and road sides. *Sundakkai* (*Solanum torvum*) is consumed by 85% of households after removing the seeds and boiling the immature fruit skin. The second most consumed vegetable is tomato (*Siruthakkali*), which is consumed by

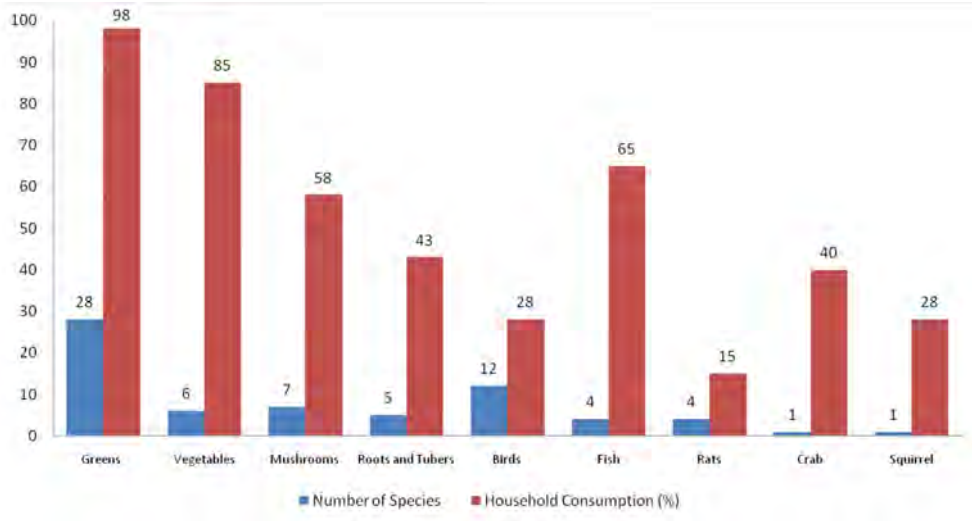

Figure 2. Patterns during the rainy season.

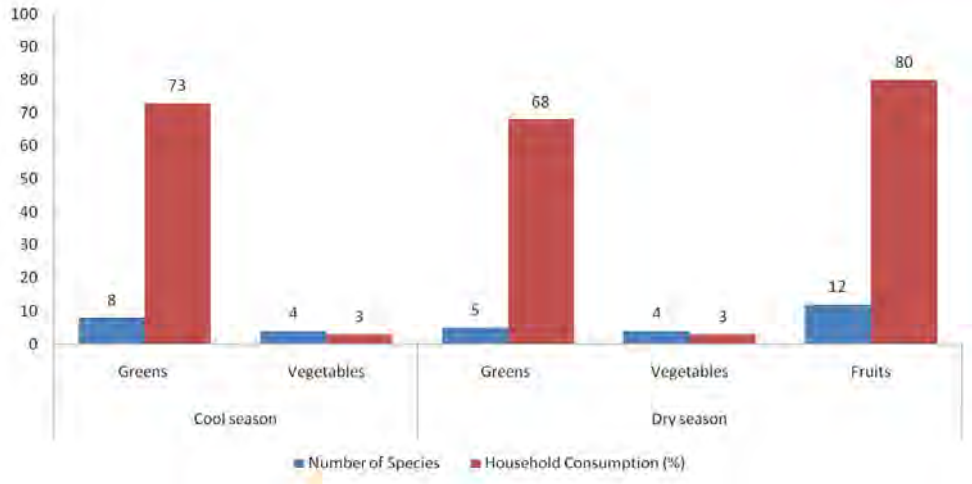

Figure 3. Patterns during the dry and cool season.
Note: Data of the cool and dry seasons have been combined into a single figure since the number of species was very low.

65% of households. More than 50% of households consumed two out of six species of mushrooms foraged from nearby farmlands and forest. Roots and tubers (five species) are available only during the rainy season and are occasionally consumed by households by boiling and peeling the skin. *Malangizhangu* is a major tuber collected from forests and is consumed by 43% of households. The trapped and hunted wild food species in the study area are birds, fish, rats, crab, squirrel and mongoose and mostly men and children are involved in their trapping and hunting. Twelve bird species are occasionally trapped and hunted mostly from farms and forest and consumed by the households. *Puluthiyanguruvi* (*Upupa epops*) is the most common one

and consumed by 28% of households. Two out of four fish species; *Kuravalai Meen* and *Paratai Meen* are consumed by 65% and 45% of households respectively. Crab is consumed by 40% of the surveyed households. Four species of rats and one species of mongoose are also consumed by a few households. Women are mostly involved in the foraging of wild food, which includes greens (leafy vegetables), mushrooms, vegetables and fruits. Roots and tubers are collected jointly, while men are mostly associated with trapped and hunted wild food, which includes fish, crabs, rats, birds, squirrels and mongoose. It was also reported that children played a role in hunting and trapping animals and birds. They use specially designed bows from which they aim small stones for hunting and killing birds and other small animals.

Patterns during the Cool and Dry Season

In contrast to the rainy season, approximately one-third and one-fifth (see Table A1) of the greens are available during the cool and dry seasons respectively. The most dominant greens during cool and dry seasons are *Vallarai* (*Centella asiatica*), consumed on an average by 70% of the households. Green *Ponanganni* (*Alternanthera sessilis*) is consumed by 28–33% of the households in both cool and dry seasons. *Manathakali* (*Solanum nigrum*) and *Pulichakeerai* (*Oxalis corniculata*) are consumed by 5–10% of households, while the other six green species are consumed by only 3% of the households. Four vegetable species are available and consumed during both the cool and dry seasons. Twelve fruit species are commonly consumed by the surveyed households and collected near farms and forests. Three fruit species: *Nava pazham* (*Syzigium cumini*), *Nellikaai* (*Phyllanthus* sp.) and *Kunni pazham* (*Salvadora persica*) are mostly consumed by 50–80% of the households.

Locations of Collections, Trapping and Hunting

Locations of foraging, trapping and hunting are critical since they have a strong access dimension and are subjected to unwritten norms, institutionalized rules and their social interpretations. There are 11 food groups being consumed by the surveyed households. More than 80% of the greens, vegetables, mushrooms and rats are primarily collected from farmlands and the remaining from forests. Fruits (84%), roots and tubers (100%) are mostly collected from the forests. Birds are mostly trapped in forests (75%). Squirrels and mongooses are either trapped in forests and crabs are collected from farmlands.

Other Factors Influencing Consumption of Wild Foods

Knowledge forms an important component of wild foods in terms of identification, processing and cooking. When questioned about the source of knowledge related to wild foods, 62% of the respondents answered that they learnt about wild foods from their parents and close relatives, while 38% reported horizontal transmission involving peers, mostly friends and neighbours. Children learnt about wild foods mostly from their parents while going out to collect wild foods, a process very critical for knowledge transmission across generations. Most of the greens were identified using the shapes of leaves, while mushrooms were identified based on colour, shape, size and stalk. Knowledge about identification and cooking of greens among wom-

en is mostly learnt from mothers, sisters-in-law or mothers-in-law and additionally from friends and close relatives.

When asked about the reasons for the consumption of wild foods, 52% of respondents interviewed reported that the primary reason for consumption of wild foods was the belief that they were nutritious, while 48% reported that they consumed wild foods as a habit that has been handed over generations. One of the respondents mentioned that parents visiting children staying in hostels for tribal children in the plains during weekends carry dishes of wild foods relished by them, indicating their preference among the younger generation. Some of the reasons cited by respondents for the non-consumption of wild foods include distance required to cover for collection, gathering, foraging, trapping and hunting of wild foods and lack of time due to preoccupation with work. A few of the respondents reported that the forests were the locations in which tubers were found in sufficient quantities during the respective seasons but restrictions by personnel of the Forest Department acted as a deterrent to its collection and thereby its use.

Conclusion

The present study provides a bird's eye view of wild food species foraged, trapped and hunted by tribal households in Valappur Nadu of Kolli Hills. In order to draw some broad inferences based on the study, the authors felt that the framework of food security in its four dimensions – access, availability, utilization and stability (FAO, 2009b) – would be appropriate.

The access dimension of wild foods includes foods foraged, gathered, trapped or hunted from commons and seasonal commons (forests, water courses, roadsides, private lands, seasonal fallows and field edges). Such commons are important sources of food security for indigenous people in many countries and they hedge them from extreme food scarcity. Rules and norms of access to agricultural fields, forests, wastelands and water are therefore critical for the collection of wild foods. Based on the responses, access in the commons and seasonal commons, where the bulk of the greens are found, is mostly open access, but restrictions to forest lands where most of the tubers are found is a bottleneck for wild food collectors and users.

Availability of wild foods is largely a biophysical dimension subject to weather and climatic conditions. Many of respondents were of the opinion that there was a gradual decline in the availability of different species of wild foods. Further biophysical studies on the availability and quantities are required to assess if a declining local wild food resource is associated with a shrinking area, the implications of changes in land use, notably the cropping pattern, leading to changes in availability of species that can be used as food. Another aspect that also emerged from respondents is that women chose to use alternatives found in vegetable shops in the locality instead of wild foods that require time and effort collecting and preparing.

The absorption dimension of wild foods seems to be largely sociocultural. Three aspects that surfaced during interactions include taste preference, erosion or lack of knowledge related to wild foods and the view that wild or gathered foods are inferior to cultivated foods. Children exposed to wild foods are likely to consume them when they grow up. Those not exposed are not likely to consume them due to lack of familiarity. Hence this logically leads to the aspect of knowledge about its uses and practice of using them. From a utilization perspective, species rich in micronutrients are likely to make an important contribution to household nutrition security.

Open-ended answers provided by some households indicate that there is a strong belief that wild foods are nutritious and contribute to overall health and well-being. One of the examples include a response regarding consumption of pork, which is believed to improve immunity and popular with a section of the younger generation.

The authors are of the view that the stability dimension is deeply entrenched in the three dimensions discussed above and a host of individual, household and community-level factors clubbed together with local, state and national policies. Women generally plucked leaves of different species of greens and ensured that at least a part of the plant was left behind to mature and reproduce, a fundamental process linked to sustainability. The locations in which some of these plants are found are visited by households whenever required. Some households cited lack of time and interest to forage, trap or hunt as one of the major constrains, while others cited lack of a peer group in foraging, trapping or hunting leading to a decline.

Appropriate interventions such as the introduction of some of the wild species into home gardens or farmland will ensure that they would continue to contribute to the household food basket and dietary diversity. Special efforts are required to educate the younger generation about the value of wild foods and their contribution to nutrition and well-being. In addition, favourable government policies may be explored to improve access to wild food diversity found in commons and seasonal commons as a means of supplementing household nutrition.

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Appendix

Table A1. Details of wild foods used by the Malayali tribe in the study area.

Food group	Vernacular name	Scientific name	% of HH consumption			Sources	Part used	Cooking method	Frequency
			Rainy	Cool	Dry				
Greens	Manathakali	*Solanum nigrum*	98.0	15.0	10.0	Farm land	Leaf and Fruit	Boiled and roasted	Regular
	Vallaari	*Centella asiatica*	93.0	72.5	67.5	Farm land	Leaf	Raw, boiled and roasted	Regular
	Pannakkeerai	*Digera muricata*	93.0			Farm land	Leaf	Boiled and roasted	Regular
	Kuppakkeerai	*Amaranthus viridis*	85.0		2.5	Farm land	Leaf	Boiled and roasted	Regular
	Pulachaikkeerai	*Oxalis corniculata*	80.0	7.5	5.0	Farm land	Leaf	Boiled	Regular
	Ponnanganni	*Alternanthera sessilis*	75.0	27.5	32.5	Farm land	Leaf	Boiled and roasted	Regular
	Sengeerai	*Amaranthus cruentus*	68.0	2.5		Farm land	Leaf	Boiled and roasted	Regular
	Eengilkkeerai	*Acacia pennata*	45.0	5.0		Farm land and forest	Leaf	Boiled and roasted	Regular
	Avulari	*Indigofera tinctoria*	43.0	2.5		Farm land and forest	Leaf	Boiled and roasted	Regular
	Munna keerai	*Premna integrifolia*	40.0			Farm land, forest and road side	Leaf	Boiled and roasted	Regular
	Kendipulichan	*Hibiscus sabdariffa*	30.0			Farm land	Leaf	Boiled and roasted	Regular
	Sirukeerai	*Amaranthus polygonoides*	28.0			Farm land	Leaf	Boiled and roasted	Regular
	Thagarakkeerai	*Cassia tora*	28.0			Farm land and forest	Leaf	Boiled and roasted	Regular
	Kattamanakkukeerai	*Jatropha curcas*	8.0			Farm land and forest	Leaf	Boiled	Regular
	Thandukkeerai	*Amaranthus caudatus*	5.0			Farm land	Leaf	Boiled	Regular
	Thumbakkeerai	*Leucas aspera*	5.0			Farm land	Leaf	Boiled and roasted	Regular
	Agathikkeerai	*Sesbania grandiflora*	5.0			Farm land and forest	Leaf	Boiled and roasted	Regular
	Kannupoola	*Aerva lanata*	3.0			Farm land	Leaf	Roasted	Regular
	Mullukkeerai	*Amaranthus spinosus*	3.0			Farm land	Leaf	Boiled	Regular

Table A1 *cont.*

Food group	Vernacular name	Scientific name	% of HH consumption			Sources	Part used	Cooking method	Frequency
	Aivirali or Aiveli	*Bryonia laciniosa*	3.0			Farm land	Leaf	Boiled	Regular
	Mudakathaan	*Cardiospermum halicacabum*	3.0			Farm land	Leaf	Boiled	Regular
	Velacheri keerai	*Cleome gynandra*	3.0			Farm land	Leaf	Boiled	Regular
	Karisalanganni	*Eclipta prostrata*	3.0			Farm land	Leaf	Boiled	Regular
	Karandipooti	Not identified		2.5		Forest	Leaf	Boiled	Seasonal
Vegetables	Sundakkai	*Solanum erianthum*	85.0	2.5	2.5	Farm land, forest, pond and road side	After removing seed	Boiled	Occasional
	Siruthakkali	*Physalis minima*	65.0	2.5	2.5	Farm land and pond	Full	Boiled	Occasional
	Seenimelakkai	*Capsicum annuum*	48.0	2.5	2.5	Farm land and road side	Full	Boiled	Occasional
	Mullukathiri	*Solanum melongena*	33.0	2.5	2.5	Farm land	After removing skin	Boiled and roasted	Occasional
	Kunnikkaai	*Solanum nigrum*	8.0			Farm land	Full	Boiled	Occasional
Fruits	Naval pazham	*Syzygium cumini*			80.0	Forest	Fruit		Seasonal
	Nelikaai	*Phyllanthus emblica*			62.5	Forest	Fruit		Seasonal
	Kunni pazham	*Salvadora persica*			50.0	Farm land	Fruit		Seasonal
	Yerumaikanni	*Rubus ellipticus*			35.0	Forest and farm land	Fruit		Seasonal
	Kaayalakka pazham	*Memecylon umbellatum*			27.5	Forest	Fruit		Seasonal
	Kotta pazham	*Ziziphus xylopyrus*			25.0	Forest	Fruit		Seasonal
	Kovappazham	*Coccinia grandis*			15.0	Forest	Fruit		Seasonal
	Magulam pazham	*Mimusops elengi*			12.5	Forest	Fruit		Seasonal
	Kuliri pazham	*Ottelia alismoides*			7.5	Forest	Fruit		Seasonal

	Thatbootpalam	*Passiflora calcarata*		5.0	Forest	Fruit		Seasonal
	Eecham pazham	*Phoenix sylvestris*		2.5	Forest	Fruit		Seasonal
Mushrooms	Vadamakkaalaan	Not identified	58.0		Farm land and road side	Full	Boiled and roasted	Occasional
	Pookkaalaan	Not identified	53.0		Forest	Full	Boiled and roasted	Occasional
	Puthukkaalaan	Not identified	30.0		Farm land	Full	Boiled and roasted	Occasional
	Maathikatta kaalaan	Not identified	18.0		Farm land and forest	Full	Boiled and roasted	Occasional
	Kaattukkotakaal-aan	Not identified	8.0		Farm land	Full	Boiled and roasted	Occasional
	Varagankaalaan	Not identified	5.0		Farm land	Full	Boiled and roasted	Occasional
	Elisulikkikaalaan	Not identified	3.0		Farm land	Full	Boiled	Occasional
Roots and Tubers	Malangizkangu	*Amorphophallus campanulatus*	43.0		Forest	After remov-ing skin	Boiled	Occasional
	Mullankizhangu	*Dioscorea alata*	13.0		Forest	After remov-ing skin	Boiled	Occasional
	Aattukkaal kizhangu	*Drynaria quercifolia*	5.0		Forest	After remov-ing skin	Boiled	Occasional
	Mullanmuradu	*Dioscorea cayennensis*	3.0		Forest	After remov-ing skin	Boiled	Occasional
	Maravalli kizhangu	*Manihot utilissima*	3.0		Forest	After remov-ing skin	Boiled	Occasional
Birds	Puluthiyanguruvi	*Upupa epops*	28.0		Farm land and forest	Full	Boiled and roasted	Occasional
	Kolakkozhi	*Pelecanus philippensis*	10.0		Farm land	Full	Boiled	Occasional
	Chittu kuruvi	*Passer domesticus*	8.0		Forest	Full	Roasted	Occasional
	Kondiliyan	*Pycnonotus haemor-rhous*	8.0		Farm land and forest	Full	Roasted	Occasional
	Vavvaal	*Pteropus livingstonii*	5.0		Forest	Full	Roasted	Occasional
	Kokku	*Grus grus*	5.0		Farm land	Full	Roasted	Occasional
	Pura	*Columba livia domes-tica*	3.0		Forest	Full	Roasted	Occasional

Table A1 *cont.*

Food group	Vernacular name	Scientific name	% of HH consumption	Sources	Part used	Cooking method	Frequency
	Sembothu	*Centropus sinensis*	3.0	Farm Land and Forest	Full	Boiled and Roasted	Occasional
	Kuyil	*Eudynamys scolopaceus*	3.0	Forest	Full	Roasted	Occasional
	Kaudhari	*Perdix perdix*	3.0	Forest	Full	Roasted	Occasional
Fish	Kuravalai Meen	*Channa punctatus*	65.0	Farm Land and River/Pond	Full	Boiled and Roasted	Occasional
	Parattai Meen	*Trachurus trachurus*	45.0	River/Pond	Full	Roasted	Occasional
	Vilongu	*Anguilla bengalensis bengalensis*	3.0	River/Pond	Full	Roasted	Occasional
	Aara Meen	*Ophidium aculeatum*	3.0	Farm Land and River/Pond	Full	Boiled and Roasted	Occasional
Rats	Alageli	Not identified	15.0	Farm Land	Full	Boiled and Roasted	Occasional
	Konthukaal eli	Not identified	10.0	Farm Land	Full	Boiled and Roasted	Occasional
	Sundai eli	Not identified	8.0	Farm Land and Forest	Full	Roasted	Seasonal
	Velleli	Not identified	3.0	Farm Land	Full	Boiled and Roasted	Occasional
Crab	Nandu	Not identified	40.0	Farm Land	Full	Boiled and Roasted	Occasional
Squirrel	Anil	*Funambulus palmarum*	28.0	Farm Land and Forest	After removing shell	Boiled and Roasted	Occasional
Mongoose	Keeri	*Herpestes javanicus*	3.0	Farm Land	Full	Roasted	Occasional

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College Student Literacy of Food Animal Slaughter in the United States

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Abstract. Despite the growing influence of food justice and conscious consumption in Western society, Westerners exhibit limited knowledge of non-human animal oppression in the food system. This study asked students in seven classes of Introduction to Sociology offered in a private New Jersey university to estimate how many non-human animals are killed for food every year in the United States. Although students had been exposed to reading and lecture material covering speciesism and non-human animal oppression in the food system, results demonstrate major variation in student retention and awareness. Most students (66%) severely underestimated the magnitude of killing; the median response was just 65 million while the bottom 10% of responses averaged a guess of 24 667. Exam grade was slightly correlated with student responses, but gender was not. These findings support existing research on consumer ignorance and social psychological theories that predict cognitive barriers to understanding large-scale suffering, alerting educators and policymakers to the difficulties in raising food literacy.

Introduction

As non-human animal rights activists can attest, the American populace has a limited understanding of non-human animal treatment in the food system (Colb, 2013). Strong ideological barriers and corporate suppression ensure that Americans put little thought into their food choices beyond presentation and price in stores and restaurants. Adherence to a plant-based diet and veganism as a political position are correlated with greater educational attainment (Margolis, 2013), but it remains the case that most Americans, educated or not, consume the flesh, hair, reproductive secretions, and labour of non-human animals with little awareness to the suffering entailed in these relationships. Beyond the immediate harm imposed to farmed non-human animals, animal agriculture is linked to zoonotic disease outbreaks, antibiotic resistance, a variety of preventable and life-threatening dietary illnesses, climate change, the extermination of free-living non-human communities, and race, class, and gender oppression in production practices. The variety and potency of these problems seem to have little impact on levels of awareness. Activists and policymakers alike have been vexed by the difficulty in raising consumer consciousness to the political nature and social consequences of animal-based food systems.

This study does not purport to solve this multifaceted mystery, but it does contrib-

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ute to existing vegan demographic studies by offering a brief quantitative analysis of one American university's food literacy. A number of psychological barriers and structural constraints ensure that consumers' food literacy remains rather low, and, as the results of this brief study demonstrate, isolated educational attempts may not be sufficient to overcome this issue. Segregation, socialization, and social psychological conditions ensure that ignorance to non-human animal suffering remains high, even though participants had been exposed to contradictory evidence. Results indicate that individualized attention to food illiteracy may not be the best investment of resources. Instead, a structural approach that targets consumers through influential institutions and agents of socialization will be necessary.

Literature Review

The Politics of Sight

Food consumption is a deeply personal and physically intimate human behaviour, and yet the structures that govern it are taken for granted and have become largely invisible. It is the nature of systems to remain out of sight and out of mind until they are disrupted, with this disruption subsequently forcing the attention of consumers. Timothy Pachirat explores this phenomenon in *Every Twelve Seconds: Industrialized Slaughter and the Politics of Sight* (2012), whereby the societal civilizing project has introduced a highly limiting and impermeable system of bureaucracy. Bureaucracy divides and separates society while also shrouding the distasteful aspects of production. With production segmented and dispersed, food literacy is baffled, and often intentionally so given the likelihood that consumer consciousness will lead to disenchantment and abstention. Consumers might only become aware of this bureaucratic structure when disease outbreaks surface and tracing contagions to the source proves difficult. This same structure hides violence against non-human animals (and vulnerable workers who are often undocumented, poor and female), compartmentalizing and dispersing production across many states, factories, and distribution centres. As with food-borne illnesses, it is difficult to attribute a source to the animal products that fall into the plate many miles from their origin. What is more, few of these products in any way resemble the cows, chickens, and other animals from whom they were taken. For consumers, what they see at the point of consumption has been greatly manipulated and what they do not see in the production process is tightly controlled.[1]

Indeed, Paul McCartney (2014) once observed that 'if slaughterhouses had glass walls, everyone would be a vegetarian.' It is this deliberate obfuscation that is precisely functional for a system that arguably runs counter to the sensibilities of many empathetic human consumers. Sociologists have offered a more sophisticated analysis regarding the politics of sight, noting that visibility is only one of many senses that is confused by institutional food practices (Cole and Stewart, 2014). While senses (sight, sound, smell, taste and touch) are all objectively registered, they are *subjectively* experienced. It is culture that ascribes meaning. Subsequently, rationalized, regimented and segmented societies that categorize non-human animals as commodities and machines ensure that they will not be interpreted as feeling or suffering. In fact, they do not 'exist' at all. Non-human animals, once objectified, are absorbed into rationalized systems and removed from human sensibility. Disruption to the cultural logic is needed to restore non-human animals to fields of awareness.

Scientific research, critical journalism, and social-movement activity are all potential sources of disruption given their ability to raise awareness to hidden systems and illuminate social problems. This has certainly been the case as food justice popularized in the late twentieth twentieth century and the non-human animal rights movement entered its second wave. Cultural concern with food production is not a modern phenomenon of course, and reaches at least as far back as the food safety acts of the early twentieth century. This legislation was spawned, in part, by the investigative work of journalists such as Upton Sinclair, whose 1906 *The Jungle* opened a window to the cruelty and violence of the American slaughterhouse system. A century later, Eric Schlosser's 2001 *Fast Food Nation* and Michael Pollan's 2006 *The Omnivore's Dilemma*, among others, would reinvigorate public interest in the ethics of food production. Some animal-centric investigative pieces, such as Ruth Harrison's 1964 *Animal Machines*, also commanded the attention of the public and inspired policy changes (Sayer, 2013).

These movements and writers have been impactful. Attitudinal research conducted by non-human animal advocacy groups indicates that Americans have new sensibilities about other animals. Most Americans now believe that some animals are sentient and emotionally sophisticated, while about half believe that farmed animals deserve equal moral consideration as other species (Faunalytics, 2016). Importantly, this change in attitude is matched, at least in part, by behavioural change. Approximately 8 million Americans identify as vegan or vegetarian, and over one-third of the country dines on plant-based meals regularly (Stahler, 2015). Plant-based eating is certainly not a foreign concept in the United States. Many ate little to no animal flesh out of economic necessity prior to the industrialization of the food system. Others were ethically motivated. America hosted a lively and influential vegetarian movement from the mid-nineteenth century through the Progressive Era, which certainly popularized healthful eating and compassion for other animals (Shprintzen, 2015). Following the rationalization of the food system after World War II and heavy government subsidies to support animal agriculture's expansion, however, flesh products became plentiful, abundant, and nearly unavoidable. American sensibility shifted in response. Today, about one in 10 Americans consider themselves former flesh abstainers, while over 80% of Americans have never tried a plant-based diet (Asher et al., 2014).

Food Literacy

While the cultural impact of activism and journalism cannot be overstated, contemporary research suggests that the consciousness-raising they elicit among audiences may be fleeting. Awareness is only half the battle, as rationalized systems make deviance from social norms of behaviour and conventional wisdom both difficult and resource intensive. For instance, one study explored the resonance of Pollan's *The Omnivore's Dilemma* among college students whereby students were assigned the book in tandem with food justice documentaries and integrative homework assignments. Participants reported a marked improvement in food choices, consuming more vegetables having completed the course (Hekler et al., 2010). Another study, however, also explored the impact of *The Omnivore's Dilemma* on college students who had been assigned the book, and found that, within a year, their critical consciousness had dimmed and most behaviour changes had reversed (Hormes et al., 2013).

These results highlight the difficulty of consciousness-raising through cultural disruption, but education has elsewhere been shown to be at least somewhat impactful. Instructors of animal studies courses, for example, have reported significant attitude and behaviour changes (Flynn, 2003; Linné, 2016). The main drawback to this approach is that some degree of selection bias would be expected in humane education programmes, as students who already harbour empathy with non-human animals would be more likely to register for such classes.[2] Research that does not rely on convenience sampling of humane studies classrooms is thus poised for more relevance. Of these studies, findings still indicate that education is impactful. A meta-analysis of student attitudes and perceptions found that education increases receptiveness to plant-based eating and also increases feelings of participant self-efficacy regarding their perceived ability to transition from animal foods (Corrin and Papadopoulos, 2017). Medical research presents similarly positive results. A study of Greek adolescents increased their vegetable intake and decreased their consumption of non-human animal bodies as their food education improved (Tsartsali et al., 2009). One American study also found decreased consumption of 'meat' as food knowledge increased (Yen et al., 2008). Educational channel also matters. An online course administered domestically and internationally by the animal agricultural industry found that online learning was exceptionally effective in shaping consumer attitudes about non-human animal welfare (Carr et al., 2016).

Ultimately, however, despite considerable non-human animal rights work against speciesist food production and a respectably robust vegetarian population, food literacy remains rather low in the United States. Research in other Western nations find similar patterns. Finnish researchers, for instance, have identified only a moderate level of consumer consciousness to 'meat' production's negative impact on the environment. There is also, however, a high level of interest in counteracting this damage with more sustainable consumer choices (Pohjolainen et al., 2016). Although Finland is more progressive than the United States in terms of environmental policy (in 2016, it ranked number one on the Environmental Performance Index), its vegetarian and vegan population is comparable (Vinnari et al., 2009). Likewise, a Swiss study also observed low levels of knowledge about the environmental impact of 'meat' production. These respondents believed that other countries (with presumably lower welfare standards) were to blame for any injustices in the food system (Shi et al., 2016).

A 2005 European Union report underscores this confusion as it relates to the treatment of non-human animals, finding that most respondents assume that welfare standards in Europe are high. Few consumers genuinely considered the well-being of other animals when making food purchases, suggesting that the assumption of high welfare allows the consumer to disengage from the political implications of their food choices. Of interest, the majority of these respondents had visited a 'farm' where non-human animals are exploited, and were thus more likely to demonstrate a concern for the welfare of their victims (European Commission, 2005). Presumably, this visit facilitated the return of their sensibility to other animals. Outside of Europe, a study of Australian adolescents also found limited knowledge of non-human animal welfare (Ronto et al., 2016). Likewise, Brazilian research indicates low levels of knowledge among urban citizens regarding standard factory-farming practices (Hötzel et al., 2017). Research on food literacy as it impacts on non-human animals is rather limited, but does demonstrate that rates are consistently low in regions where animal products are heavily consumed.

Institutional Narratives, Segregation, and Other Barriers to Food Literacy

Educators concerned with the ethical, environmental, and health consequences of low food literacy thus face an uphill battle in shaping the sensibilities and behaviours of their audience. University courses and social movements are ultimately limited in their reach, and these must compete with industry interests that subject Americans to well-funded media campaigns designed to increase consumer trust and patronage. Susceptibility to these messages is heightened given the low food-literacy levels necessary to make informed decisions. American foodways foster complacency and discourage critical thinking, as this lends to a more predictable (and ultimately profitable) system. The knowledge-interest nexus created by 'Big Food' in its collaboration with government institutions systemizes food choices and invisibilizes alternatives. Here, anti-speciesism scholars identify what Acampora (2016) terms 'epistemologies of ignorance' as particularly conducive to anthropocentric social structures and ideologies.

This process impacts consumers at an early age, beginning at the family level and refining in the school system. The archetypal farm of Old McDonald and other cultural myths contribute to this ignorance by facilitating non-truths and cognitive dissonance (Cole and Stewart, 2014). Children are socialized by their parents to accept 'meat' consumption as soon as they are capable of digesting solid foods, while cow's breastmilk is often introduced even sooner despite high levels of indigestibility, especially among children of colour (Scrimshaw and Murray, 1988). Socialization processes carefully obscure the animal origin of food (Bray, 2016). Flesh is most often prepared and described in ways that create dissonance and discourage empathy (Kunst and Hohle, 2016). 'Bacon', for instance, does not physically resemble the pig from whom it came, nor does its name. Language, in particular, conveys shared meanings about the status of other animals, both reflecting and shaping a speciesist culture. Human–non-human relationships are culturally policed in an unconscious manner with the regular use of otherizing and pejorative language (Dunayer, 2001). Speciesism is thus ritualistically upheld through daily discussion, particularly when communicators refer to non-human animals as 'animals', 'meat', or 'it', and when they create insults out of stigmatized non-human identities such as 'cow', 'bitch', 'dog', 'rat', and 'whale'.

Distancing increases non-human objectification and human insensibility, but closeness can disrupt this process. Regular exposure to species that are traditionally treated as food objects can improve awareness to their personhood (Hazel et al., 2015). That said, proximity is not a cure-all. As one study found, while young rural children who have higher exposure to food animals are aware that non-human animals must be killed to produce 'meat', they are unfamiliar with the reality of confinement or killing, even those children whose parents work in agriculture (Meischen and Trexler, 2003). Most humans are structurally distanced from institutionalized violence against other animals throughout their life course. Pribac (2016) has suggested that the segregation of non-human animals institutionalized for food production is a leading prejudicial barrier (as has been shown to be the case in American race relations).

The consumer's 'out of sight, out of mind' position is aggravated by the rise of reduce and reform solutions popular with non-profits and policymakers. These pro-industry approaches are designed to modify suffering, rather than eliminate it. As Cole (2011) observes, 'humane' farming practices purport to increase the visibility of the food system and the non-human persons within it, but in a controlled man-

ner in which producers shape consumer knowledge and awareness in such a way as to maintain the invisibility of the inherent cruelties that remain. 'Free-range' farm narratives will highlight the freedom of movement granted to non-human inmates, for example, but avoid discussing product sourcing, transportation, and slaughter, which must remain hidden due to the unpleasant violence they inherently entail. This industry strategy is useful in deflecting criticism before it arises, astutely shaping the discourse and consumer imagination. Ultimately, this humane-washing has more of an impact on the psychologies of consumers than the actual lives of non-human victims.

Social Psychology and Dissonance

Structural, cultural, and environmental conditions are critical, but human psychology poses its own set of hurdles even without the added manipulation of the state and industries. For one, research on confirmation bias finds that individuals grappling with information, be it new or recollected, gravitate toward that which supports their existing beliefs. Likewise, they are inclined to overlook or dismiss information that contradicts these beliefs as well (Nickerson, 1998). This bias has even been observed among consumers of scientific evidence, which does not bode well for non-human animals who might be spared by research supporting their capacity for suffering.

An individual's interpretation of data is also influenced by their concept of self. In a study measuring the influence of vegan pamphlets, for instance, exposure to information about non-human animal treatment created an increase in concern about speciesism and a desire to eat less flesh among those who had *already* indicated to researchers that they were someone who identified as a caring consumer. This participant behaviour is likely a psychological effort to marry attitudes and behaviours (Prunty and Apple, 2013). This bias is thus useful for those who are already sympathetic to the interests of other animals, but it is not especially applicable to most American consumers who have little sensibility to other animals' conditions.

Awareness to non-human suffering brings with it considerable psychological trauma, and consumers may actively avoid knowledge to prevent this negative affection (Pribac, 2016). Indeed, a number of denial mechanisms are likely to be employed, and these are easily compounded by enlightenment fatigue. As social psychologist Stanley Cohen summarizes, people simply become 'tired of the truth' (2001, p. 187). This reaction has been described as 'willed blindness' (Gjerris, 2015), while some go so far as to term it 'empathetic laziness':

> 'Laziness is present in those who possess a vague sense that animals are treated badly in food-production, but decline to sharpen that awareness into concrete and specific knowledge. When someone declines to read or watch films about the brutality of meat (and milk and egg) production, choosing willful ignorance over knowledge of what the animals experience, they exhibit moral laziness, as well as (often) a kind of cowardice.' (Jenni, 2016, p. 34)

While psychological research has its merits, framing resistance as a matter of blindness, laziness, cowardice, or some other personal failing overly individualizes (in an ableist fashion) what is actually a common and predictable human response to normalized structures of oppression. The sociological research examined above coun-

ters Jenni's incomplete account of individual will or choice. Ignorance to non-human injustice is a toxic mixture of political and economic interests, sociological conditioning, and human psychological tendencies. Human economic structures and human brain structures work together to generate self-reproducing systems that make unimaginable violence quite banal and unremarkable.

Methodology

Again, this study does not attempt to explain how these low levels of food literacy manifest, but it is able to evidence the degree of resistance that exists in American consumers, even relatively educated ones. Data was collected from the results of one extra credit question on a mid-semester exam administered to seven sections of an introductory sociology course in a New Jersey four-year private institution. This question asked: 'Approximately how many land mammals are killed for food in the United States each year?,' and students were given a blank space to write their answer. The gender and test score of the students were also recorded. Because the question counted for two points of extra credit toward their exam score, students were expected to have taken the question seriously. Approximately three weeks prior to the test, the students had been presented with a regular 80-minute lecture on speciesism and the experience of non-human animals in the American food system. The lecture structure was consistent with regular course activity, and speciesism was integrated with disciplinary concepts such as culture, inequality, institutions and socialization. Students were told the estimated number of land animals killed in the United States each year as of 2011 (approximately 10 billion), as well as the number killed globally (approximately 65 billion). This information was listed on a PowerPoint slide for note-taking purposes. The lecture was supplemented by a sociological article written by David Nibert (2003), 'Humans and Other Animals: Sociology's Moral and Intellectual Challenge', which numbered the oppression of non-human animals in the 'millions' or 'hundreds of millions'.

This study is significantly limited in that it explores comprehension of a very narrow aspect of speciesism and draws from only one course offering at one university. There is no control group, as the speciesism lecture is an important element to the course design and I was not prepared to omit it from any classes. This course is primarily taken by first-year students, although students of all academic levels register. Because it is an introductory course that counts for a general education requirement for the university, students of all disciplinary backgrounds choose the class. This university is a private institution with a somewhat conservative student body. Approximately 60% of the student population is female, which is comparable to the national university gender ratio (Corbett et al., 2013). The gender ratio in the sample classes are slightly more skewed, with 68% of respondents being female. About half of the students at the sample university are first generation, which is also comparable to the national average (Staklis, 2010). Located on the Jersey Shore, most students are New Jersey natives and not geographically proximate to agricultural systems. Although the university is in the New York City area and has a moderately active vegan/vegetarian community with a handful of plant-based restaurants, it is not in any way as robust as food justice hotspots in other parts of the country such as Brooklyn, Los Angeles or Portland. This study is not intended to be generalizable, but does expect to contribute to the scientific understanding of consumer awareness to non-human animal suffering.

Results

When presented with a lecture on the topic and incentivized to remember this information in preparation for an exam, do students retain a reasonable estimate of how many non-human animals are killed for food in the United States? A total of 196 students completed the exam, but 41 (21%) did not answer the extra credit question. Averages were employed when the responses given were estimates. For example, if a student wrote, '3 million to 5 million', four million was recorded. Students who did not answer were recorded as 'no answer'. As predicted, the majority (66%) of respondents significantly underestimated the number of non-human animals killed in the United States for food. Only 2.5% significantly overestimated, and the remaining 29% were in the ballpark with responses between 1 billion and 1 trillion. The median response was 65 million, or just 0.006% of the actual number of land-dwelling non-human animals killed in the United States (which is 10 billion). Quite a few students guessed lower than 10 000. In fact, the bottom 10% of responses averaged a paltry 24 667. The lowest guess was just 1,000. Given that thousands of non-human animals are killed just to meet the menu requirements of the campus cafeteria each semester, these results indicate a profound ignorance of the American food system and its impact on vulnerable species.

Recall that some students vastly overestimated the level of American speciesism. Overestimates in the many trillions were common. Although the test question explicitly asked for an estimate of land animals only, estimates in the trillions are more realistic given that the students were likely considering water inhabiting species, and this record-keeping weakness in the official statistic was explained to students during lecture. However, overestimating can also indicate a disconnect from the reality of speciesism if students are guessing large, abstract numbers from of a place of ignorance that is similar to the under-estimators. Due to these exceedingly high guesses, the average response for the entire study was skewed to 328 trillion. The top 10% of responses averaged 2.8 trillion.

While this article has reviewed the socializing impact of corporations and the state that supports them as well as psychological barriers to persuasion, there are additional spurious variables that may have interfered with student comprehension. For instance, no morally shocking images were utilized in the lecture, although some research suggests that images of non-human animal suffering can have a lasting impact on the viewer's memory (Tiplady et al., 2015) and can reduce audience denial mechanisms (Cohen, 2001). Students will also have variances in learning and test-taking capabilities, and many were first-year students still mastering skills necessary for college success. It should also be noted that the acceptance rate at this particular institution is extremely generous, suggesting that many participants may not have the same levels of commitment or educational advantage that would be expected of the average American university student.

Gender was also considered. While students in this study were all exposed to the same information, I was not able to control for the effect that gender socialization has on the interpretation and absorption of data. Research supports that women are more attuned to the suffering of others (Mercadillo et al., 2011), non-human animals included (Herzog et al., 2015). Men, alternatively, have been encouraged to associate flesh consumption with masculinity and are discouraged from empathizing with weaker groups. Information that conflicts with these masculine values would be theoretically less likely to resonate or retain as consistent with confirmation bias. However, gender did not significantly influence responses, although slightly more

of those who severely underestimated were women (Figure 1). An independent t-test could not confirm a significant relationship between gender and guess (Table 1).

Students with higher test scores were, as one might expect, more likely to report an accurate answer. This suggests a correlation between educational commitment, intelligence, and food literacy. The average exam grade for the sample was 75 (a 'C'), which is precisely 'average' by American university standards. Forty-two percent of A-level students answered within a reasonable range, compared to just 25% of B students, 10% of C students, 11% of D students, and 8% of students who failed. The distribution of responses by grade are presented in Figure 2. A-level students,

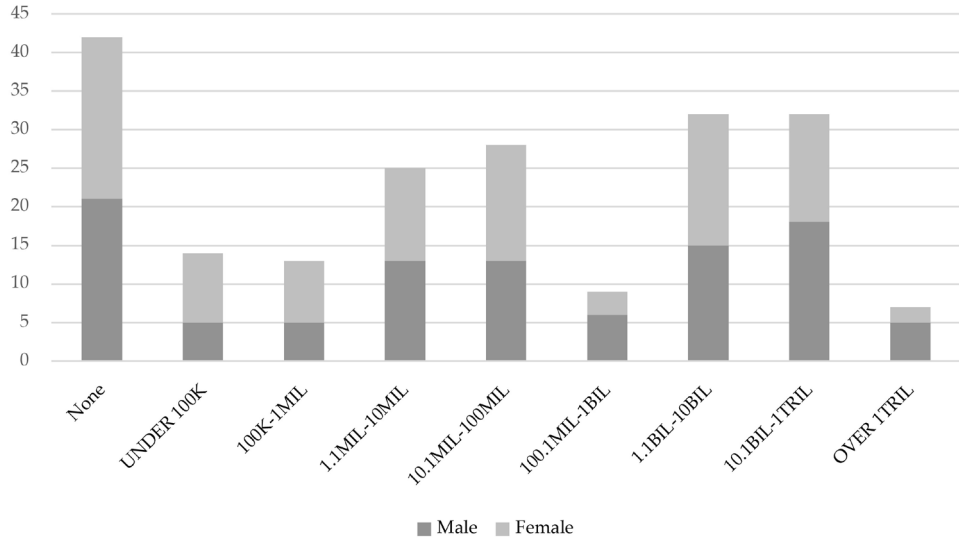

Figure 1. Gender distribution by percentage.

Table 1. Test for relationship between gender and guess (numbers guessed).

a. Group statistics.

Gender	*N*	Mean	Std. deviation	Std. error mean
Male	62	4.04E11	1.757E12	2.231E11
Female	134	1.93E11	1.747E12	1.509E11

b. Independent samples test.

	Levene's test		T-test for equality of means						
	F	*p*	*t*	*df*	2*p**	Mean†	Std. error†	CI‡	
								Lower	Upper
Equal variances assumed	2.220	.138	.786	194	.433	2.112E11	2.688E11	–3.189E11	7.412E11
Equal variances not assumed			.784	118.210	.435	2.112E11	2.693E11	–3.222E11	7.445E11

Notes: * 2-tailed significance; † mean and std. error of difference; ‡ 95% confidence interval of difference.

however, made up only a small portion of the sample. A linear regression analysis rendered an R^2 of just 0.002, such that the student's exam grade only explains 0.2% of their guess (Table 2). This regression also indicated that, for every point an exam

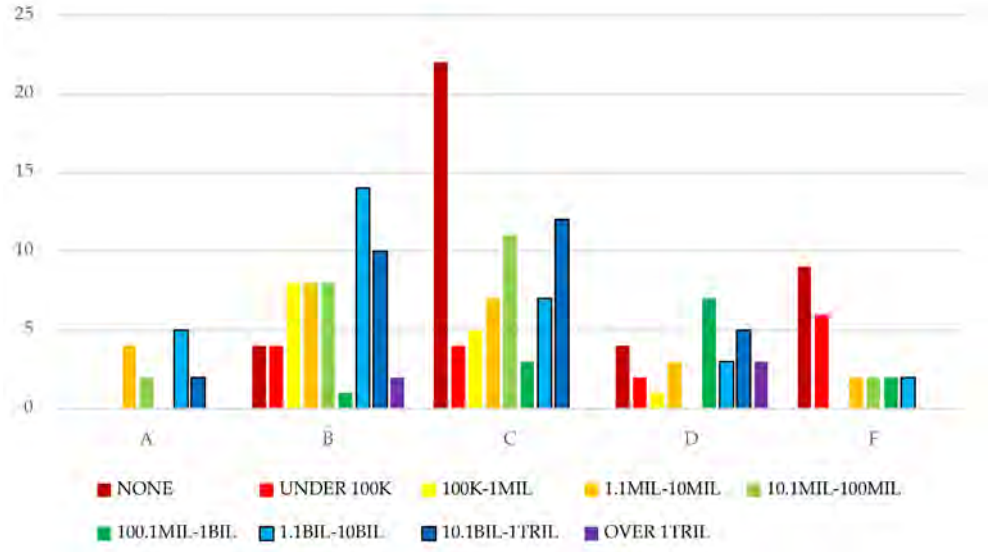

Figure 2. Distribution of student responses.
Note: Scores within a reasonable range (between 1.1 billion and 1 trillion) are shaded in blue and are outlined.

Table 2. Relationship between exam outcome and student response.

a. Model summary.

Model	*R*	R^2	Adjusted R^2	Std. error of the estimate
1	.043*	.002	–.003	1.751E12

b. Anova.†

Model		Sum of squares	*df*	Mean square	*F*	*p*-value
1	Regression	1.083E24	1	1.083E24	.353	.553*
	Residual	5.948E26	194	3.066E24		
	Total	5.959E26	195			

c. Coefficients.†

Model		Unstandardized coefficients		Standardized coefficients	*t*	*p*-value
		β	Std. error	β		
1	(Constant)	7.257E11	7.945E11		.913	.362
	Exam grade	–6.334E9	1.066E10	–.043	–.594	.553

Notes: * predictors: (constant), exam grade; † dependent variable: number guessed.

grade increases, the student's guess decreases by 6.3 billion, but, again this is not significant ($p = .553$).

Cognitive dissonance regarding speciesism and poor instruction might be partly to blame, but student individuality must also be considered. Presumably, students who scored higher were more likely to keep up with assigned readings, attend lecture regularly, and study in advance of exam time, while underestimations can be explained by lower student preparedness. Data overload was also a variable. Some students confused the number of non-humans killed in the United States (10 billion) with the number of those killed globally (65 billion), indicating that the lecture material had been absorbed, but simply confused or partially remembered. That one in five respondents did not even feel confident enough to hazard a guess is also telling. Some of these students may have declined to answer knowing that they could not recollect the exact number from lecture. Some may have skipped the day of lecture. Most of these students were C, D, and F students. No A students failed to answer, and only 7% of the non-responses were associated with B students.

Conclusion

While the dramatic results presented here would be troubling coming from any American demographic, that these results derive from *university students* who have been exposed to lecture material on speciesism in the food system is especially indicative of powerful sociological and psychological barriers to food literacy. University students are expected to have an edge over the general population given that they are trained in critical thinking and are exposed to fundamental concepts of social justice as part of the liberal education provided by most American universities. The results of this study conflict with research that finds food literacy to be positively associated with education. Students are a privileged group, and yet the students in this study remain grossly ignorant of actual killing levels. No control group was utilized in this study, but seeing that so many students estimated non-human animal killing at such low levels, it would be difficult to imagine that students not exposed to the lecture could score much worse. Additional research into the knowledge base of the general public would presumably identify similar, if not poorer, literacy levels. Educators and policymakers must be prepared for diverse audiences and constituents. They must also presume profound ignorance to the truth.

Obviously, most consumers *do* realize that non-human animals must be killed to produce the food that humans eat. Most also have at least a vague understanding that animal agriculture is a stressful, painful and unfair experience for other animals. The results here indicate that awareness of the degree to which this killing takes place is lacking. Complicating this consciousness is the problem that most consumers are not clear on how to link up knowledge and attitudes with the appropriate behaviour (Prunty and Apple, 2013; Cornish et al., 2016). Social movements and educators are fighting to present an alternate view of the social world with the support of scientific evidence, only to be rebuffed by the more powerful forces of social psychology and structural invisibility wielded by industry, state and other agents.

Nonetheless, psychological research does suggest that exposure to a multitude of scientific sources can improve the audience's ability to think critically and acknowledge conflicting information (Stadtler et al., 2013), thus suggesting that greater media and scientific literacy could improve food literacy. Humane educators and policymakers would be advised to explore sustained intervention efforts as opposed

to one-time-only or sporadic techniques. When I debriefed my students after the test and placed their low numbers into context, most students smiled and laughed when they realized how unrealistic their guesses had been. At least for my student respondents, participation in this study may increase their scientific proficiency and put a dent in their dissonance. Additional research on effective strategies of enlightenment and persuasion will be needed to illuminate mechanisms of change and resistance in consumption patterns.

Notes

1. Here the terms referring to sight and vision are intended to be metaphorical in keeping with Pachirat's language; however, this unnecessarily excludes visually impaired persons who also have relationships with non-human animals. For this reason, Cole and Stewart (2014) advocate language of 'sensibility' over 'visibility', particularly as sight is only one way of experiencing other animals.
2. More information on humane education is hosted by the Institute for Humane Education and the Animals and Society Institute.

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Challenges and Opportunities for Market Integration to Improve Food Security among Smallholder Farming Households in Western Kenya

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Abstract. African smallholder farmers produce food both for home consumption and commercial purposes, but these farmers are often net food buyers in local markets. To what extent do markets play a role in making food available and accessible throughout the year? This study assessed: (a) the extent of smallholder farmers' involvement in market trading networks, and (b) the role of markets in access to food at household level. All plant and animal species grown or reared for food were inventoried on 30 smallholder farms in six villages of Mumias District and Vihiga District, Western Kenya. A survey of available food products was conducted in three markets in Mumias and four markets in Vihiga near the surveyed farms. The market was the main source for cereals in both districts, while in Mumias District, fruits and animal source foods were also mainly sourced from markets. Regarding market trading systems, 15% of the 48 food products were sold by the farmers, 10% were sold by small-scale traders, while 75% were sold by large-scale traders. The study shows that local markets are mainly utilized by market traders who bring produce from outside the study areas. To increase incomes to enable access to diversified foods, organized smallholder farmers can be integrated better in the local market system, in two key ways: (a) by tapping into increasing market demand for 'niche' products uniquely available through on-farm production, and (b) by value addition of farm produce lost at post-harvest to increase year-round availability of diversified foods.

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Introduction

Unlike in the developed countries where close to 15% of total income is devoted to food (Regmi and Meade, 2013), spending on food represents 50–80% of developing country consumers' budgets (Smale et al., 2009). The population of Eastern and Southern Africa is predominantly rural (Barrett, 2008), with 60–80% of the rural households, including a large proportion of smallholder farmers growing food crops, being net food buyers of the same crops they grow (Mehra and Rojas, 2008; Barrett, 2008; Smale et al., 2009). This is mainly because they are unable to meet the subsistence needs of their families through their own production and must purchase the remainder, usually at higher prices (Smale et al., 2009, 2012). Due to dependence of rural households on market purchase for food supply, in some cases making up to 90% of all the food consumed (Baiphethi and Jacobs, 2009), markets play a crucial role in achievement of household food security. With the scarce cash directed towards meeting staple food needs first in rural markets (Smale et al., 2009; Thorne-Lyman et al., 2009), household food transfers (Baiphethi and Jacobs, 2009) and subsistence production (Aliber and Hart, 2009; Baiphethi and Jacobs, 2009) enhance accessibility to affordable foods.

While the majority of smallholder farmers prioritize subsistence production as a household food security strategy, agricultural production that raises household incomes is critical to guarantee longer-term food security and improve well-being (Mehra and Rojas, 2008). To guarantee both household food consumption needs and market demand, surplus agricultural output needs to be generated (Omiti et al., 2009). Surplus smallholder farmers comprise of 20–30% of rural households while an additional 10–15% of rural households are net deficit producers who nevertheless sell a proportion of their crop soon after harvest (Poulton et al., 2006a), when prices are at their lowest. Crop sales by poor households occur straight after harvest because they are desperate for cash, hence these 'distress sales' are driven by short-term survival needs (Leavy and Poulton, 2007) rather than a longer-term focus on farming as a business enterprise.

For smallholder farmers selling their produce in formal markets, there are many steps in the value chain to take the product from producer to consumer (KIT and IIRR, 2008). Smallholder farmers who are unable to supply directly to wholesale or retail markets sell their produce to spot market traders (Rao and Qaim, 2010; Wiggins, 2012), who act as market intermediaries. Travelling traders, including many part-time traders who spend most of their time farming, meet the farmer at their farm to collect and pay for the produce in cash. Until the trader sells the produce to someone else, they must bear all costs and any unpredictable losses that may occur while the produce is under their ownership (KIT and IIRR, 2008). Although traders specialize in marketing the produce (Collier and Dercon, 2014), the majority of smallholder farmers regard them as 'middlemen' who gain profits for themselves along the value chain, while paying farmers poor prices for their produce (Wiggins, 2012). With this suspicion, cooperation between smallholder farmers and traders is relatively underdeveloped and this could be closely related to lack of market access for smallholder farmers (KIT and IIRR, 2008). Lack of formal market access is also associated with poor infrastructure together with long distances to markets and poor access to information on prevailing market produce prices (Delgado, 1999; Leavy and Poulton, 2007; Alene et al., 2008). These poor conditions translate to high exchange costs, which are usually too high for smallholder farmers to enable many transactions to take place (Delgado, 1999; Alene et al., 2008). Households have dif-

ferent abilities to mitigate these market transaction costs, resulting in differential market participation among smallholder farmers (Alene et al., 2008), with a majority of the farmers in low-income rural areas opting out of markets (Barrett, 2008) as market product sellers.

It is acknowledged that in cases when smallholders engage in markets, they only trade in small volumes. However, there exists a knowledge gap on the extent of smallholder farmer involvement in market trading networks, especially in regions with good market access. Secondly, although on-farm food production is insufficient to meet smallholder farming household food needs and markets have been shown to be important for sourcing mainly staple food grains (Jayne et al., 2006), there exists a gap in knowledge of the diversity and amounts of other food groups also sourced from markets, in addition to other food channels. To address these two knowledge gaps, this study addresses two research questions:

1. To what extent are smallholder farmers integrated into the market trading networks for selling their produce in regions with good market access?
2. What is the role of markets in access to food at household level among smallholder farmers?

Methodology

Study Area and Data Collection

Primary market data were collected in September and October 2012, while farm data were collected both in September/October 2012 and November/December 2012 in Mumias and Vihiga districts, Western Kenya. Mumias and Vihiga districts mainly represent the humid Lower Midland (LM1) and Upper Midland (UM1) agroecological zones, respectively (Jaetzold et al., 2005). The selection of Mumias and Vihiga districts as study sites was with an aim to represent different agroecological zones, and thus most likely a different level of agro-biodiversity, with an added advantage of geographical closeness to each other and both regions being close to local markets. Table 1 shows details on geographical, climatic and agricultural characteristics of the two districts.

Smallholder farm sizes in Kenya mainly range from below 0.2 to 3 ha, according to the Government of Kenya's (2010) estimates. The current policy framework governing the Kenyan land sector, in particular the *Sessional Paper No. 3 of 2009 on National Land Policy* (NLP), recognizes three categories of land: community land (previously referred to as trust land), public land (formerly referred to as government land) and private land (Government of Kenya, 2009). The NLP offers a wide array of incentives with the aim of ensuring land tenure security, such as security on community land as well as the acquisition of land rights by inheritance, with or without a will. In our household surveys, various forms of land ownership were reported by smallholder farmers. The majority (97%) owned private land (90% owned inherited land, while 7% had bought their land) while only 3% occupied community land. More than half of the households (63%) possessed land title deeds, which were registered mainly under the name of their in-laws, generally under the name of a member of the family of the head of household (57% of the households) or that of the wife's family (7% of households). Title deeds with the name of the nuclear family's head of household were reported for only 3% of the surveyed households. The remainder of the respondents (33%) did not know the names used in their household's title deeds.

Table 1. Overview of geographical, climatic and agricultural characteristics of Mumias and Vihiga districts, Western Kenya

Characteristic	Mumias District	Vihiga District
AEZ	Lower Midland (LM1)	Upper Midland (UM1)
Altitude	1300–1500 metres above sea level	1500–1900 metres above sea level
Annual mean temperature	21.0–22.2°C	18.5–21.0°C
Total annual rainfall	1650–1850 mm	1800–above 2000 mm
Rainfall pattern	Bimodal with long rains from end of February to end of March and short rains from end of July to November/December	Bimodal with long rains from end of February to end of March and short rains from mid-July to November/December
Soil types	Ferrasols	Combination of cambisols and lithosols
Main crops	Cash crops: sugarcane Food crops: sorghum, cassava, sweet potatoes	Cash crops: tea, coffee, sugarcane Food crops: maize, beans, cowpeas

Source: Jaetzold et al., 2005.

This study was conducted in tandem with a larger, cross-sectional research project entitled 'Improving Nutrition through Local Agrobiodiversity'. It purposefully selected six villages in order to cover the above-mentioned different climatic zones, three villages in Mumias and three in Vihiga districts, out of 30 villages from the larger study. The latter were sampled according to district village lists with number of households per village applying a 'probability proportional to size' approach (Magnani, 1997), with larger villages given a greater chance of selection than smaller villages. A total of 30 households, 15 in Mumias and 15 in Vihiga districts, in the six villages (five households per village) were then randomly selected to represent 10% of the 300 households sampled by the larger study. In both September/October 2012 and November/December 2012, the same smallholder farming households were surveyed.

Smallholder farmers participated in the selection of major local markets near the surveyed farms in Mumias and Vihiga districts. The average walking distance to the nearest major local market was 30 minutes (ranging from 5–60 minutes). Seven major local open-air markets, three in Mumias and four in Vihiga districts, were surveyed on seven non-consecutive market days. Simple random sampling was adopted to select market traders to be interviewed (Abukutsa-Onyango, 2002) in all the different market stands with an aim of sampling the whole market. With this, at least 10% of market stands representing each food group were randomly sampled for the market trader interviews. In those cases where the market trader randomly selected was unavailable to answer the questions, a different market trader representing the same stand was purposefully sampled (Abukutsa-Onyango and Onyango, 2005). A total of 65 market traders representing 65 different stands were interviewed. Figure 1 shows a map of the two study areas, indicating the six villages and seven markets where the survey was carried out.

All present food plant and livestock species were inventoried per farm by recording species names and counting individuals of each species. On each farm, the head of household or his/her representative was interviewed using a semi-structured questionnaire to collect data on: (a) basic demographic and socio-economic house-

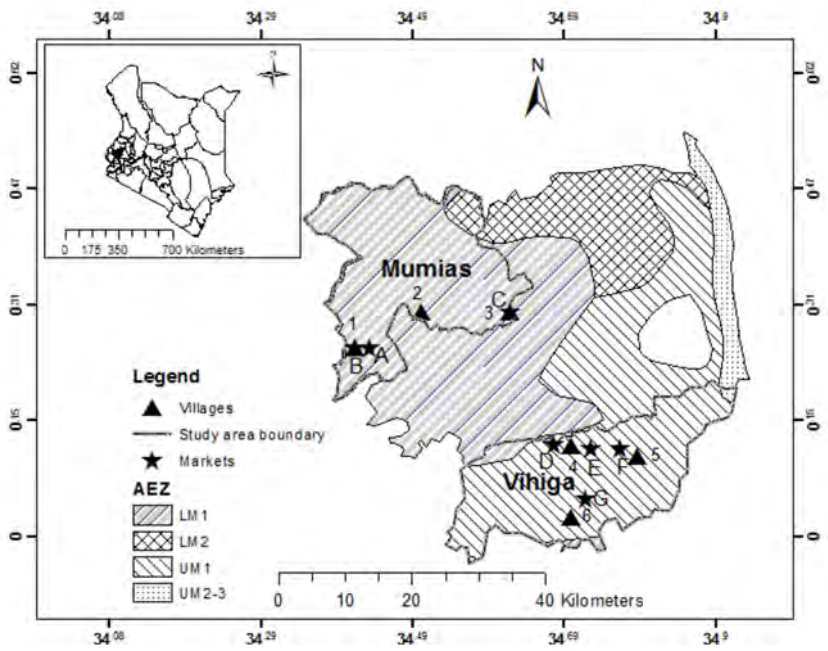

Figure 1. Map of study area in Western Kenya.
Notes: Mumias District is categorized as humid Lower Midland (LM1), Vihiga District is categorized as humid Upper Midland (UM1) agroecological zones; the village (triangle symbols) codes: 1. Khushipari A, 2. Emahanga , 3. Busokho, 4. Hombala, 5. Wambenge, 6. Lodondo; the market (star symbols) codes: A. Buhuru, B. Mumias, C. Makunga, D. Kilingili, E. Mudete , F. Chavakali, G. Majengo.

hold characteristics; (b) names, production, and uses of food plant and livestock species produced on the farm; (c) products of plant and livestock species consumed by households. In addition, during November/December 2012, respondents reported the source of the foods that they consumed within the household for the last five times. This time span ranged from the last 24 hours to the last few months, depending on the food items. During the November/December 2012 survey, farmers also reported specific walking distance approximations to the nearest market and the frequency of nearest market visits in a month. The market survey was utilized to capture market food biodiversity available for purchase by smallholder farmers and sources of the market produce. A semi-structured questionnaire was utilized to collect market data, in September and October 2012, on: (a) edible food species available, (b) sources of produce, (c) prices of different foods, and (d) seasonal availability of these foods.

Data Analysis

All present on-farm and market food plant species were assigned to one out of the seven major FAO-defined food plant groups, according to statements on their main use (FAO, 2011). Simple descriptive statistics such as means, frequency counts and percentages were computed to characterize farms and markets according to species richness and abundance, as well as the proportions of market produce sold by dif-

ferent types of market traders.

There were species identification challenges in the local markets when identifying leaves of the following local vegetables: (a) *Amaranthus cruentus* ssp. *hybridus* and *Amaranthus hybridus* complex (collectively classified as *Amaranthus* species) (b) *Corchorus acuntangulus*, *Corchorus olitorius*, *Corchorus trilocularis* and *Corchorus tridens* (collectively classified as *Corchorus* species) (c) *Cucurbita maxima* and *Cucurbita moschata* (collectively classified as *Cucurbita* species) (d) *Solanum villosum*, *Solanum scabrum* and *Solanum americanum* (collectively classified as *Solanum* species) (e) *Crotalaria ochroleuca* (classified as *Crotalaria* species). Although it was possible to obtain specimens of some unidentified plants for proper identification, plant identification at the species level was in some cases still challenging, especially with the different *Amaranthus* species. In most cases, however, it was possible to identify species while conducting the farm survey, where higher diversity among these species was documented (Maundu et al., 1999). For the sake of consistency and comparability of market and farm species, all the above-mentioned species were taxonomically classified in one of the five respective groups.

Results

Profile of the Local Markets and Market Traders

The seven open-air markets have at least one market trading day. There are two daily markets (Makunga and Majengo markets), one biweekly market (Mumias market) and four weekly markets (Buhuru, Mudete, Kilingili and Chavakali markets). Four of the seven markets (Chavakali, Majengo and Mudete markets in Vihiga District and Mumias market in Mumias District) are municipal council markets, centrally located in rural town centres where local administrative offices are based while the others are rural markets (Table 2). Trading in all the seven local markets is subject to daily market trading fees and taxes, ranging from US$0.3 to US$1, mainly depending on the quantity of produce to be traded. Buhuru rural market in Mumias District had the highest number of different produce (30) mainly because it is a mixed market trading in live animals, animal source foods and a variety of farm produce (Table 2).

All the seven markets in the two districts are readily accessible by tarmac roads, except Buhuru rural market, which is accessible by gravel road. This makes it inaccessible during wet weather due to the slippery nature of the road, yet it had the highest number of different types of produce out of the seven markets surveyed. In Mumias District, the average walking distance to the nearest market is 37 minutes, with an average of 10 market visits per month for each household. In Vihiga District, it takes an average of 32 minutes to walk to the nearest market, with an average of eight market visits per month per household.

Out of the 65 market traders interviewed, 40% were male and 60% were female traders. A majority (97%) of the female traders, with an average age of 39 years, were owners of the stands while 62% of the male traders, with an average age of 32 years, owned the stands. Both female and male traders had been in the market trading business for an average of at least 10 years. Slightly more than half of the female traders (51%) and 31% of male traders sold a variety of produce on one stand, ranging from two to seven different food groups. Vegetables, followed by fruits, were the most popular combinations in the mixed market stands. The rest of the market trad-

Table 2. Frequency of products in seven markets in Mumias and Vihiga districts, Western Kenya, September/October 2012.

Food group	Frequency of food products in Mumias markets						Frequency of food products in Vihiga markets								Overall frequencies
	Buhuru Rural		Mumias Municipal		Makunga Rural		Mudete Municipal		Majengo Municipal		Kilingili Rural		Chavakali Municipal		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	%
Animal source foods	7	23	1	4	3	13	3	11	3	11	3	12	3	11	12
Cereals	3	10	0	0	3	13	3	11	2	7	4	15	2	7	9
Fruits	3	10	6	25	3	13	3	11	2	7	3	12	6	22	14
Pulses/nuts/seeds	5	17	1	4	5	21	2	7	2	7	3	12	2	7	11
Starchy roots/ tubers/green bananas	2	7	1	4	2	8	2	7	2	7	3	12	2	7	8
Vegetables	10	33	15	63	8	33	12	44	14	50	7	27	10	37	41
Spices/condiments	0	0	0	0	0	0	2	7	3	11	3	12	2	7	5
Total produce	30	100	24	100	24	100	27	100	28	100	26	100	27	100	100

ers specialized in particular market products, mainly selling animal source foods. Among female traders, chicken-only and fish-only stands were most popular while cattle-only stands were the most popular among male traders. Sixty different plant and animal species were documented on the surveyed farms while 48 different food products were available in the local markets (Table A1).

There was an overlap of 58% of on-farm products that were also available in the markets. 'Niche' products unavailable in the local markets but uniquely available through on-farm production comprised of one animal source food, 12 fruits, three pulses/nuts/seeds, three starchy roots/tubers/green bananas and three vegetables (Table 3).

Main Foods Available in Markets and for Household Food Consumption

The different food types available in all the markets and farms were grouped into eight of the major FAO-defined (2011) food groups, namely: (i) cereals, (ii) fruits, (iii) pulses/nuts/seeds, (iv) starchy roots/tubers/green bananas, (v) vegetables, (vi) spices/condiments, (vii) animal source foods, and (viii) high-sugar foods. In the context of this study, the high-sugar food refers to sugarcane (*Saccharum officinarum*), found on farms but not in the local markets surveyed. During the September/October 2012 market survey, vegetables had the highest availability in all the markets, with a frequency of 41%, followed by fruits (14%), animal source foods (12%), pulses/nuts/seeds (11%), cereals (9%), starchy roots/tubers/green bananas (8%), and spices/condiments (5%) (Table 2). The vegetable food products available in all the markets were bulb onions (*Allium cepa*), white cabbages (*Brassica oleracea* var. *capitata*), African kale (*Brassica oleracea* var. *acephala*) and tomatoes (*Solanum lycopersicum*). *Amaranthus* species, *Solanum* species and cowpea leaves (*Vigna unguiculata*) were available in six out of the seven markets.

Markets also play a role in contributing to household food consumption of smallholder farmers throughout the year. During the last five times a certain food group had been consumed at the household level, the market was the main food source for cereals in both Mumias and Vihiga districts while in Mumias District, fruits and animal source foods were also mainly sourced from markets. In Vihiga District, a considerable proportion of fruits, animal source foods, starchy roots/tubers/green bananas and spices/condiments were sourced from family and friends. In both districts, the four key food groups sourced from farms were vegetables, spices/condiments, pulses/nuts/seeds, and starchy roots/tubers/green bananas (Figure 2).

On-farm food production by smallholder farmers is mainly for home consumption, though some proportion is also utilized for commercial purposes. This is through both formal and informal market channels (Figure 3), with the latter mainly through barter within the community. Formal market channels are mainly utilized for selling cash crops, mainly tea (*Camellia sinensis*) in Vihiga District and sugarcane (*Saccharum officinarum*) in Mumias District, classified as spices/condiments and a high-sugar food, respectively. The proportion of pulses/nuts/seeds that are sold through in-kind exchange is equal or higher, compared to those sold through formal market channels in Mumias and Vihiga districts (Figure 3).

Pre- and Post-harvest Losses

Some of the on-farm produce for either home consumption or for selling in both

Table 3. Overlaps and gaps in products available in seven markets and on 30 farms in Western Kenya, between September and October 2012

Food group	Overlaps in products available in markets and farms	Products available only in markets or farms	
		Market-only products	Farm-only ('niche') products
Animal source foods	Cattle	Fish	Rabbit
	Chicken		
	Goat		
	Sheep		
	Pig		
Cereals	*Sorghum bicolor*	*Eleusine coracana*	
	Zea mays	*Oryza sativa*	
		Triticum aestivum	
Fruits	*Ananas comosus*	*Citrullus lanatus*	*Annona muricata*
	Citrus limon	*Citrullus sinensis*	*Carica papaya*
	Mangifera indica		*Dovyalis caffra*
	Musa sapientum		*Eriobotrya japonica*
	Persea americana		*Morus alba*
			Passiflora species
			Passiflora edulis
			Physalis peruviana
			Psidium guajava
			Solanum betaceum
			Syzygium cuminii
			Vitex doniana
Pulses/nuts/seeds	*Arachis hypogaea*		*Cajanus cajan*
	Glycine max		*Lens culinaris*
	Phaseolus vulgaris		*Vigna subterranea*
	Sesamum indicum		
	Vigna radiata		
Spices/condiments	*Capsicum annuum*	*Allium sativum*	*Camellia sinensis* (sold in other markets)
		Coriandrum sativum	*Coffea arabica* (sold in other markets)
		Zinziger officinale	
		Starchy roots/tubers/ green bananas	
	Ipomoea batatas		*Colocasia esculenta*
	Manihot esculenta		*Dioscorea bulbifera*
	Solanum tuberosum		*Musa paradisiaca*
Vegetables	*Allium cepa*	*Brassica oleracea* var. *capitata*	*Cleome hirta*
	Allium fistulosum	*Spinacia oleracea*	*Basella alba*
	Amaranthus species		*Erythrococca bongensis*
	Brassica carinata		
	Brassica oleracea var. *acephala*		
	Cleome gynandra		

Table 3 *cont.*

Food group	Overlaps in products available in markets and farms	Products available only in markets or farms	
		Market-only products	**Farm-only ('niche') products**
Vegetables	*Corchorus* species *Crotalaria* species *Cucurbita* species *Daucus carota* *Solanum lycopersicum* *Solanum melongena* *Solanum* species *Vigna unguiculata*		
High-sugar foods			*Saccharum officinarum* (sold in other markets)

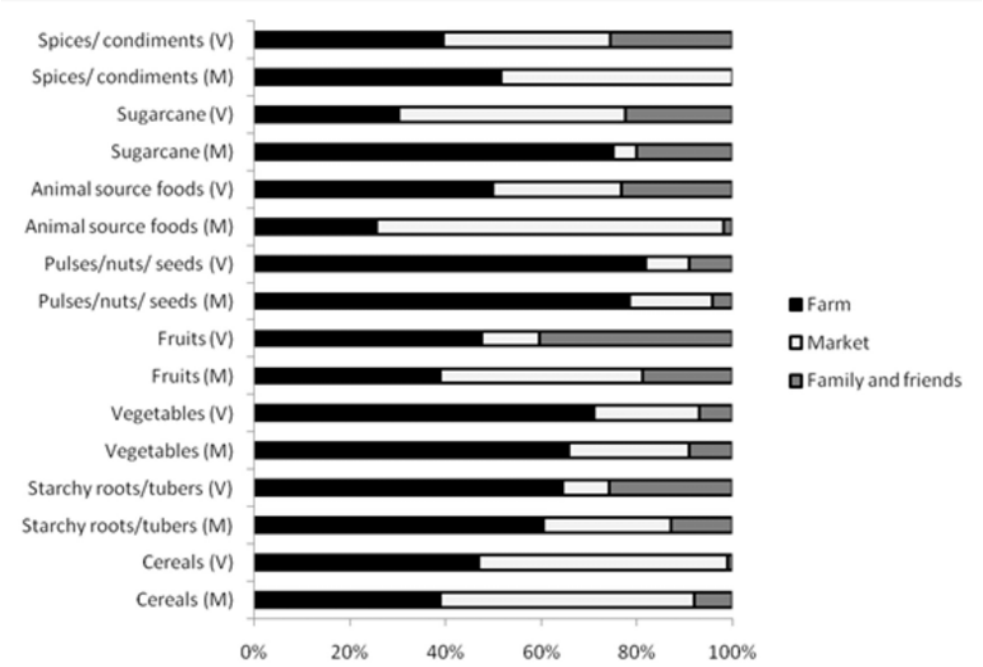

Figure 2. Food sources for the different food groups given as the last five consumptions among households in Mumias (M) and Vihiga (V) districts, November/December 2012, N = 30 (15 per district).

formal and informal markets is lost through pre- and post-harvest losses. Between January and December 2012, 10% of the smallholder farmers had experienced pre-harvest food losses while 37% had experienced post-harvest food losses. Although negatively affecting a small proportion of smallholder farmers, these farmers men-

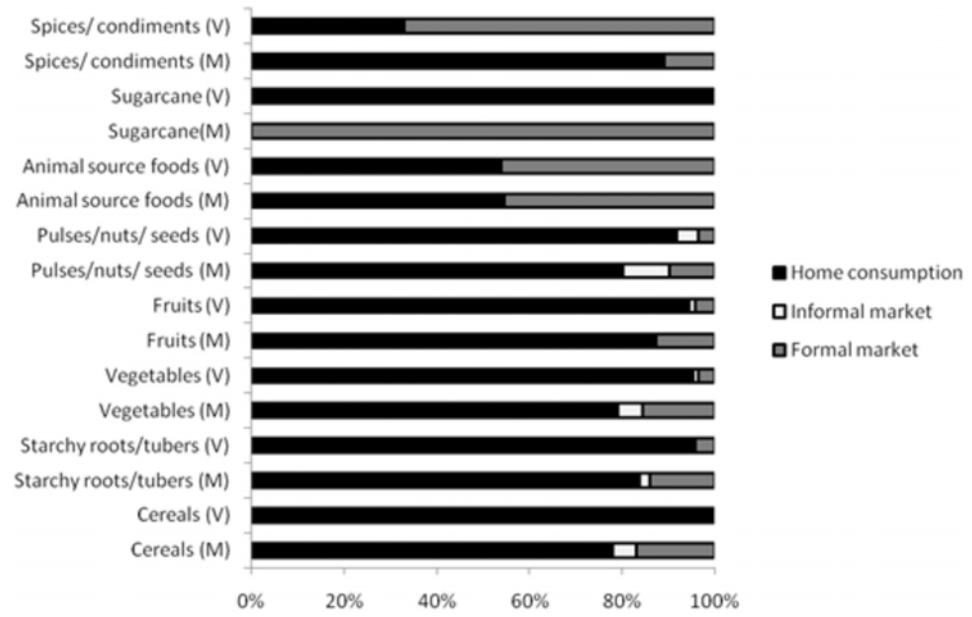

Figure 3. Main food uses of on-farm products among households in Mumias (M) and Vihiga (V) districts, September/October 2012, N=30 (15 per district).

tioned that 'hail stones' are mainly responsible for pre-harvest food losses of a diversity of on-farm crops in Vihiga District, a more humid region. In both Vihiga and Mumias districts, post-harvest food losses are mainly due to poor markets for surplus fruits and vegetables, followed by poor storage conditions of cereals.

In January and December 2012, the main foods lost were fruits and vegetables but also pulses and cereals. The key fruits affected were guavas (*Psidium guajava*), avocados (*Persea americana*) and mangoes (*Mangifera indica*). During high harvest seasons, the quantity of fruits is too much for household food consumption and they would sometimes be left to rot and also birds would eat and spoil the ripe fruits. This post-harvest loss is mainly because there is low market demand for seasonal fruits in high supply. One farmer reported that when fruits are available in high quantities, the market price for a 50 kg bag of avocados can be as low as US$0.4. Within one month of high vegetable harvest, a different farmer experienced losses of cowpea leaves (*Vigna unguiculata*), African kale (*Brassica oleracea* var. *acephala*), Jew's mallow (*Corchorus* species) and slender leaf (*Crotalaria* species), due to poor market prices as they were too much for both household and livestock consumption. The main cereal affected by post-harvest loss is maize, due to aflatoxin contamination as a result of storage of the cereal in damp conditions. According to the farmers, a main cause of pre-harvest food loss in Vihiga District is excessively cold conditions resulting in 'hail stones' that destroy on-farm crops. For example, in September and November 2012, a diversity of on-farm crops, including cowpea leaves (*Vigna unguiculata*), fruit bananas (*Musa sapientum*), avocados (*Persea americana*) and guavas (*Psidium guajava*),

had been destroyed.

Participation in Local Market Trading System

While the geographical and sociocultural settings in formal markets are of trading between smallholder farmers and interested buyers (whether known or unknown) in open-air markets, informal markets are characterized by in-kind exchange of farm produce by smallholder farming households (mainly to known buyers, such as family and friends) away from designated market places. Although smallholder farmers have surplus on-farm produce and engage mainly in informal market channels, their involvement in formal market channels is minimal. The only market produce smallholder farmers were selling directly were milk, *Amaranthus* species, African kale (*Brassica oleracea* var. *acephala*), sweet potatoes (*Ipomoea batatas*), avocados (*Persea americana*), groundnuts (*Arachis hypogaea*) and common beans (*Phaseolus vulgaris*), the latter three being a produce from only one smallholder farmer (who was selling their on-farm produce at the market). Fifteen per cent of the 48 food products were sold by smallholder farmers (who were also part-time market traders), 10% were sold by small-scale/travelling traders (who directly sourced their products from local smallholder farmers), and 75% of the products were sold by large-scale traders/wholesalers, who did not directly source their products from smallholder farmers but rather sourced their products from small-scale traders, large-scale farmers from within the district, other districts and from neighbouring countries. The food groups 'fruits', 'pulses/nuts/seeds' and 'starchy roots/tubers' were mainly sourced from neighbouring countries such as Uganda (Table 4).

Discussion

Smallholder Farming Households Rely on Multiple Food Sources

This study shows that smallholder farmers rely on farms, markets and existing social networks such as family and friends in meeting household food consumption needs. This finding corroborates with a study in the Amhara region of Ethiopia where the three most common ways of food acquisition among rural households are on-farm production, purchase from markets and gifts (Negatu, 2004). There is a general consensus that rural households mainly access food through subsistence production, markets and household transfers (Baiphethi and Jacobs, 2009), yet never through only one source.

On-farm Production as a Food Source

In the study sites, smallholder farms are essential in meeting household food needs for a number of food groups that are also highly available in markets. While reducing reliance on markets for most household food consumption needs, these foods also affordably provide diverse nutritional value. The main strategy employed by the smallholder farmers to reduce unnecessary market visits is by consumption of alternative foods available through on-farm production, such as seasonally available fruits and starchy roots/tubers/green bananas. In this study, though oranges (*Citrus sinensis*) were the most highly available fruits at the local markets, fruits that

Table 4. Types of market traders and origin of products in the seven markets in Mumias and Vihiga districts, September/October 2012.

Food group	Type of market trader	Origin	
Animal source foods	A, B	A	Market trader's farm
		B	Within district, Other districts (Kakamega, Kisumu, Busia, Luanda, Lodwar, Nandi)
Cereals	B, C	B	Within district, Other districts (Busia ,Kitale, Nandi, Eldoret, Busia, Kapsabet, Kisumu)
		C	Someone's farm
Fats and oils	B	B	Within district
Fruits	A, B, C	A	Mumias
		B	Other districts (Kakamega, Kisumu, Bungoma, Siaya, Machakos and Kitui, Marakwet, Mombasa), neighbouring countries (Uganda, Tanzania)
		C	Chavakali (Someone's farm), Mumias (Someone's farm)
Pulses/nuts/seeds	A, B	A	Buhuru
		B	Other districts (Busia, Kakamega, Kisumu, Luanda, Nairobi), neighbouring countries: Uganda
Spices/condiments	B	B	Within district (Mumias, Majengo), Other districts (Bungoma, Kakamega, Kisumu, Mombasa, Nairobi)
Starchy roots/tubers/green bananas	A, B	A	Kisumu, Mumias
		B	Within district (Chavakali, Majengo), Other districts (Busia, Bungoma, Kakamega, Mount Elgon area, Kiambu, Marakwet, Nairobi, South Nyanza, Timboroa), neighbouring country (Uganda)
Vegetables	A, B, C	A	Mumias (market trader's farm)
		B	Within district (Mumias, Majengo, Makunga), Other districts (Kakamega, Kapsabet, Nandi, Mount Elgon area, Kisumu, Kitale, Luanda Mwea, Nairobi, Narok)
		C	Makunga (someone's farm), Kilingili (someone's farm)

were widely consumed by smallholder farming households were guavas (*Psidium guajava*), mangoes (*Mangifera indica*), avocados (*Persea americana*) and fruit bananas (*Musa sapientum*). With regard to starchy roots/tubers/green bananas, though potatoes (*Solanum tuberosum*) were widely available in local markets, they were not consumed by smallholder farming households. In the two study sites, smallholder farmers plant and consume more than one variety of cassava (*Manihot esculenta*) and sweet potatoes (*Ipomoea batatas*). The popularity of sweet potatoes and cassava (*Manihot esculenta*) for home consumption could be a survival strategy to acquire a cheap source of starchy roots and tubers. This finding on the popularity of the three cassava varieties, MM95/0183 ('Migyera'), 'SS4' and MM96/1872, for on-farm production corroborates with a study conducted among a cassava consuming community in Nambale, Western Kenya, reiterating the popularity of 'SS4' and 'Migyera', with the latter the most preferred variety for cooking (Nungo et al., 2012).

Although vegetables were the most frequently available food items in the local markets, smallholder farmers in both districts mainly relied on vegetables sourced from their farms during the November/December short rainy season. The high availability of vegetables in markets could be explained by a Western Kenya market study suggesting that market availability of a particular kind of vegetable is

associated with its high demand (Ekesa et al., 2009). Although smallholder farmers endeavoured to increase their vegetable self-sufficiency through farm production, adequate vegetable yields depend on many factors, including seasonality, implying that markets remain essential for year-round vegetable supply. At the same time, it is common to cook different vegetables together in one meal in Western Kenya, for example cowpea leaves (*Vigna unguiculata*) are mostly cooked together with Jew's mallow (*Corchorus* species) (Ekesa et al., 2009). Despite high-volume farm harvests of a local favourite vegetable during one season, crop losses may deplete a household's vegetable reserve. For example, one smallholder farmer growing Jew's mallow lost the entire crop within one month post-harvest, which could necessitate sourcing the vegetable elsewhere when desired for home consumption. In addition, farmers may not always grow all the different types of vegetables they consume in a meal themselves, necessitating them to access the other vegetables from alternative sources, including markets.

Markets and Social Networks as a Food Source

While farms are more important for sourcing a diversity of nutrient-rich food groups, markets play an important role in the provision of foods inadequately available through on-farm production, especially cereals. The importance of cereals is backed up by a study suggesting that staples are one of the main ingredients of most of the food that is consumed by rural households, and they rely on such staples for a large share of their daily calories (Smale et al., 2009). In Mumias and Vihiga districts, as in the rest of Western Kenya, dry maize grain is milled to produce a fine maize flour, which is used to make a cooked paste known as *ugali* (Mwololo, 2010), considered a staple and a delicacy among the Luhya community, the predominant community in the two study sites.

The importance of working social networks for food access is exemplified by sourcing of starchy roots/tubers/green bananas and fruits from family and friends in Vihiga District, though the percentages exchanged and consumed are lower than those sourced from on-farm production. Family and friends, who in most cases were also farmers, shared their produce with the smallholder farmers, whether the family and friends' produce was in surplus or not. Seasonally available fruits that were in high supply for smallholder farming household consumption, but in low demand at the local markets, were also shared among family and friends. A study conducted among smallholder farmers in Embu District of Eastern Kenya found that most (76%) of the farmers grow crops for home consumption rather than for the market, due to poor market prices (Stocking et al., 2003). This could be the case with green bananas (*Musa paradisiaca*), which were readily available through on-farm production and for smallholder farming household consumption, but were unavailable in local markets.

Smallholder Farming Households Rarely Sell Their Surplus On-farm Produce in the Formal Markets

Smallholder farmers grow on-farm produce for both home consumption and for commercial purposes. With the exception of sugarcane and spices/condiments, the highest proportion of a majority of the food groups were utilized for home con-

sumption, with the remainder sold. Apart from sugarcane in Mumias District and tea in Vihiga District, animal source foods are also sold in formal markets in addition to their utilization for home consumption. Animal source foods sold in formal markets are mainly cattle but also goats, sheep, rabbits and pigs, while chickens are reared by smallholder farming households mainly for their eggs. Though it has been suggested that poor smallholder farming households tend to sell rather than consume the animal source foods they produce (Allen, 2003; Dror and Allen, 2011; Smith et al., 2013), this applies mainly to large livestock, such as cattle, where sale could also contribute to household food security by providing income that can be used to purchase staple foods (Smith et al., 2013) or pay for non-food items such as school fees, household goods and repairs.

Though studies suggest that poor infrastructure leads to high transaction costs, which in turn limit the extent of smallholder farmer engagement in formal market exchanges (Omamo, 1998; Nagarajan et al., 2007; Dury et al., 2011), physical access to formal markets is not necessarily a limiting factor in this study. This is because both study sites are well connected to local markets mainly by tarmac roads, with the nearest local urban or rural market relatively close to the smallholder farming households. However, the smallholder farmers in this study still do not participate in formal market trading network as sellers, suggesting that it takes more than good infrastructure for rural households to engage and participate in formal markets (Omiti et al., 2009). While trading smallholder farm produce between households and relatives strengthens family relationships (Maroyi, 2009), informal market channels in this study were probably selected depending more on the type of market information a farmer has access to and the need to reduce market transaction costs. As in this study, though formal sources of market information such as newspapers and mobile phones are available in the rural areas, they are inaccessible to the majority of smallholder farmers who do not purchase or read newspapers on a regular basis (Omiti et al., 2009). While all smallholder farmers in this study either own or have access to a mobile phone, these phones are mainly for socializing and less frequently for communicating with potential buyers and discovering market prices (Mutabazi et al., 2013). Though travelling traders could serve as more accessible contacts on prevailing market prices, limited repeated transactions with these traders hamper long-lasting business relationships that facilitate insightful market information dialogues. Therefore, optimal use of the existing mobile phone technology could facilitate the building of relationships with market traders to improve smallholders' market access. However, the underdeveloped cooperation between market traders and smallholder farmers could also be because market traders seem more interested in having regular and consistently high-quality supplies (KIT and IIRR, 2008) whereas smallholder farmers trade mostly in small volumes of variable quality (Hazell, 2005).

Secondly, informal markets are characterized by lower transaction costs, as all trading of food crops and livestock in formal rural markets attracts fees and taxes (Ellis and Bahiigwa, 2003; Ellis and Mdoe, 2003). In addition to this, surplus pulses/nuts/seeds, a less perishable produce, was sold in both formal and informal markets in this study, with a preference for informal markets due to the flexibility of products and services that the produce could be traded for. For example, a farmer exchanged surplus soya beans (*Glycine max*) and groundnuts (*Arachis hypogaea*) for payment of their children's school fees. Informal selling of surplus on-farm produce, while offering flexibility in the mode of payment, incurs little or no transaction costs as compared to transporting and selling produce in formal markets. Barrett et al. (2000)

suggest that when smallholder farmers participate in markets, they are engaged in low-return market activities, such as petty trading at weekly rural markets, mainly because they have little financial choice, which also applied to the situation in Western Kenya.

Market Traders Mainly Source Produce from Distant Areas

This study shows that the majority of the market produce is not sourced from within the region, which is confirmed by a Western Kenya study showing that most market products come from neighbouring districts, not from within the same area (Abukutsa-Onyango, 2002). This is partly because some produce, such as lemons (*Citrus limon*), oranges (*Citrus sinensis*) and animal source foods such as fish, are not produced in the local area, necessitating market traders to purchase such produce from neighbouring areas.

For locally available produce, three main observations explain why traders least source their market produce from local smallholder farmers, based on informal discussions with market traders. They concern quantity, price and quality. Firstly, while smallholder farmers are unable to consistently supply market traders with high quantities of produce, traders acquire sufficient quantities of plant produce from other readily accessible sources, which saves both time and money. Among smallholder farmers, surplus on-farm produce for selling is highly available immediately (one to two weeks) after the harvest season, after which the remaining quantities are reserved for home consumption. It could also be that as a result of many traders in search of the (same) produce, smallholder farmers run out of surplus stock for selling soon after harvesting. With high quantities unavailable for selling, traders in search of market produce would be required to search for produce from many different farmers to get desired quantities, which is time consuming. The same applies for animal source foods, where one trader remarked that in most cases, a trader can only get five chickens from five different local smallholder farmers while in other neighbouring districts where chicken rearing is common (such as Nandi district), they can get a hundred chickens from one source. Secondly, in cases where the produce is available in high quantities for a longer time span, for example sweet pepper (*Capsicum annuum*), few of the smallholder farmers will have the produce, and most likely having incurred high production costs, the produce can be quite expensive for traders to buy. In those cases, it is more profitable for market traders to buy such produce in places of high availability, even if in different districts or even countries. Thirdly, where the produce is highly available and affordable, it may be unsuitable for local markets. For example, many smallholder farmers harvest maize when it is too young, which is good for selling as roasted or boiled maize, but not suitable for selling as grain, as it is not preferred for grinding into maize flour. The low frequency of sourcing of produce from smallholder farmers further agrees with studies suggesting that smallholder farmers are rarely integrated in local markets (Rietbergen et al., 2002; Kruijssen et al., 2009) generally due to variability in the quantity and quality of their produce.

While smallholder farmers dealing in food crops and livestock in this study have poor access to markets, smallholder farmers growing the two main cash crops, sugarcane and tea, are well connected to domestic and regional markets. In Mumias, sugarcane smallholder farmers are offered institutional support through out-grower schemes, with farmers accessing a ready market, among other benefits (Govereh et

al., 1999). Similar producer support is mirrored by smallholder tea farmers in Vihiga District. In this study, though the smallholder farmers dealing in food crops and livestock lack formal institutional support, they also rarely organize themselves (formally or informally) to market existing produce or develop better markets for their produce. Organized farmers have the potential to enhance the quantity and quality of their produce, which in turn facilitates better cooperation with market traders, with traders offering higher prices and a loyal business relationship lasting years (KIT and IIRR, 2008).

Organized Smallholder Farmers Stand to Benefit by Filling in Market Gaps

Despite their current minor involvement as sellers in local market trading networks, smallholder farmers who get organized in the study sites could potentially benefit from better market integration, in two key ways: by filling in the local market gaps and by local product value addition. In the first instance, smallholder farmers have the capacity to fill in the market gaps by diversifying their on-farm produce to match produce available and in demand in the local markets. In this study, smallholder farmers do not currently produce in-demand food items uniquely available in local markets such as spices/condiments (*Allium sativum*, *Coriandrum sativum* and *Zinziger officinale*) and animal source foods. With changing tastes increasing rural and urban demand for some food products such as indigenous vegetables (Gotor and Irungu, 2010; Muhanji et al., 2011; Chege et al., 2015), organized smallholder farmers can also tap into these markets by introducing 'niche' products unavailable in markets but uniquely available through on-farm production, for example rabbits (Table 3). While rabbit-breeding was not practised commercially in the Western Kenya study sites during the survey period, smallholder farmers in some other parts of the country have established market linkages based on this niche product. While many Kenyans are unaware that rabbit meat can adequately substitute other protein sources (Borter and Mwanza, 2011), in 2009 a smallholder-run organization based in Central Kenya, the Rabbit Breeders Association of Kenya (RABAK), started their enterprise by addressing the misconceptions around rabbit meat consumption. They did so by educating community members on the nutritional and economic value of rabbit meat through extensive campaigns in annual national agricultural fairs, monthly local farmers' meetings and ad hoc media coverage. RABAK received a boost from one of the leading regional supermarket chains, supplying it with about two tonnes of rabbit meat every month to date, thus substantially increasing the farmers' market share. RABAK has also partnered with about six other collaborators offering many forms of support, including procurement of RABAK's rabbit fur, thus establishing the smallholder farmers' rabbit market niche (RABAK, 2014). Thus, while there is a need for various stakeholders to stimulate education on nutrition to help build market integration for smallholders based on their niche products, it is also likely that when organized smallholder farmers initiate such ventures, other interested stakeholders may eventually partner with them. This collaboration may in turn result in sustainable support schemes, such as food cooperatives (Jaklin et al., 2015). In addition, some of these food groups, including small ruminants and starchy roots, are subject to relatively few transaction costs (Delgado, 1999). Moreover, with diversification in early-maturing and late-maturing produce, some of these niche products unavailable on every farm around the same time could be sold for a good price and the profits utilized to meet household food needs. Further, when

vegetables, fruits and livestock products become more plentiful and cheaper, they could improve the nutritional status of households (Poulton et al., 2006b). However, there are still many risks associated with building markets for niche products. For instance, institutional support schemes depend not only on the product in question but also on the contrasting interests and power dynamics of these producer organizations (Varga, 2015).

In the second instance, preservation and value addition of surplus perishable products is a strategic market entry point for organized smallholder farmers, not only to increase farmers' incomes, but also to bridge hunger gaps during out-of-season periods. In this study, surplus fruits, vegetables and cereals are mainly lost through post-harvest losses. This is because most smallholder farmers produce their food items at the same time, resulting in high seasonal supply and low demand (Omiti et al., 2009). In this study, though few farmers (37%) are affected by post-harvest foods losses, the surplus seasonal produce that eventually makes it to the market fetches low prices, resulting from the limited ability of producers to store surplus produce (Weinberger and Lumpkin, 2007) especially in seasons of high availability. The issue may be more complex than limited storage facilities, as farmers often have little choice but to sell their produce immediately so as to meet their short-term cash needs (Godfray et al., 2010). However, through pooling of resources, seasonal surplus supply can be processed at different levels (factory, village, household, individual) and to different degrees (minimal, culinary, 'ultra-processing') (Monteiro and Cannon, 2010) into higher value produce with a longer shelf life, such as dried fruits and vegetables, which can fetch higher prices and meet food demands during seasons of food deficiency. For example, organized smallholder farmers in the Mgeta region in Tanzania market local goat's milk yoghurt through a semi-formal local goat farmers cooperative, which has a greater impact on improving their livelihoods than selling highly perishable surplus milk (Lie et al., 2012). Thus, reduction of food waste by value addition could contribute to increased food availability (Kader, 2003; Sagar and Kumar, 2010) as well as to rural development and poverty reduction by improving agribusiness livelihoods (Hodges et al., 2011).

Although this study is limited by identification of morphologically similar local vegetables in the local markets as well as by market and farm species identification down to variety level, the findings provide insights to addressing the challenges that smallholder farmers face in market participation, with an aim of increasing market integration for improved household food security.

Conclusions

Smallholder farmers with different farm and environmental settings utilize multiple channels of continuous food supply. Markets are more important for sourcing cereals, a staple food inadequately available through on-farm production, while their own farms are more important for sourcing a diversity of nutrient-rich food groups, with working social networks playing a supporting role. Although surplus on-farm produce for selling is seasonally available, smallholder farmers prefer to sell such produce in informal markets as they are associated with lower transaction costs. At the same time, market traders in formal markets mainly source their produce from distant areas, including other countries, due to the small and inconsistent volumes that smallholder farmers trade in. As a consequence, smallholder farmers are least integrated in formal markets. Improving smallholder farmer access to formal mar-

kets in general and to market traders in particular goes hand in hand with efforts in organizing smallholder farmers to fill in the local market gaps and to add value to surplus perishable products. This in turn holds the potential to increase food incomes and close out-of-season food and nutrition gaps. The increased incomes could enable access to diversified foods and reduce the need for food self-sufficiency, with an overall impact on improving household food security.

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Appendix

Table A1. List of food plant species (sorted by food-use groups), their scientific and common names, and their availability in seven markets and 30 farms surveyed in Mumias and Vihiga districts, Western Kenya, September/October 2012.

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part/product available)	Availability on farms (where applicable, animal part/product available)
Cereals					
1.	*Zea mays*	Maize	Mahindi	Available	Available
2.	*Eleusine corocana*	Finger millet	Mtama	Available	Unavailable
3.	*Oryza sativa*	Rice	Mchele	Available	Unavailable
4.	*Sorghum bicolor*	Sorghum	Mawele	Available	Available
5.	*Triticum aestivum*	Wheat	Wimbi	Available	Unavailable
Fruits					
6.	*Ananas comosus*	Pineapple	Nanasi	Available	Available

Table A1 *cont.*

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part/product available)	Availability on farms (where applicable, animal part/product available)
Fruits					
7.	*Annona muricata*	Soursop	Mtomoko	Unavailable	Available
8.	*Carica papaya*	Papaya	Paipai	Unavailable	Available
9.	*Citrus limon*	Lemon	Ndimu	Available	Available
10.	*Citrullus lanatus*	Watermelon	-	Available	Unavailable
11.	*Citrus sinensis*	Orange	Chungwa	Available	Unavailable
12.	*Dovyalis caffra*	Kei apple	–	Unavailable	Available
13.	*Eriobotrya japonica*	Loquat	Zabibu	Unavailable	Available
14	*Mangifera indica*	Mango	Embe	Available	Available
15	*Morus alba*	White mulberry	Mfurusadi	Unavailable	Available
16	*Musa sapientum*	Dessert banana	Ndizi ya kuivisha	Available	Available
17	*Passiflora* species	Granadilla	-	Unavailable	Available
18	*Passiflora edulis*	Passion fruit	Marakucha	Unavailable	Available
19	*Persea americana*	Avocado	Parachichi	Available	Available
20	*Physalis peruviana*	Cape gooseberry	-	Unavailable	Available
21	*Psidium guajava*	Guava	Pera	Unavailable	Available
22	*Solanum betaceum*	Tree tomato	Gogwe	Unavailable	Available
23	*Syzygium cuminii*	Java plum	Zambarau	Unavailable	Available
24	*Vitex doniana*	Black plum	Fudu	Unavailable	Available
Pulses/nuts/seeds					
25	*Arachis hypogaea*	Groundnut	Njugu karanga	Available	Available
26	*Cajanus cajan*	Pigeon pea	Mbaazi	Unavailable	Available
27	*Glycine max*	Soy bean	Soya	Available	Available
28	*Lens culinaris*	Lentil	Kamande	Unavailable	Available
29	*Phaseolus vulgaris*	Common bean	Maharagwe	Available	Available
30	*Sesamum indicum*	Sesame	Simsim	Available	Available
31	*Vigna radiata*	Mung bean / greengram	Ndengu	Available	Available
32	*Vigna subterranea*	Bambara nut	Njugu mawe	Unavailable	Available
Spices/condiments					
33	*Allium sativum*	Garlic	Kitunguu saumu	Available	Unavailable
34	*Camellia sinensis*	Tea	Chai	Unavailable	Available
35	*Capsicum annuum*	Chilli pepper	Pilipili	Available	Available
36	*Coffea arabica*	Coffee	Kahawa	Unavailable	Available
37	*Coriandrum sativum*	Coriander	Dhania	Available	Unavailable
38	*Zinziger officinale*	Ginger	Tangawizi	Available	Unavailable
Starchy roots/tubers/green bananas					
39	*Colocasia esculenta*	Taro	Nduma	Unavailable	Available

Table A1 *cont.*

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part/product available)	Availability on farms (where applicable, animal part/product available)
Starchy roots/tubers/green bananas					
40	*Dioscorea bulbifera*	Air potato	-	Unavailable	Available
41	*Ipomoea batatas*	Sweet potato	Kiazi kitamu	Available	Available
42	*Manihot esculenta*	Cassava	Mhogo	Available	Available
43	*Musa paradisiaca*	Cooking banana	Ndizi ya kupika	Unavailable	Available
44	*Solanum tuberosum*	Irish potato	Kiazi	Available	Available
Vegetables					
45.	*Allium cepa*	Bulb onion	Kitunguu	Available	Available
46	*Allium fistulosum*	Spring onion	Kitunguu cha kijiti	Available	Available
47	*Amaranthus* species	Amaranth	Mchicha	Available	Available
48	*Basella alba*	Indian spinach	Nderema	Unavailable	Available
49	*Brassica carinata*	Ethiopian cabbage	Kanzira	Available	Available
50	*Brassica oleracea* var. *acephala*	African kale	Sukuma wiki	Available	Available
51	*Brassica oleracea* var. *acephala*	(White) cabbage	Kabichi	Available	Unavailable
52	*Cleome gynandra*	Spider plant	Mkabili	Available	Available
53	*Cleome hirta*	Spider plant	Mkabili	Unavailable	Available
54	*Corchorus* species	Jew's mallow	Mlenda	Available	Available
55	*Crotalaria* species	Slender leaf	Mito	Available	Available
56	*Cucurbita* species	Pumpkin	Malenge	Available	Available
57	*Daucus carota*	Carrot	Karoti	Available	Available
58	*Erythrococca bongensis*	–	Shirieto	Unavailable	Available
59	*Solanum lycopersicum*	Tomato	Nyanya	Available	Available
60	*Solanum melongena*	Egg plant	Biringanya	Available	Available
61	*Solanum* species	Black nighshade	Mnavu	Available	Available
62	*Spinacia oleracea*	Spinach	-	Available	Unavailable
63	*Vigna unguiculata*	Cowpea	Kunde	Available	Available
High-sugar foods					
64	*Saccharum officinarum*	Sugarcane	Miwa	Unavailable	Available
Animal source foods					
65	*Bos taurus*	Cattle	Ng'ombe	Available (whole animal, milk, meat)	Available (whole animal, milk)
66	*Gallus gallus domesticus*	Chicken	Kuku	Available (whole animal, egg)	Available (whole animal, egg)

Table A1 *cont.*

No.	Scientific name	Common English name	Local Swahili name	Availability in markets (where applicable, animal part/product available)	Availability on farms (where applicable, animal part/product available)
Animal source foods					
67	*Tilapia* species	Tilapia fish	Samaki ya tilapia	Available	Unavailable
68	*Capra aegagrus hircus*	Goat	Mbuzi	Available (whole animal)	Available (whole animal, milk)
69	*Ovis aries*	Sheep	Kondoo	Available (whole animal)	Available (whole animal)
70	*Sus scrofa domesticus*	Pig	Nguruwe	Available (meat)	Available (whole animal)
71	*Oryctolagus cuniculus*	Rabbit	Sungura	Unavailable	Available (whole animal)

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Mimetic Quality: Consumer Quality Conventions and Strategic Mimicry in Food Distribution

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Abstract. Quality is a key dimension of markets and competition in advanced capitalist societies. While political economy recognizes the role quality plays for consumers' purchasing strategies, it is less attentive to quality as a contested field where symbolic struggles and strategic manoeuvring take place. We argue that the quality-based strategies of hybrid organizations in food distribution represent a combination of different worlds of quality and judgment devices. This combination defines a camouflage strategy through which conventional food distribution chains such as high-end supermarkets conquer specific zones of the quality space. We thus maintain that the quality strategies of these organizations are explicitly boundary-spanning. To be successful, hybrid organizations need to cover both new and traditional quality conventions, overcoming divisions among different worlds while maintaining a coherent profile. This effort requires a strategy that is able to leverage situation-specific cultural meanings quite independently from individual-level attributes.

Introduction

In economics, quality attributes differ on the ease with which consumers can unpack them (Nelson, 1970; Tirole, 1988). Search attributes can be verified at the time of the transaction (e.g. the colour of a wine), experience attributes can be assessed only after the transaction has taken place (e.g. the taste of a wine), credence attributes cannot be verified and are based on consumers' trust (e.g. whether wine is produced from organic grapes). Credence goods are key drivers for quality-based markets, where intangible dimensions of quality play a crucial role (Beckert and Aspers, 2011). In

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this article, we will argue that general references to 'quality as credence goods' are unsatisfactory from a sociological point of view. Quality, in fact, is a contested field where symbolic struggles (Pecoraro and Uusitalo, 2013) and strategic manoeuvring take place (Callon et al., 2002; Boltanski and Thévenot, 2006; Negro et al., 2007).[1] We will analyse this process with regard to food distribution, comparing alternative and conventional food chains. Alternative food networks (AFNs) are a wide-ranging body of practices dealing with food provisioning in a different way from the mainstream agri-food system (Murdoch et al., 2000). AFNs usually take the form of grassroots experiments aimed at reorganizing the food system along ethical, political, moral and health lines (Micheletti et al., 2004; Honkanen et al., 2006; Onozaka et al., 2010; Sassatelli, 2015). While giving a clear analytical definition of AFNs is difficult, these phenomena tend to rely on different forms of spatial, economic and social proximity between supply and demand (Kebir and Torre, 2012).

To detect mimetic strategies in the quality space, we argue that AFNs should not be analysed *in isolation* but along a continuum with conventional food networks. As recently suggested by Ponte (2016), there is an increasing dissatisfaction with neatly allocating empirical phenomena into one or another convention, moral order or stabilized compromise. A more accurate perspective would entail examining how consumers and producers simultaneously interact through multiple justifications (Boltanski and Thévenot, 2006), as opposed to selectively engaging in single worlds. Although this approach is not new theoretically, empirically it has 'rarely [been] taken into consideration' (Ponte, 2016, p. 20; see also Stamer, 2018). Strategic maneuvering of capitalist hybrid organizations within the quality space, we maintain, is a key element to single out the strategies that support capitalism's ability to *adapt* to new challenges and criticisms. The empirical analysis of consumer quality conventions in food distribution is our empirical case in point.

The article is structured as follows: in the first part, we set out the key concepts of our analytical framework at the crossroads of different but complementary bodies of literature, namely conventions theory, judgment devices and omnivorism. In the second part, we illustrate the research design, methods and data. In the third, we discuss the empirical findings. Finally, in the conclusions we go back to the research question and elaborate further on the key concept of *mimetic quality* at different analytical levels.

Theoretical Framework: Quality as a Contested Field

The consumption of symbolic goods and the commodification mechanisms of quality spaces are key elements for capitalism to flourish: not by covering existing needs but by eliciting new ones' (Streeck, 2016, p. 212). In this line, political economy admits that quality is one of the most important forces leading to the economic growth of firms and markets; however, as Reeves and Bednar emphasize (1994), searching for a distinctive definition of quality just yields inconsistent results (see also Gallarza et al., 2011). Quality, the argument goes, is not a static feature, defined once and for all. Rather, focusing on food cultures, we can argue that quality is 'fluid and malleable, and tends to shift as a good passes from one social context to another' (Murdoch and Miele, 2004, p. 159) and from one individual to another, as a result of the process of *qualification* carried out by every actor involved in the supply chain (Callon et al., 2002). In fact, as claimed by Callon and colleagues, the evaluation of the quality of food products depends on the interaction between two different dimensions, one

referring to the intrinsic attributes of goods – such as shape, color, taste, consistency – and one related to the extrinsic judgment of individuals (Callon et al., 2002; see also Murdoch and Miele, 2004, p. 159).

A consequence of this definition is that, in the *economy of quality*, prices and information are not enough to assess the worth of goods (see Callon et al., 2002; Beckert, 2016). Quality is first and foremost a *judgment* grounded on credence/trust useful to deal with the complexity of transactions. While we concur with the prominence of credence goods for quality-based markets, we nonetheless argue that references to credence goods simply shift the problem: where does credence/trust come from? Credence is a symbolic dimension that implies structures of meaning whose explanatory power needs to be accounted for (Beckert, 2009; Karpik, 2010). Moreover, how does this symbolic dimension matter in the analysis of markets and capitalism? As Wolfgang Streeck observes: 'a rising share of the goods that make today's capitalism economies grow would not sell if people dreamed other dreams than they do' (Streeck, 2016, p. 212). The 'worlds of quality conventions' perspective (Eymard-Duvernay, 1989; see also Sylvander, 1995; Thévenot, 1995; Biggart and Beamish, 2003; Boltanski and Thévenot, 2006; Borghi and Vitale, 2006; Stark, 2011; Ponte, 2016) provides a useful starting point to answer this question. Boltanski and Thévenot (2006) develop six 'worlds' of legitimate common welfare (inspirational, domestic, opinion/fame, civic, market and industrial worlds), which allow actors to reduce semantic uncertainty and facilitate coordination.[2] According to conventions theory,[3] price is the main management form of a particular market only if there is no semantic uncertainty about quality. When differences in prices directly express shared differences in quality, market coordination applies. But when price alone cannot translate quality, actors set up other conventions and forms of coordination. In domestic coordination, uncertainty about quality is solved through interpersonal trust (i.e. long-term social ties between actors). In industrial coordination, uncertainty is reduced through common enforceable standards. Civic coordination works where there is collective commitment to welfare and/or public interest. In the world of fame, uncertainty about quality is solved through public celebrity, and worth derives from the opinion of experts. Finally, in the inspired world, what is worthy is what cannot be controlled, what is felt in inner experience, manifested by feelings and passions and what rejects habits and routines (Ponte, 2009).

Convention theory has been summarized by Ponte (2016) in two main streams: the worlds of production framework (Salais and Storper, 1992; Storper and Salais, 1997) and the orders of worth approach (Boltanski and Thévenot, 2006). These two streams converge in Lucien Karpik's perspective, where orders of worth pair with different judgment devices that provide consumers with the knowledge to evaluate the 'worth of goods' (Karpik, 2010, p. 96).

Such devices can be differentiated in relation to the nature of the transmitted knowledge: we will thus have *personal devices* and *impersonal devices*. The former consist of networks of interpersonal relationships based on the personal and multiple interpretations of reality that are spontaneously generated and network based. The latter convey a different kind of knowledge, unmediated by direct experience and therefore homogeneous for all consumers (certifications, guides, rankings). Both personal and impersonal devices generate specific coordination regimes: personal devices support reticular regimes, professional regimes and interfirm regimes, while impersonal devices sustain authenticity regimes, mega-regimes, expert-opinion regimes and common-opinion regimes. As we show below, the quality-based strat-

egies of so-called hybrid organizations (Haigh et al., 2015) represent a clear combination of different worlds of quality and judgment devices. We argue that this combination defines a *camouflage* strategy through which conventional food chains (e.g. high-end supermarkets) conquer specific zones of the quality space. This key point leads to the idea of *mimetic quality* as a distinctive boundary-spanning strategy (Goldberg et al., 2016).[4]

For which kind of consumers are these boundary-spanning quality strategies particularly effective? First of all, for omnivores who display appreciation for *diversity* as symbolic marker of high status (Peterson and Kern, 1996, p. 903). Consumers in hybrid food chains seek artisanal quality *and* food safety standards, freshness *and* convenience, a link with the territory *and* variety, uniqueness *and* large quantities. But as the literature on omnivorous consumers states: 'the meaning of omnivorous taste… does not signify that the omnivore likes everything *indiscriminantly*' (Peterson and Kern, 1996, p. 904). For instance, consumers who enter a high-end supermarket do not expect to find a plethora of undifferentiated goods. Similarly, those who turn to a local producer or a solidarity purchasing group do not expect to find tropical fruits from a large multinational corporation. Consumers in their purchasing choices need to rely on *some sort* of coherence in the overall definition of quality (Murdoch and Miele, 1999, p. 468; Kirwan, 2006). Accordingly, the profile of food retailers requires a distinctive positioning in the quality space. In this connection, it is worth recalling that criteria of distinction (Bourdieu, 1984) based on omnivorousness are centred not so much on *what* one consumes, but rather on the *way* items of consumptions are reflectively enjoyed in *concrete purchasing practices* (Peterson and Kern, 1996, p. 904). Following Goldberg and colleagues (2016), we thus argue that to be successful hybrid organizations need to overcome divisions among different worlds of quality while keeping a coherent profile in connection with consumer purchasing *experiences*. This effort requires both a marketing strategy and an organizational setting able to leverage situation-specific cultural *meanings* of quality that – quite independently from individual-level attributes of consumers (Kirwan, 2006) – work as 'distributed apparatus[es] of qualification' to *decouple* quality conventions from the individual traits of consumers. These apparatuses work as 'quality devices': they are assemblages (both discursive and material) that intervene in the *construction* of markets (Muniesa et al., 2007). These 'atmospherics' (Vida et al., 2007, p. 469) devices do not just refer to 'the tailoring of the designed environment to enhance the likelihood of desired effects or outcomes' (Greenland and McGoldrick, 1994, p. 2), as the applied marketing literature would suggest. As Callon et al. (2002, p. 205) state they work as tools for distributed cognition in which information and references are spread out between many elements. Accordingly, the consumer's preferences are tied *into* them.

If quality conventions were framed only as given consumer desires to be 'enacted upon', the coherence among such diverse metrics would alternatively rely on utility maximization – as agents hold a well-defined preference ordering and they can trade off quality conventions – or on internalized values systems that coherently build the overall quality profile of purchasing choices. Both perspectives have been challenged repeatedly by the sociology of qualities and qualification, which emphasizes the situational features of qualification and judgment (Boltanski and Thévenot, 2000). In this connection, 'talking of quality means raising the question of the controversial processes of qualification, processes through which qualities are attributed, stabilized, objectified and arranged' (Callon et al., 2002, p. 199). Quality is thus a processual competence that occurs in *situations* where valuation is spatially localized

and temporally marked (Hutter and Stark, 2015).

Data and Research Design

The Local Context

In order to shed light on the quality-based strategies carried out by social actors in the agri-food sector, we focus on the positioning of different supply chains – both conventional and alternative – in Piedmont, a region in the north-west of Italy with a particularly favourable context for quality food production (Dansero and Puttilli, 2014). Considering a continuum between conventional and alternative forms, five supply chains have been singled out:

1. Hypermarkets and supermarkets. These large-scale retail systems are not uniformly distributed in Italy, with northern regions showing greater development than southern ones, though there are differences and exceptions (Arcidiacono, 2016). Piedmont represents a peculiar case due to the large number (nearly 2,000) of these outlets, their average floor area, which is higher than in the rest of the country (309 m^2 in Piedmont compared to 279 m^2 in Italy as a whole; AGCM, 2013), and, at the same time, the low market concentration that sees the lead retailer controlling only about 20% of the regional market (in several other regions this figure is close to 50%) (Arcidiacono, 2016). Large-scale retailers thus stand out in Piedmont both for widespread diffusion and high differentiation.
2. High-end food retailers. Piedmont is the birthplace of Eataly, a retailer-cum-restaurant that specializes in quality food. The first store opened in Turin in 2007, on the initiative of founder Oscar Farinetti. In the following years, several other stores were opened in Italy and abroad (Germany, Turkey, United Arab Emirates, Japan, Korea, USA, Brazil). Eataly has been influenced and sponsored by Slow Food, a movement that aims to safeguard local food cultures and traditions. Founded in the 1980s, Slow Food now has more than 100 000 members in 150 countries. While benefiting from Slow Food's aura, Eataly is a true for-profit company, with annual revenues of €400 million and sales growth of 28% in 2015. Since 2014, a merchant bank owns 20% of the company, which will be listed on the stock exchange in 2019.
3. Traditional local markets. These spaces have been facing different trends. On the one hand, the introduction of stricter regulations, together with the diffusion of supermarkets, has led to a relative decline in their numbers. On the other hand, a long-standing tradition of produce freshness and a favourable quality–price ratio has kept the habit of buying at markets alive among local people. Piedmont falls in the second scenario, with around 1,000 traditional markets regularly held in the region (Regione Piemonte, 2012), most of them on a weekly basis at least. The city of Turin, the region's capital, has more than 40 daily markets.
4. Farmers' markets. In the wake of increasing interest in locally grown food, a significant number of initiatives have been developed to promote direct sales from local, small-scale farmers. In addition to on-farm sales, these initiatives include both the participation in traditional local markets and the creation of monthly, ad hoc farmers' markets, frequently promoted by organizations such as Coldiretti and Confederazione Italiana Agricoltori (CIA). In Piedmont, the percentage of local farms involved in direct (off-farm) sales is nearly twice the

national average (Piedmont 9.4%, Italy 5.2%), and 87 farmers' markets take place regularly (Pettenati and Dansero, 2015). In Turin alone, nearly 300 local farmers participate in traditional markets; there are also 11 farmers' markets.

5. Solidarity purchase groups. These are self-organized networks of individuals and families who buy food – and sometimes other goods – directly from producers. This kind of community-supported agriculture appeared in Italy in the mid-1990s and then gradually spread, reaching over 1,000 cases in 2011.[5] In Piedmont there are no less than 170 solidarity pruchase groups, over 130 of which are located in the Turin province.

The dynamism of Piedmont's agri-food panorama makes the region ideally suited for a case study that aims to deepen knowledge of the quality positioning of different supply chains.

Data Collection and Sampling method

Data collection was based on a questionnaire administered to a sample of consumers (N=1,090) from the above five supply chains, which investigated purchasing habits, quality conceptions, expected quality dimensions and socio-economic features. Data collection was carried out from March 2014 to June 2015 by trained interviewers supervised by the research group. To diminish self-selection biases, in each supply chain the interviewers contacted one in every five consumers, regularly varied the point of administration (rotating in different locations within the markets or supermarkets), and operated on different days of the week (from Monday to Saturday) and time slots (morning, afternoon and evening). With regard to high-end retailers, data gathering took place in one of Turin's Eataly stores. Regarding local markets, municipal data allowed us to identify 29 daily markets in Turin where there are both traditional vendors and farmers. Starting from this list, we adopted a stratified sampling method, first dividing the 28 smaller markets in three strata based on their number of farmers' stalls, then randomly extracting from each stratum four specific markets.[6] Finally, we added to the sample the biggest market in town, Porta Palazzo, which represents a peculiar case being the largest open-air market in Europe, with around 800 stalls in total, including about 90 farmers' stalls. We thus obtained a sample of 13 municipal markets. Finally, we selected four different solidarity purchase groups (SPGs) in the Turin province, according to location (in the city or in the neighbouring municipalities) and number of members (small to medium groups, up to 50 adherents, and groups with more than 50 members). After obtaining the commitment of the managers in each group, the interviewers participated in the distribution of food and administered the questionnaire to SPG members.

Overall, 1,090 questionnaires were administered: 385 in large-scale retailers (35.3% of the total sample), 251 in high-end ones (23%), 216 in traditional local markets (19.8%), 87 in farmers' markets (8%), and 151 in SPGs (13.9%).[7] The final sample was composed of 483 males (44.3%) and 602 females (55.2%), with a mean age of responders equal to 47.[8] The distribution in age classes highlights the prevalence of adults (35–64 years old), representing 45.8% of the sample (499 cases), while 266 (24.4%) belonged to the young class (18–34) and 163 (15%) to the elderly one.[9] With respect to socio-economic status, data were available for 931 interviewees and showed that 40.7% belonged to the employed middle class (379 cases), 13.1% to the self-employed middle class (122 cases), 14.4% to the upper class (134 cases), 12.9% to

the lower class (120 cases), while 176 responders (18.9%) had an undefined occupational class since they were not employed at the time of the data collection. Consistent with this socio-economic profile, it was found that a large share of respondents (41.3%) had a monthly net income of between €800 and €1,500. Among the others, 37% claimed to earn less than €800 per month and 21.8% to have at its disposal more than €1,500 per month.[10]

Empirical Findings

We will now put to the test the previously delineated theoretical framework by outlining three hypotheses.

- Hp. 1. Quality *mixes* are emerging in the world of food consumption. These do not overlap neatly with the 'conventional–alternative' dichotomy, are *self-contained*, and do not mirror the random world of omnivorism.
- Hp. 2. Food supply chains select their quality positioning accordingly. *Multipolar* strategies to intercept the increasing complexity of quality spaces are evolving, adding new quality conventions without giving up traditional ones.
- Hp. 3. New multipolar strategies are built on clear-cut organizational leverage and judgment devices that support the *situational* production of meaning for consumers within specific food chains, independently of micro-level individual attributes.

We measured the level of importance of seven quality conventions using a Likert scale with items ranging 1–10 (2 items, total score from 0 to 20). Empirical results show that all conventions are considered important by a high number of consumers, although the less recognized one is the market convention, in which only 14.7% of consumers score higher than the median value (14). The most important quality convention is the environmental one, in which 85.1% of consumers score above the median value. In addition, market and inspiration conventions show greater variability, meaning that they are valued in the opposite way by relevant consumer groups (Figure 1 and Table 1).

To test the first hyphotesis, we checked for the multipolarity of quality conventions. As Figure 2 clearly shows, many consumers fall under a high number of quality conventions: the modal value of conventions to which consumers give importance

Figure 1. Quality conventions: mean scores and standard deviation.

Table 1. Consumer judgments of quality conventions in the five supply chains.

Food supply chains		Domestic	Environmental	Civic	Opinion	Inspirational	Market	Industrial
Total	mean	15.36	16.56	15.63	15.40	12.78	8.91	12.01
	std.dev.	3.32	3.07	3.26	3.36	4.11	4.24	3.39
	min	2	2	2	2	1	2	2
	max	20	20	20	20	20	20	20
	mode	16	20	20	16	14	10	11
Hypermarkets and supermarkets	mean	15.40	16.28	15.77	14.87	13.34	9.51	12.20
	std.dev.	2.89	2.88	2.96	3.38	3.62	3.98	3.24
	min	6	5	4	2	2	2	2
	max	20	20	20	20	20	20	20
	mode	16	20	20	16	14	10	13
High-end food retailers (Eataly)	mean	15.81	16.64	15.74	15.62	13.83	9.52	13.12
	std.dev.	2.79	2.98	3.19	3.08	4.06	4.42	3.51
	min	7	6	2	7	2	2	2
	max	20	20	20	20	20	20	20
	mode	16	20	16	16	16	10	15
Traditional local markets	mean	15.34	15.97	14.95	14.64	12.74	9.80	12.26
	std.dev.	3.33	3.02	3.36	3.42	3.95	4.10	3.62
	min	5	4	2	2	2	2	2
	max	20	20	20	20	20	20	20
	mode	16	20	16	14	14	10	13
Farmers' markets	mean	16.63	17.54	16.48	16.49	12.83	8.62	11.63
	std.dev.	2.94	2.64	3.09	2.90	3.97	4.35	3.35
	min	6	10	8	9	2	2	3
	max	20	20	20	20	20	19	20
	mode	20	20	20	20	16	11	11
Solidarity-based purchasing groups	mean	13.44	16.36	15.16	15.35	10.97	6.86	10.71
	std.dev.	3.81	3.60	3.48	3.72	4.46	3.65	2.70
	min	2	2	2	2	1	2	2
	max	20	20	20	20	20	20	17
	mode	14	20	15	16	13	2	11

above the median value is four out of seven. The quality space is thus structured along different attractors.

Is this multipolarity organized *and* boundary-spanning? To analyse the underlying structure of the quality space, we performed a principal component analysis applied to 14 items over seven conventions. The analysis shows that two clear-cut quality profiles emerge, which synthesize both distinctive and boundary-spanning conventions (Table 2). As for the first factor, quality is anchored to a set of socially relevant meanings represented by food (environmental, domestic, civic, inspirations); we label this factor 'soft quality'. The second factor includes dimensions referring to public reputation and price (opinion and commercial conventions); we label this factor 'hard quality'. As loading values show, the industrial convention is transversal to these two components. The regime of the industrial world is determined

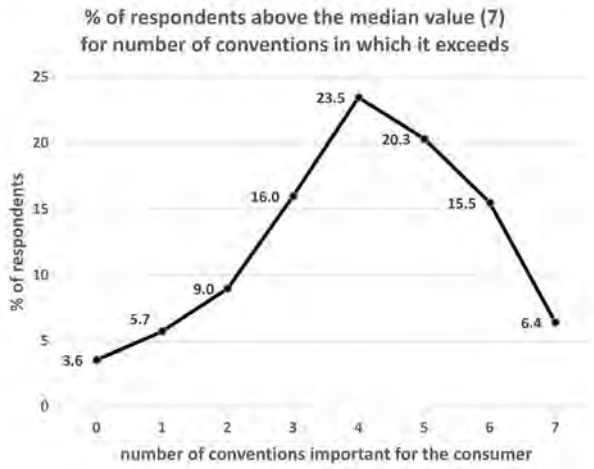

Figure 2. Percentage of respondents above the median value (7) for the number of conventions.

by the centrality of technical standards and is dominated by a logic of functionality and standardization. As Boltanski and Thévenot (2006) argued, the confrontation between the worlds of quality leads to different forms of *compromise* and *conflict*. Our findings point to a divide between the two worlds of quality (soft and hard) and to a likely compromise grounded in the industrial quality convention, which displays a double belonging and hence sets a potential common ground.

The empirical evidence further supports the idea that consumers cannot be generically defined as 'random omnivores'. Although characterized by multiple adherences to quality conventions (Figure 2), an ordered multipolarity with boundary-spanning traits is clearly at work (Table 2).

To test the presence of supply strategies designed to intercept this ordered multipolarity, we analysed consumers' quality representations, distinguishing them depending on the supply chain they use most frequently to purchase food. If the consumers intercepted by different supply chains have quality representations that are consistent with the chain's profile, this would confirm that operators are able to differentiate their offerings with respect to the emerging 'soft' and 'hard' dimensions of quality. As stated, we expect that situational, chain-specific features matter more than individual-level variables.

First of all, supply operators differ greatly from one another with respect to the quality profile prevailing among the consumers (Figure 3). Representations focusing on hard quality (public reputation and prices) are widely present among consumers who regularly shop in supermarkets and traditional local markets, with more than 60% of consumers being above the average value, while representations centred on soft quality attributes are less important, with just over 40% above average. Farmers' markets maximize instead the soft quality component (nearly 70% of customers is above average), but to the detriment of the hard quality one. These findings are broadly consistent with the chains' profiles.

As we will discuss in more detail in the next section, the positioning of Eataly within the quality space in Figure 3 stands out as a case of *hybrid strategy*. Figure 3

Table 2. Latent dimentions of quality conventions.

Item loadings for principal component analysis. Rotated component matrix.		Factor 1	Factor 2
		Soft quality	Hard quality
Domestic	Vegetables and fruits are quality goods when: they are grown according to tradition.	.513	.222
	Do you feel comfortable buying vegetables and fruits: from those who you trust?	.598	.004
Environmental	Vegetables and fruits are quality goods when: they are environmentally friendly.	.709	–.042
	Do you feel comfortable buying vegetables and fruits: from those who respect the environment when producing and trading?	.797	–.146
Civic	Vegetables and fruits are quality goods when: they are the product of the work and commitment of many people of a territory.	.660	.094
	Do you feel comfortable buying vegetables and fruits: from those who care not only about their personal interest?	.708	–.068
Inspiration	Vegetables and fruits are quality goods when: the product mirrors the passion with which it was made.	.662	.104
	Do you feel comfortable buying vegetables and fruits: from those who do it with passion and commitment?	.751	-.002
Opinion	Vegetables and fruits are quality goods when: they have a solid reputation due to awards or experts' opinion.	.335	.652
	Do you feel comfortable buying vegetables and fruits: from those who sell only widely judged high-quality products?	.266	.717
Market	Vegetables and fruits are quality goods when: they have a high price.	–.050	.767
	Do you feel comfortable buying vegetables and fruits: from those who sell more expensive products?	–.101	.816
Industrial	Vegetables and fruits are quality goods when: they have been produced and processed according to strict rules.	.510	.278
	Do you feel comfortable buying vegetables and fruits: from those who sell products that have followed a standardized production process?	–.138	.769

Notes: Extraction method: principal component analysis; rotation method: equamax with Kaiser normalization; rotation converged in three iterations. The proportion of variance explained by the two factors: 50.9%; weighted sample (every supply chain has the same weight); final test: Kaiser-Meyer-Olkin Test: KMO = 0.823, Bartlett test sig. = 0.000.

shows that Eataly leverages on both dimensions of quality: it scores slightly higher than SPGs on the soft quality dimension, outperforming to some extent generalist supermarkets and traditional local markets on the hard one. SPGs display a different positioning: they score well in the soft dimension of quality, underperforming in the hard dimension in terms of public reputation and price. All in all, the empirical evidence illustrated so far reasonably supports the second hypothesis.

To find support for the third hypothesis, we checked first the statistical significance of the above-illustrated differences between supply chains. As Table 3 shows, differences between groups are statistically significant.

To check if the effect on quality positioning (Figure 3) of the chains' attributes is stronger than the effect of individual-level attributes (such as gender, age, birth-

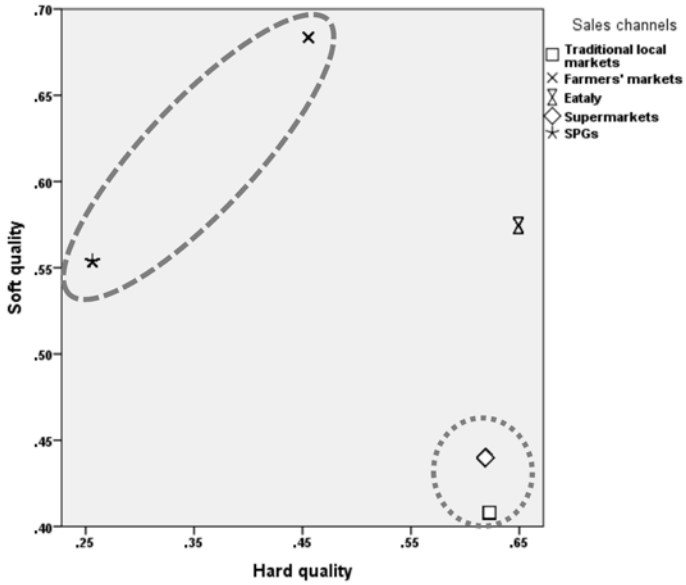

Figure 3. The quality space: hard and soft quality.
Note: the axis value is the percentage of consumers over the mean value of the factor by sales channel.

Table 3. Quality dimensions and supply chains (ANOVA analysis).

		Sum of squares	*df*	Mean squares	*F*	*p*-value
Soft quality supply chains	Between groups	7.163	4	1.791	7.344	.000
	Within groups	234.086	960	.244		
	Total	241.250	964			
Hard quality supply chains	Between groups	15.720	4	3.930	17.065	.000
	Within groups	221.084	960	.230		
	Total	236.804	964			

place, social class and income), we estimated the parameters of a linear regression.[11] The first model introduces the supply chains as independent variables, the second model adds gender, age, birthplace, social class, and income as control variables. The results (Table 4, models a1, a2, b1, b2) show that the supply chain effect is significant, consistent with the hypotheses, and independent from individual-level attributes. As shown in Table 4, both Eataly and, to a larger extent, the farmers' markets are able to attract customers who consider the soft quality component important. On the opposite side, the supermarkets are ineffective in expressing this concept of quality (see negative intercept). Socio-demographic variables are all non-significant ($p < 0.01$) and do not change the weight of the chains' parameters, which maintain their influence as expected.

Both the farmers' markets and, especially, the SPGs have a negative effect on the hard quality component, while for Eataly and the traditional local markets the effects are not statistically significant. Introduction of the socio-demographic variables

Table 4. The supply chain effect on hard and soft quality.

	Model a1			**Model a2**			**Model b1**			**Model b2**		
Dependent variable	Soft quality			Soft quality			Hard quality			Hard quality		
Observations	964			964			964			964		
R^2	0.033			0.054			0.075			0.105		
p-value	0.000			0.000			0.000			0.000		
Durbin Watson	1.913						1.846			1.841		
	B		**SE**	**B**		**SE**	**B**		**SE**	**B**		**SE**
(Constant)	–.110	*	.052	–.388	**	.128	.188	**	.051	.397	**	.125
Traditional local markets	–.159		.087	–.110		.089	.017		.085	–.002		.087
Farmers' markets	.471	**	.121	.496	**	.122	–.333	**	.118	–.325	**	.119
SPGs	.003		.102	.233		.155	–.758	**	.100	–.789	**	.151
Eataly	.222	**	.083	.226	**	.085	.073		.081	.070		.082
Female				.071		.064				–.034		.062
Young 18–34 years old				.199		.110				–.342	**	.107
Adults 35–64 years old				.149		.099				–.062		.096
Piemonte				.026		.083				–.189	*	.081
Northern Italy (other than Piemonte)				–.044		.106				–.086		.103
Center Italy				–.225		.149				.162		.145
Abroad				–.232		.157				–.152		.153
Upper class				.200		.137				.038		.133
Self-employed middle class				.095		.135				–.068		.131
Employed middle class				.240	*	.114				–.012		.111
Not employed				.031		.130				.087		.127
Net income 800–1500 €/month				–.090		.077				.082		.074
Net income > 1500 €/month				–.043		.098				.086		.095

Notes: Reference profile: large-scale system, male, over 65 years old, from Southern Italy, working class, net income < 800 €/month; *p < 0.05, **p < 0.01; the VIF inspection excludes collinearity among the variables.

in the model does not change the influence of the chains, as individual-level attributes are not statistically significant ($p < 0.01$). These results are coherent with the different chains' positioning in the quality space (Figure 3).

Finally, we tested the organizational strategies that chains pursue to support their positioning in the quality space. We expected that the quality-based strategies of Eataly would exemplify a clear combination between different worlds of quality *and* judgment devices. To this end, we measured consumers' ratings of expected quality through nine items (score from 1 to 10), following a customary model of analysis of quality dimensions (Parasuraman et al., 1994). The analysis aimed at exploring the differences in expected quality among consumers who regularly make purchases in the five chains, and then bringing out the competitive advantage of the organizational strategies pursued.

As Figure 4 illustrates, consumers' expectation exhibits high and homogeneous

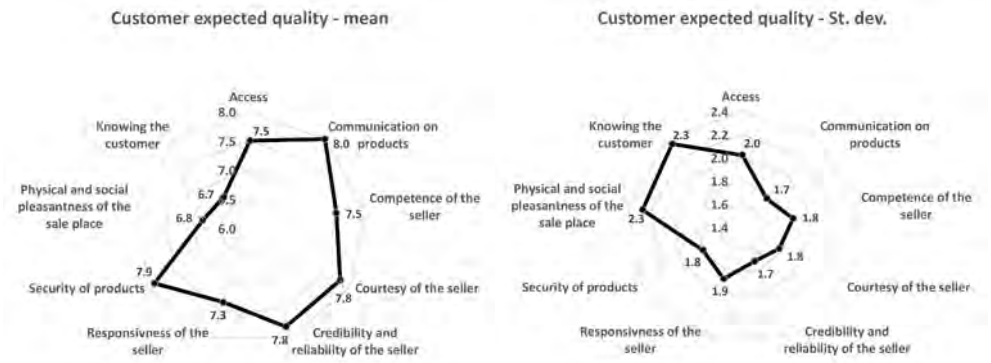

Figure 4. Expected quality.

values with regard to security, credibility, courtesy and product communication, while showing greater variability and less homogeneous judgements on knowing the customer, ease of access, physical and social pleasantness of the site.

To single out organizational leverages, we performed a principal components analysis. Two clearly different dimensions emerged.

The first factor, which we call 'the seller matters', highlights an expectation of quality that is focused on the personal relationship with the seller, on their expertise and reliability. The second factor, called 'the retail environment matters', points to an expectation that is related to the ease of access and to the physical and social pleasantness of the retail environment. The need for personalized answers is the only dimension that is transversal to the two factors, although its loading score is higher for the second factor. Thus, the structure of consumers' quality expectation can be summarized by referring to these two areas, which highlight different organizational strategies carried out by the operators in the supply chains. One is centred on the seller, the other on the retail environment; in both cases, personalized knowledge emerges as relevant.

We then analysed the position of the operators in the different supply chains with regard to the use of these organizational levers (Figure 5).

As Figure 5 shows, the positioning of the supply chains along the two dimensions highlights the different practice of the organizational levers. The farmers' markets and the SPGs are positioned to the extreme of the vertical axis, with almost 80% and 70% of consumers exhibiting above-average levels of importance attributed to the seller. In this case, the lever is the personal relationship with the seller. Conversely, large-scale supermarkets minimize personal relationships, without proposing a real alternative to the traditional markets. Once again, the case of Eataly has a peculiar position that is coherent with the role of the organizational lever used to manage the previously outlined score on the soft dimension of quality (Table 5). Eataly manages the soft dimension not through personal devices, but by the means of impersonal and commercial devices, which score very high. As Table 6 shows, these positionings are highly statistically significant.

Once again, we estimated the parameters of a linear regression model in order to compare the market segmentation ability of different chains, controlling for the effect of socio-demographic variables. The results (Table 7, models c1, c2, d1, d2) show that the supply chains' effect is significant, consistent with the hypotheses, and

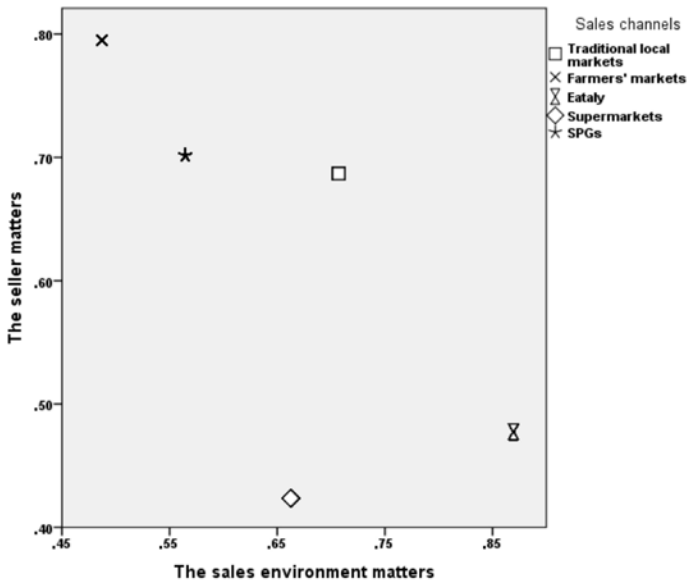

Figure 5. Positioning in the expected quality space.
Note: the axis value is the percentage of consumers over the mean value of the factor by sales channel.

Table 5. Latent dimensions of expected quality: seller v. sales environment.

Item loadings for principal component analysis. Rotated component matrix.	**Factor 1**	**Factor 2**
What features of the sales service deems important, when you choose where to buy fruit and vegetables?	The seller matters	The sales environment matters
Access	.129	.650
Communication on products	.691	.206
Competence of the seller	.864	.011
Courtesy of the seller	.712	.295
Credibility and reliability of the seller	.783	.141
Responsiveness of the seller	.707	.307
Security of products	.620	.295
Physical and social pleasantness of the sale place	.121	.851
Knowing the customer	.398	.588

Note: extraction method: principal component analysis; rotation method: equamax with Kaiser normalization; rotation converged in 3 iterations. Proportion of variance explained by the two factors: 58.2%; weighted sample (every supply chain has the same weight); sample variables are transformed into their logarithms; final test: Kaiser-Meyer-Olkin Test: KMO = 0.876, Bartlett test: sign. = 0.000.

independent from individual-level attributes.

Discussion and Conclusion

In this article, we have analysed consumer quality conventions in different agri-

food supply chains, both conventional and alternative, and we have highlighted the strategies adopted by retail organizations positioning themselves coherently in the quality space combining different quality conventions and judgment devices. We first showed that multipolar, but ordered, quality profiles are widespread among consumers. Consumers' quality positioning, on the one hand, denies the existence of random omnivorous profiles; on the other hand, it does not blindly reflect the 'conventional–alternative' polarization. We then shifted attention to the food supply side, bringing out the consistency between consumers' quality representations and the chain's quality profile, confirming the existence of differentiated strategies that are carried out by operators to enact quality conventions quite independently from individual-level attributes of consumers. Table 8 provides a summary of these 'chain-effects' on the quality positioning in reference to large-scale food distribution.

Traditional markets, farmers' markets and solidarity purchasing groups share the relevance attributed to the seller, showing high quality expectations related to this relationship. But some differences in their positioning emerge. In traditional markets, the centrality of the personal relationship with the seller and the irrelevance of all the other dimensions describes a situation in which *quality is in the relationship*, namely direct contact with the vendor embodies the *generic* quality expectation of consumers. In the farmers' markets, the vendor is perceived as an intermediary and a guarantor of a *specific* kind of quality. In this case, therefore, *soft* quality is in the relationship. In solidarity purchasing groups, a sort of negative feeling against hard quality is found. This might be due to the low importance that these consumers give to market and labels/experts' opinion as quality signals that are widespread in 'conventional' agri-food chains. At the same time, the personal relationship with the seller is crucial for quality expectations. For this reason, we can say that in solidarity purchasing groups *quality is the relationship*. Finally, we observed the case of hybrid organizations such as Eataly. In this case, quality strategies seem to be designed to combine different worlds of quality and judgment devices. Eataly, in fact, is able to hold together the ability to respond to soft quality expectations and to leverage on the retail environment features. In other words, consumers of high-end supermarkets do not look for a specific seller, they look for a particular *sales atmosphere*. And the retail environment is the organizational lever that Eataly relies on to generate the experience of soft quality. Eataly thus shows a specific mimetic ability: it valorizes the soft dimension of quality, without renouncing the hard one, by mimicking the trusting relationship of AFNs through impersonal judgment devices strategies, where the atmosphere substitutes for the personal relationships with specific sellers. As Eataly's owner Oscar Farinetti has stated: 'The street market has been a tremendous inspiration for me, I tried to recreate its atmosphere inside Eataly' (Fiory, 2014). In Eataly's case *quality is in the air*. These findings support the idea that – in the experience of consumers – Eataly looks like a new large-scale distribution retail format that offers a new food distribution paradigm inspired by concepts such as sustainability, sharing and responsibility (Sebastiani et al., 2013). It goes without saying that the atmosphere in question clashes with the protests of Eataly employees against low wages and precarious contracts, with the huge purchasing power the company exerts on its suppliers, and with Farinetti's tremendous political capital, which allowed him to have a key role in the food-themed Universal Exposition of 2015 in Milan. From this point of view, the strategic mimicry of Eataly and its positioning in the quality space stand out as *camouflage*.

With regard to the 'conventional–alternative' dimensions of food production and

Table 6. Positioning in the expected quality space (ANOVA analysis).

		Sum of squares	*df*	Mean squares	*F*	Sig.
The seller matters * Supply chains	Between groups	17.131	3	5.710	25.015	.000
	Within groups	184.445	808	.228		
	Total	201.576	811			
The sales environment matters * Supply chains	Between groups	12.770	3	4.257	20.709	.000
	Within groups	166.092	808	.206		
	Total	178.862	811			

distribution, at the macro-level mimetic quality points to the capacity of capitalism to absorb critical pressures (Boltanski and Chiapello, 1999). In the case of Eataly, this seems to occur primarily through narratives. When, during a public event, a Sicilian farmer complained that Eataly sold his produce at five times the price it paid him, Farinetti began a long tirade on the concept of narrative, claiming that a product has no value if one is not able to build a narrative about it (Bukowski, 2015). Mimetic quality thus activates new justificatory discourses, in order to resist the anti-capitalist critique encoded in AFNs' narratives: 'in fact, critique has an internally transformative influence on capitalism. Capitalism incorporates the values that were the basis for its critique' (Rendtorff, 2014, p. 261). At the meso-level, the concept of mimetic quality points to the relevance of organizational hybrids, those organizations that respond strategically to new quality mixes and combine institutional logics in unprecedented ways (Haigh et al., 2015).

We tried to show how quality conventions/orders of worth combine differently in different worlds of food/worlds of production (Salais and Storper, 1992; Storper and Salais, 1997). As Stefano Ponte argued (2016, p. 16): 'analytically, the literature has developed along two distinct (but sometimes overlapping) approaches: a first that engages with a agro-food adaptation of the "worlds of production" framework; and a second that applies the "orders of worth" approach of Boltanski and Thévenot and further elaborations of "quality conventions"'. The empirical test of the *mimetic quality* concept provides a bridge between these two approaches. Furthermore, our findings support the idea that if imitation results in isomorphism in responding to the same institutional environment (DiMaggio and Powell, 1983), *creative mimicry* results in variation and hybrid forms in response to given institutional demands and expectations (Oliver, 1991). While mere imitation goes along with habit, imitation and compliance, creative mimicry implies active agency for co-optation, influence and control.

But creative mimicry must be able to adapt quickly to evolving demands and local symbolic constraints. If, as we argued, quality is temporally and spatially marked, its historical timing would also make a difference: strategic mimicry needs to adapt quickly to different constellations of factors. In this connection, further analyses that take into account differences in time and space are therefore needed. For instance, a better understanding of Eataly's mimetic strategies is likely to come from a comparative analysis of how organizational levers change in different contexts. While a retail environment that reproduces the traditional market's atmosphere exists – and seems to work – in Italy, in other Eataly stores around the world other mimetic strategies might be implemented in order to meet different consumer expectations

Table 7. The supply chain effect on the expected quality.

	Model c1			**Model c2**			**Model d1**			**Model d2**		
Dependent variable	The seller matters			The seller matters			The sales environment matters			The sales environment matters		
Observations	935			935			935			935		
R^2	0.035			0.065			0.079			0.118		
p-value	0.000			0.000			0.000			0.000		
Durbin Watson	2.012			1.997			1.993			1.993		
	B		**SE**	**B**		**SE**	**B**		**SE**	**B**		**SE**
(Constant)	–.202	**	0.055	-0.447	**	0.129	.034		.051	.311	**	.118
Traditional local markets	0.337	**	0.088	0.394	**	0.090	.044		.081	.005		.083
Farmers' markets	0.394	**	0.123	0.443	**	0.124	–.372	**	.114	–.368	**	.114
SPGs	0.328	**	0.103	0.613	**	0.155	–.298	**	.095	–.562	**	.142
Eataly	–0.06		0.085	–0.077		0.087	.444	**	.079	.475	**	.080
Female				0.043		0.065				.034		.060
Young 18–34 years old				0.120		0.111				–.404	**	.102
Adults 35–64 years old				0.200	*	0.100				–.030		.092
Piemonte				–0.062		0.085				–.032		.078
Northern Italy (other than Piemonte)				0.007		0.109				–.109		.100
Center Italy				–0.081		0.152				–.049		.139
Abroad				–0.583	**	0.158				–.005		.145
Upper class				0.105		0.138				–.080		.126
Self-employed middle class				0.054		0.138				–.144		.126
Employed middle class				0.189		0.115				–.020		.105
Not employed				0.043		0.133				–.057		.122
Net income 800–1500 €/month				0.003		0.078				–.121		.072
Net income > 1500 €/month				0.132		0.100				–.183	*	.092

Notes: Reference profile: large-scale system, male, over 65 years old, from Southern Italy, working class, net income < 800 €/month; *$p < 0.05$, **$p < 0.01$; the VIF inspection excluded collinearity among the variables.

and ideas about what quality. Comparative case studies focusing on Eataly's stores in New York, Chicago, Monaco, Istanbul, San Paolo, Dubai, Tokyo or Seoul could provide useful elements to understand how the quality strategies pursued by hybrid organizations adapt to local circumstances.

Finally, at the micro level, the idea of mimetic quality points to purchasing choices as a situational competence, resulted from a complex process of qualification (Callon et al., 2002). This competence consolidates normative orientations, moral standards,

Table 8. Quality conventions and worlds of production.

	Eataly	Traditional markets	Farmers markets	Solidarity purchasing groups
Soft quality	Positive	No effect	Positive	No effect
Hard quality	No effect	No effect	Negative	Negative
Seller matters	No effect	Positive	Positive	Positive
Sales environment matters	Positive	No effect	Negative	Negative
Quality strategy	Soft quality is *in* the air	Quality is *in* the relationship	Soft quality is *in* the relationship	Quality *is* the relationship

in-group or out-group boundaries and the agent's behaviour accordingly. Purchasing choices thus build recognition rules and they generate a sense of belonging to a group, real or imaginary. Situational competence, if properly managed and performed, has a symbolic value *representing* that we are part of a common belonging (e.g. food activist, food experts, food lovers). This shapes individual identity anchoring it to a wider identity, i.e. to a collective profile or to an order of worth. For what mimetic quality in food networks is concerned, a positive feedback seems to be at work: the more hybrid organizations successfully imitate alternative quality conventions and shape their organizational settings accordingly, the more important consumer situational competence is. At the same time, the more the situational competence is effective, the more that specific combination of quality conventions is reinforced. This would appear to confirm the idea (Callon et al., 2002; Callon and Muniesa, 2005) that in the 'service economy' the situational qualification of products *within* the procurement process is a key concern for the organization of markets.

Notes

1. The concept of 'symbolic struggles' quite naturally links to Bourdieu's analysis (e.g. 1984, p. 281). While this connection is certainly plausible, it is worth to point out how our approach differs from Bourdieu's. Bourdieu was mainly interested in those strategic actions designed to *accumulate* symbolic capital and in the *conversion* from one capital form to another. We are more interested in how quality-based fields are built on tensions, disputes and compromises of different 'worlds of quality' (see Boltanski and Thévenot, 2006). Moreover, we maintain that forms of compromise and conflict among quality conventions are spatially and temporally marked, while Bourdieu links them to structural locations of subjects in terms of class position. However, we share with Bourdieu the idea that quality is first and foremost connected to power and conflict in a given social field.
2. Later contributions add two further worlds: the environmental world and the projects-based world (cf. Boltanski and Chiapello, 1999).
3. In the field of agri-food consumption and production, the theory of conventions has been applied to a variety of research problems summarized by Ponte (2016) in two main analytical streams: the worlds of production framework (Salais and Storper, 1992; Storper and Salais, 1997) and the orders of worth approach (Boltanski and Thévenot, 2006). All these contributions converge in the idea that 'in reality clear distinctions cannot be made between definitions of quality and that boundaries between categories are often blurred' (Sage, 2003, p. 7).
4. It is worth underlining that organizational strategies are *signals*, which, unlike *signs*, are pieces of information intentionally emitted by an agent (cf. Gambetta, 2005, 2009).
5. Data retrieved from Retegas, the Italian network of SPGs (see <http://www.economiasolidale.net>). Because online registration is voluntary and some researches were carried out locally, Retegas estimates that there are about twice as many registered solidarity purchasing groups (Grasseni, 2013).
6. The three strata included (i) markets with 1–4 farmers' stalls, (ii) markets with 5–8 farmers' stalls, (iii) markets with 9–13 farmers' stalls.

7. The total number of questionnaires refers to valid cases for which the supply chain where the administration occurred constitutes the predominant, or at least habitual, place of food purchasing.
8. Minimum age 19, maximum age 86, standard deviation 16.2. Data were missing for 5 respondents (0.5%).
9. With regard to age, data were missing for 162 respondents (14.9%).
10. The number of missing values for occupational class was 159, and there were 327 missing values for monthly net income.
11. In the model, the reference group is that of large-scale system consumers, having the following social profile: male, over 65 years old, born in the South of Italy, working-class member with a low-income.

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The Social Construction of Quality in Agri-food Localized Systems (SYAL): The Case of the Montpeyroux Wine Arrangement, France

GILBERTO MASCARENHAS AND JEAN-MARC TOUZARD

Abstract. The approach based on localized agri-food systems (SYAL, from the French acronym) has brought about new perspectives for analysis of local productive arrangements, complementing and expanding the theoretical background of clusters and industrial districts. In addressing physical, institutional, cultural and relational factors, SYAL's approach has enabled a more dynamic view of the processes underlying the creation, resilience and evolution of these arrangements. However, studies on this topic have only focused on some of these factors. This article aims to analyse how these factors interplay and are integrated into the consolidation of productive arrangements focused on improving the quality of local products. To that end, a case study was conducted in a wine arrangement in Montpeyroux, Southern France, which found synergies, complementarities and a reinforcement process involving these factors in the genesis and configuration of the arrangement, thus showing that methodologies that consider them in an integrated way can provide a better understanding of these arrangements in general and further strengthen SYAL assumptions.

Introduction

The trend towards standardization of agricultural products driven by globalization has prompted a counter-trend of valuing products typical of a territory where the social construction of their quality turns out to strengthen economic activity and to be a competitive advantage in domestic and international markets (Goodman, 2003; Bowen and Mutersbaugh, 2014). This process takes place by means of innovations in production models that have changed from a productivist perspective towards a quality-driven rationale. Such models seek to value a territory and to meet a diversified demand for products that stand out for their contributions to environmental, social or cultural issues (Allaire and Sylvander, 1997; Schermer et al., 2011).

Hence, local clusters have increasingly become drivers of this differentiated production model that has found in collective action the primary factor driving the territory's tangible and intangible resources. In order to address such complexity,

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approaches based on a agglomeration of activities, localization, local assets and the individual action of firms that characterize the theoretical approaches to industrial districts (Marshall, 1891) and clusters (Porter, 1993, 1999) were complemented by theoretical contributions from the new economic sociology centred on actors' actions and networks (Chiffoleau and Touzard, 2014). The territory that was once seen as a mere substrate for the optimal combination of resources has come to be considered a kind of organization endowed with its own reproduction and development rationales (Pecqueur, 1996). The productive space formerly characterized as a generic resources reserve that can be appropriated, imitated and transferred in an open market came to be understood as a structure focused on the ongoing construction of specific resources and capabilities (Veltz, 1993). Analysis of productive arrangements building on this complexity came to constitute a new approach called localised agri-food systems – SYALs, *systèmes agroalimentaires localisés* (Boucher, 2006; Muchnik et al., 2008; Poméon and Fraire, 2011).

The SYAL approach appeared in France in the mid-1990s, when CIRAD researchers were seeking for a more specific framework to analyse the crisis of Latin American and African countries with regard to the food and environmental challenges faced by agri-food systems in these countries (Boucher et al., 2006). SYALs are defined as 'production and services organisations (units of agricultural production, agrifood enterprises, markets and stores, restaurants, services) linked by their characteristics and by their relationship to a specific territory' (Muchnik, 2009, p. 1). Thus, in the SYAL dynamics, the territory, products, actors and their institutions and know-how, food habits and networks would combine to produce a specific form of agri-food organization (Boucher and Reyes Gonzalez, 2013).

Within the scope of productive arrangement studies, the SYAL approach has been mobilized as a concrete object – that is, a visible set of activities over territory – or as a method to support the development of rural territories (Muchnik, 2009). Theoretically, the SYAL is a three-pronged approach: the concentration of agri-food companies in a given territory, building on the notions of clusters (Porter, 1999) and industrial districts (Becattini, 2003); quality scheme and certification of origin as 'distinctive signs of quality' assigned to a place; and the application of SYAL concepts toward the development of rural communities (Boucher and Reyes Gonzalez, 2013). The central assumptions that characterize this approach are intrinsically territory driven (Grass-Ramírez et al., 2016) as follows:

- territorial anchorage of products: production is carried out exclusively in defined geographical spaces;
- collective action in the territory: as a means that prompts the activation of territorial resources;
- the link between the quality of the product and the territory: the notion of terroir or place-linked quality;
- constitution and conservation of territorial patrimony: the historical recognition and symbolic value of agri-food products.

The most distinguishing feature of the SYAL approach in relation to the other productive-arrangement approaches is its focus on the local actors' capacity to activate territorial resources. According to Grass-Ramírez et al. (2016, p. 68):

> 'The most relevant feature of SIALs is their capacity to identify in the territory those resources (intrinsic and extrinsic) that are adequate to be activated through processes of collective action, which translates into an increase

> in the ability for interaction between various actors that inhabit the territory, a higher institutional presence, revaluation of the patrimony, increase in the competitiveness of rural agroindustries (RA), through strategies of product differentiation, as well as the development of a set of positive externalities for the local agrifood system.'

According to Sanz Cañada and Muchnik (2011), the interdisciplinarity and multidimensionality that characterize the SYAL approach are not previously set; instead, they build on the objects of study being analysed, which calls for distinct and complementary views. Therefore, analyses based on this approach involve a different typology for categorising ties between actors, products and territories involving those related to the natural (biophysical) patrimony; those referring to cultural patrimony (lore, identity and so forth); and those relating to socio-economic and institutional networks (Sanz Cañada and Muchnik, 2011). These ties or relations are the foundation for the social construction of quality in the territory. The concept of socially constructed quality is dynamic, in that it encompasses a process that is continually subject to change and adaptation, mobilizing elements such as authenticity, health, tradition, tastes and collective platforms[1] that are negotiated continuously in the scope of the actors' networks (Winter, 2003). Alternatively, as contended by Ilbery and Kneafsey (2000), quality is a notion that is built by actors in an attempt to develop stable and lasting networks between themselves and others within the market arena.

In addition to the multidimensionality of the factors under analysis, the SYAL approach also has a multidisciplinary character, since it involves perspectives that span several sciences, such as economic geography, economic anthropology, neo-institutional social science and sociology of agriculture/food systems (Muchnik et al., 2008; Bowen and Mutersbaugh, 2014). This breadth and multidisciplinarity, however, constrains the approach as regards the construction of a more delimited theoretical body or the choice of a single methodological tool that can be adopted in the analysis (Touzard, 2007; Torres Salcido, 2012). To Muchnik and Sautier, two key SYAL scholars, the SYAL approach is a theoretical body that is still in the development and construction stage, thus making it susceptible to being improved by new research methodologies, empirical experience and theoretical debate (Grass-Ramírez et al., 2016).

Despite these challenges, analysis of productive arrangements based on SYAL has provided new research perspectives that are applicable to the spatial organization of farm and livestock production, rendering it possible to assess how this organization is shaped, persists and evolves. This approach adopts a dynamic view of productive activity by acknowledging that a territory's tangible and intangible resources evolve based on the relations governing this territory, concentrating on analysis of the interaction and interdependence between the actors handling these resources. Among the elements considered in these analyses are factors associated with the physical milieu and institutions, with cultural or cognitive aspects, and with the actors' relations. Although the SYAL approach has been increasingly adopted in the study of agri-food arrangements, analysis has only focused on some of these factors, as there are very few studies that seek to integrate them in the analysis of a given object of study.

Accordingly, the aim of this article was to enter into a dialogue with SYAL's theoretical approach for understanding how physical, institutional, cultural and relational factors interact in the construction of a productive arrangement.[2] To this

end, we have selected a quality-oriented wine productive arrangement situated in Montpeyroux, Southern France. The research was conducted from September 2011 to January 2012 in 15 private vineyards and a cooperative that brings together 120 small winegrowers producing terroir wines.[3]

The text is organized into three parts. In the first part, we present the theoretical/methodological approaches and the procedures adopted in the research. Next, considering this framework, we analyse and discuss the factors that have contributed to shaping the Montpeyroux arrangement. In the last section, we discuss the interdependence of these factors in the origin, shape and persistence of this arrangement aiming to understand potential synergies and raising clues for studies using this approach.

Theoretical/Methodological Framework

Productive Arrangements and Their Dynamics

The competitive success of an arrangement depends on a set of factors not limited to localization or concentration of similar and complementary firms. This concentration is an outcome not a cause. In this sense, dynamic territories exhibit features derived from their historical and institutional contexts, as well as from local assets and relations between actors, which set platforms for action (Bagnasco, 1999). In SYAL, the territory is a historically and socially constructed space that is culturally characterized and institutionally regulated, where the effectiveness of the economic activity is influenced by relations marked by closeness and a sense of belonging (Muchnik, 2009). Thus, the territory is viewed as a set of factors and as relational space for its inhabitants, or even as unique social fabric shaped by natural resources, forms of production and market, while networks bring cohesion to its elements (Sepúlveda et al., 2003).

This space stems from market relations as well as from forms of cooperation based on trust (Pecqueur, 1992). In it, a territorial logic is based on valorizing local products with respect to their tangible (physical, productive) and intangible (tacit knowledge, norms, conventions, traditions and relational networks) assets (Perrier-Cornet and Sylvander, 2000). As regards governance structures (Williamson, 1985), territories and their products, if considered from a SYAL perspective, do not even fit in a conventional hybrid form (markets and hierarchies), since they are, characteristically, a form of governance that is external to the firms, situated within the regional institutional framework.[4] Therefore, in these productive arrangements, production, market strategies and governance systems are better understood through analytical schemes focusing on their embeddedness in local, institutional, cultural and relational factors (Polanyi, 1983; Granovetter, 1985; Le Velly, 2012).

These forms of governance emerging from a territory can lead to innovation, which, in turn, benefits from the locality and its dynamics. It also provides the creation of decision-making and deliberation spaces, interinstitutional coordination via collective platforms, the development of the market and quality-focused strategies and new processes, building on the territory's specific resources (Boucher and Reyes Gonzalez, 2013). Hence, the combination of physical, institutional, cultural and relational factors in a territory 'constructed' by local actors may lead to the creation of baskets of specific goods and non-transferable territorial income (Bonnal et al., 2008). In these territories social actors seek to establish an image or a specific reputation

for their products, prioritizing specific markets and adopting a product differentiation strategy hinged on a 'club' rationale (Mollard et al., 2001; Pecqueur, 2009; Mascarenhas and Wilkinson, 2014). These territories are not, however, spaces exempt from relations of power. Conflicts may occur both in the collective and individual spheres. In the first, started by 'self-interested' groups seeking to impose standards onto the others and, in the latter, through strategies of individual differentiation and competition, as well as in the context of human relationships involving asymmetry of power, inequality and discrimination, among others (Feldman and Welsh, 1995; Hinrichs, 2000; Sayer, 2001). At the collective level, relative to the economic activity itself, defensive localism and clubs can characterize strategies designed to promote the local value, while seeking monopoly-driven incomes and creating entry barriers or artificially raising prices (Winter, 2003). Thus, the territory is not viewed here just as an environment of cooperation characterized by social capital, embeddedness and unifying collective platforms. Instead, it is considered as an arena where values, norms, institutions and the construction of quality are constantly negotiated, in a context where there are attitudes of collaboration and competition, imitation and differentiation, and conflict (DuPuis and Goodman, 2005).

Research Assumptions

In this work, we have sought to analyse the influence of the factors –physical, institutional, cultural and relational – on the origin and shape of the Montpeyroux wine arrangement. This categorization was adopted to better determine, in the analysis, the influence of some proxy factors, yet without assuming any independence or anteriority of a factor over another; rather, the assumption is that they are interdependent. The four categories of factors considered in this study and their proxies were based on the authors' observations during field research and on the literature analysing the SYAL approach. This does not mean that these categories should be regarded as exhaustive or ideal, a task that would require more thorough research and a specific scope.[5] What we intended here was to conduct an exploratory analysis of these factors that may be rejected or verified in future research.

The physical factors considered were those concerning the production environment such as the soil, type of grape, climate, localization, clustering and other landscape and natural elements that may influence, to different degrees, wine production and quality, contributing to the existence of a specific terroir. These factors may constitute constraints or opportunities, drive production strategies and have spatial and temporal influence.

Institutional factors, in turn, are related to the contingent nature of the economic action and their main effect is situated in the realm of the formal and informal rules governing it. Accordingly, we have opted to analyse the influence of rules and regulations on the production models and qualification strategies, public policies supporting the activity, technical know-how and the market.

As regards cultural factors, they reflect the whole set of collective representations, such as mental systems of perception, as well as the shared values that constitute local collective platforms. Cultural factors express, therefore, the role of collective signification in the making of the actors' goals and strategies, as well as of their motivation to cooperate or compete (DiMaggio and Powell, 1983; DiMaggio, 1997). Hence, we analysed variables such as identity, quality- or terroir-related strategies of action, motivation towards the activity, and the mobilization of tacit knowledge.

Relational factors were analysed through the adoption of the social networks approach, considering the ties between actors to form a type of relationship (actor–actor networks) or the actors' participation in some event or institution (affiliation networks). Here we discuss actor–actor networks focusing on features reflecting interpersonal relationships such as trust, advice and partnership (DiMaggio, 1997). These relational factors were mobilized building on the assumption that individuals in productive arrangements are not atomized, but develop and nurture personal relations and ties of friendship, advice and partnerships that are usually recurrent (Granovetter, 1985; Borgatti et al., 2013). Thus, trust networks act as mechanisms designed to facilitate the exchange of personal information, while ties of advice enable the transfer of refined information and the circulation of tacit and expert knowledge regarding the activity. Networks also render it possible to establish problem-solving arrangements that are conducive, at the individual level, to the building of partnerships and, collectively, to the construction of common platforms (Uzzi, 1996).

Collective action, reflecting platforms or models of production and qualification, was analysed through an affiliation network, involving relationships between actor and model/platform (Aguiar, 1991; Mascarenhas, 2007). In affiliation networks, analysis shifts from interpersonal relations to engagement by these actors in building or strengthening collective platforms. These platforms, when geared to specific territorial goals – for example, to promote a local differential – need, in turn, leaders who can convey this idea and become a reference and a source of constant motivation for the others, developing what was termed by Latour (2005) an actor-network role.

To analyse relations between actors in the Montpeyroux arrangement, some network metrics were adopted seeking to assess the degree of institutionalization or social capital of the arrangement (density, reciprocity) as well as the existing power relations (centralization, influence, prestige). In relation to these metrics, we know that the density of a network expresses the number of ties between actors as a proportion of total possible ties should all actors interrelate. Denser networks exhibit a greater level of institutionalization and actors' social capital. Reciprocity, in turn, measures the degree to which, in a relationship between two actors, there are reciprocal exchanges. Power relationships in the network are important to show the extent to which certain actors can influence the behaviour of other actors. These relationships can be measured, among other means, by indicators relating to the different types of centrality. For example, the degree of centrality reflects to what extent actors exert influence ('out-ties') or command more prestige ('in-ties') than other actors and, therefore, become key behaviour modellers. The degree to which a given actor is a node for other actors' ties reflects its level of centrality and can determine constraints, interfere in the exchange of information or condition relationships between actors whose ties depend on the central actor.

In this research, we also adopted the network approach to analyse relations across factors in the territory. This procedure is hardly usual, since this approach generally addresses social, therefore human, relations, except in rare studies (Lara-Rodriguez, 2012; Palacio, 2015). The option to use this approach to analyse the interplay between human (relations, culture, institutions) and non-human (physical) factors was prompted firstly by the consideration that the latter may exhibit agency. In that, even though dispossessed of 'will and intention', they condition or influence the actions of human beings in a territory (Latour, 2005). Accordingly, we built a matrix in which the same variables are in the columns and lines (m-by-m), with the assumption of an

asymmetric behaviour among them, i.e. if x influences y, it is not assumed a priori that y influences x. The design of the proxies of the factors and the analysis of their relations was developed from information obtained in the research, from structured observation of the authors in the territory and also based on the knowledge available on the relationship between these variables.[6]

Research Procedures

The choice for the Montpeyroux wine arrangement as our case study was prompted by its peculiar configuration, involving, on the one hand, a specific partnership and, on the other, economic behaviour differentiated in relation to the economic context of winemaking in most of the French regions. In the case of partnership, there were 15 private wine cellars and one cooperative winery partnering around a joint strategy to promote the value of local wines. Generally, private cellars and cooperatives are local competitors. Regarding the economic context, the Montpeyroux arrangement was characterized by investment strategies and great resilience at a time when French viticulture was facing a crisis, and investments in the winemaking industry were falling, especially in South of France.

The field research was carried out from September 2011 to January 2012 and involved all the local wine producers – that is, we worked with the whole population and not with samples. As far as the cooperative is concerned, we interviewed its board members and president, as well as five of its 120 associates. All the interviews relied on semi-structured questionnaires and specific forms to collect quantitative and network-related data. The interviews were recorded, transcribed and submitted to content analysis (Bardin, 1977) to examine the respondents' explicit and implicit behaviours and visions regarding the factors analysed herein. Content analysis was also important to raise subjective relational aspects not directly captured in the network's forms (ties, relations, points of view), in keeping with the methodology proposed by Grossetti (Grossetti and Bès, 2001; Grossetti, 2006). During the research, we moved to the territory to gain a better understanding of the daily life of the actors, as well as to facilitate structured observation procedures. In addition to the field research, at the end of the interviewing process, a participatory follow-up event was held with the respondents and other local actors to validate the research, to share some preliminary analyses and to complement and amend them where found to be necessary.

Results

History and Production Context

The name Montpeyroux comes from the Occitan toponym Mont Peirós and means 'rocky mountain'. The city of Montpeyroux traces its origin to the Roman period and developed in medieval times, as evidenced by the castle that has dominated the local landscape since 999. Located in southern France, 38 kilometres from Montpellier, in the Occitania region, this village[7] has a stable population of 1,224 people (in 2011), whose main economic activity is the production of quality wines. Present in Montpeyroux since the Roman period, viticulture extended from the late seventeenth century and established itself as of 1940. With the creation of the Montpeyroux Artisanal Cooperative in 1950, the local production of wines steadily adopted a quality guide-

line building on a project by former members of the cooperative toward obtaining quality certification for the local production (Touzard, 2011). This initiative was further strengthened when the village obtained the appellation d'origine contrôlée label in 1982, which in turn made Montpeyroux attractive for the establishment of private vineyards given the local wines' reputation for quality.[8]

In 2011, in addition to the cooperative, there were 15 private cellars[9] producing quality wines from their grapes. The cooperative receives the grapes harvested (which are classified by type of terroir) by its 120 members and turns them into wine, which is sold at home and abroad (Table 1).

Concerning the characteristics of the actors involved in the wine industry, the average age of the grape growers at the time of the survey was 50.8 years (ranging from 32 to 76 years). Among the members of the cooperative, a larger share of producers was close to 60 years of age, which is likely to constitute an important restriction for the continuity of the activity, as their children do not wish to follow their parents' occupation. Private wine producers must hold a bachelor's degree in the production of grapes and wine. The members of the cooperative (grape growers), in contrast, do not need to have an academic background in grape production, as their activity is restricted to growing the grapes and delivering them to the cooperative. This partial activity in the wine business makes them dependent on the cooperative to wine production and commercialization.

Local grape cultivation extends over 792 hectares, with a production of 31 000 hectolitres of wine in 2012, 80% of which from the cooperative. In this sense, the cooperative has contributed to increasing the local supply bound for other markets, further boosting Montpeyroux's reputation if one considers the region's installed capacity vis-à-vis the private vineyards' output and winemaking capacity. As regards the quality of the wines, 96.4% of the production of the arrangement can be considered top quality, since more than half of it (53.2%) refers to protected designation of origin (PDO) wines, certified to be from a specific terroir, and 43.2% to protected geographical indication (PGI) wines, produced with other varieties of grapes and/or not meeting the appellation rules.[10]

Table 1. Characteristics of the production in the Montpeyroux wine arrangement, France, 2012.

Item	(a) Private vineyards	(b) Cooperative	Total (a+b)
Nr. of respondents	15	8	23
Grape-growing area (ha)	192.4	600.0	792.4
Beginning of wine production by respondents	1940	1950	–
Installed capacity (hectolitres)	14315	35000	49315
Wine output (hectolitres)	6,275	25000	31275
Average yield (hectolitres/ha)	29.3	41.7	39.5
Wine classification (%)			
• Protected Designation of Origin (PDO)	66.0	50.0	53.2
• Protected Geographical Indication (PGI)	27.8	47.0	43.2
• Table wines	6.2	3.0	3.6

Physical Factors

In the context of agriculture, and consequently in the production of grapes and wine, there are factors related to the environment, localization and concentration of enterprises that have a direct and indirect influence on the production and qualification strategies implemented by producers. Among the first are the characteristics related to soil, climate and topography, as well as the types of grapes, in the case of Montpeyroux. Similarly, there are indirect factors that, however impalpable, exert actual influence on the perception of quality by consumers, such as landscape and monuments.

Regarding soil, relief and climate conditions, it was found that land productivity in the private vineyards was, on average, 29.3 hectolitres per hectare, which signals a production characteristic of low-yield vineyards, more compatible with the norms for appellation wines (PDO) (Table 2). This feature also justifies the choice made by the Montpeyroux actors to enhance the quality of their wines at the expense of grape productivity. Similarly, the region's wavy relief (*côteaux*) and the low productivity of its soils favoured the classification of a large portion of the local soil as suitable for

Table 2. Physical factors influencing activity in the Montpeyroux wine arrangement, France, 2012.

Factor	Meaning	Performance
Soil, relief, water and climate (p_soilcl)	Low land productivity; reinforcement of terroir	Yield in the private vineyards (hectolitres/ha): • minimum: 11.3 • maximum: 60.0 • average: 29.3 • standard deviation: 13.1
Landscape and monuments (p_landsc)	Reinforce the image of the region, strengthen sense of terroir, and provide economies of scale through tourism	Mentions to elements of the local environment (landscape, fauna, flora, soils, monuments/landmarks) (%): • cooperative: 100.0 • private vineyards: 100.0 • main mentions: Mount Baudille, the ancient castle, the stonewalls, the grape landscape, ancient paths
Localization of production (p_localiz)	Proximity to relevant markets, research centres and transport and infrastructure facilities	Approx. 38 km from: • Montpellier wine market • main export distribution channels • research centres and institutions linked to grape and wine production.
Types of grape (p_grape)	Only certain types of grape are permitted in qualification strategies linked to PDO/PGI	Adoption of grape varieties adapted to local edaphic and climatic conditions and in compliance with qualification scheme requirements: • PDO Côteaux du Languedoc: 5 types (red) • PDO Montpeyroux: 5 types (red) • PGI Terrasses du Larzac et Pays d'Oc: 10 types (red and white)
Concentration of enterprises (p_cluster)	Concentration of enterprises linked to the production of quality wines	The concentration of production (clustering): • 15 wine producers and 1 cooperative

appellation wines. This was confirmed by the fact that 66% of the private vineyards' production and 50% of the cooperative's production was classified as PDO. Low productivity of the land, undulating topography and climate with wide temperature variations throughout the day also account for the development of terroirs that are suitable for PDO wines. The rugged terrain and the lack of water sources for irrigation near the city also reduce the viability of strategies of production based on high yields such as that of some PGI or table wines whose plantations are generally located in plain regions with better access to water.

Among the indirect factors, the local landscape, the relief and the existing monuments contribute to strengthening the image of the local wines by associating to them to intangible qualities linked to the origin in the consumer's perception and fostering the terroir's message. In the field research, landscape elements were considered by 100% of the producers as assets that reinforce and empower the image of terroir and contribute to the development of ecotourism in the region. As the interviews went on, we noticed a close relationship between wine producers and elements of the local landscape, particularly the flora (*garrigue*, vineyards, olive trees), local geographical features (Mount Baudille), old stone constructions (walls, roads, sheep shelters) and the ruins of the local medieval castle, a Montpeyroux landmark, together with Mount Baudille.

Regarding the types of grapes, only a few types of grapes are allowed for PDO wines in the region. In the case of PDO Languedoc, varieties allowed include Syrah, Grenache, Mourvèdre, Cinsault and Carignan, which are better adapted to the local terroir's edaphic and climatic conditions and befitting the region's goal of producing quality red wines.[11] As regards geographical indications (PGI), a greater number of varieties can be cultivated for both red and white wines.

In terms of location, Montpeyroux is close to Montpellier, a relevant wine consumption market and distribution centre to the domestic and international markets. According to the cluster and industrial district approaches, proximity to relevant markets not only enables stronger commercial ties but also the gathering of information from the demand regarding product quality and prices (White, 1981; Porter, 1999; Chiffoleau et al., 2006).

Research on clusters and industrial districts have shown that a concentration of companies focusing on the same activity favours the circulation of know-how, innovation and the establishment of institutions geared toward the territory's goals. In the case of Montpeyroux, the clustering of 15 private wineries and a cooperative to produce quality wines in a town with little over a thousand people characterizes the local arrangement as a winemaking cluster with one particular feature: these companies came together with the cooperative driven by common goals, namely seeking quality over productivity and enhancing the reputation of the local terroir. Such concentration, besides fostering collaboration (through collective platforms), also prompts competition (regarding individual, market-driven quality and reputation strategies) and the circulation of technical (expert and managerial) and tacit knowledge between and among the arrangement's actors. The concentration of quality wine producers is also a strong sign to the markets and contributes to strengthening the region's reputation.

Institutional Factors

Among the institutional factors considered here are qualification rules, production

models, the market, public policies and the stock of knowledge focused on the activity of producing quality grapes and wines.

Concerning the qualification of wines, PDO specifications (*cahier des charges*) limit wine production to 40–50 hectolitres per hectare, which is consistent with the Montpeyroux region's low productivity (Table 3). Therefore, even though the local edaphic and climatic resources (physical factors) prompt lower grape yields, they contribute nevertheless toward the development of a specific terroir and, subsequently, towards compliance with a quality standard (institutional factor) that, apart from offsetting these physical limitations, adds further value to the local wine.

Specific rules regarding grape-growing land or wine production in France also restrict entry into this economic activity, favouring the already-established grape producers and winemakers. Purchase of land for growing grapes and producing wine depends on official approval, whether by French government agencies or by industry-wide bodies.[12] Regarding the production of wine, this must be done over authorized land for such purpose, and those interested in the activity must hold a

Table 3. Institutional factors influencing activity in the Montpeyroux wine arrangement, France, 2012.

Factor	Meaning	Performance		
Qualification rules (i_qualif)	Yield restriction on grape production per hectare	Maximum yield permitted (hectolitres/ha): • Languedoc Appellation: • Montpeyroux Appellation: • geographical indication (PGI) up to		 50 42 90
Production model (i_system)	Organic or raisonnée	Organic (%): • cooperative: • private vineyards: Raisonnée (%): • cooperative: • private vineyards:		 12.0 47.0 88.0 53.0
Public support policies (i_policy)	Public policies and institutions supporting the grape and wine activity	Legal public system supporting and regulating quality, terroir wines and organic grape production like INAO; wine and grapes bodies, favouring: • research and development • sectoral organization • PDO/PGI promotion and advertising		
Technical knowledge (i_technic)	Relevant grape and wine production knowledge and technology base	Knowledge acquired through viticulture-related college degrees and access to knowledge of the various stages of wine production, from the cultivation of grapes to vinification process; technical orientations on grapes and wines by enologists.		
Market (i_market)	Domestic and international markets for quality wines	For PDO and PGI wines, the prevailing strategy is 'the best product…' for the highest price, or for higher prices than those of table or generic wines		
		Wine market (%)	Private vineyards	Cooperative
		National:	78.4	29.0
		• local/short market channels	23.7	8.0
		• dealers	38.1	11.0
		• hotels and restaurants	7.2	3.0
		• small regional markets	2.9	0.0
		• Internet	0.1	0.0
		• other	6.4	7.0
		International (importers/dealers):	21.6	71.0

college degree in this field (bachelor's degree in oenology and viticulture). In contrast, leaving the activity is limited by the land's viticultural purpose (a consideration for a prospective buyer), as farm and livestock ranching activities are not allowed. In the context of the cooperative, the associated grape growers are bound by a five-year membership contract that imposes fines on those who decide to leave the cooperative to start a private vineyard. There are restrictions even for carrying out both activities (being a private wine producer and a member of the cooperative), with a few exceptions contingent upon the context, cooperative and region. As for the wine market, marketing and advertising strategies are increasingly constrained by a specific law that prohibits advertising alcoholic beverages in France, regardless of the fact that wine consumption is a tradition that is deeply rooted in the French way of life. Accordingly, a few respondents referred to difficulties arising not only from the law restricting advertising but also from health-sector campaigns designed to reduce the consumption of alcoholic beverages, wine included.

As for the production models, the principal polarization observed among the wine producers in Montpeyroux was about the opposition (though without causing any obvious conflict at the time of the survey) between organic or biodynamic, and raisonnée models of production.[13] Organic production is carried out by 47% of the private vineyards and by 12% of cooperative members. Producers who do not fit into the organic production model consider themselves to be adopters of raisonnée agriculture, corresponding to 88% of the members of the cooperative and 53% of the private wineries. Producers who have declared themselves adopters of organic viticulture justified their choice due to issues related to health and conservation of nature. Their option was not primarily associated with the opening of new markets or obtaining premium prices. Raisonnée agriculture is based mainly on the controlled use of modern inputs (agrochemicals) and integrated control of pests and diseases.[14] Producers who have declared themselves adopters of this model of production justify not having opted for organics and biodynamics because of the risk of pests and diseases and higher demand for labour to tend the vineyards. The declaration about the adoption of both production models does not necessarily mean that the vineyards are certified (organic or raisonnée). Here, we based our classification solely on the statements of the producers interviewed. Some of them justified their non-adherence to certification schemes as resulting from excessive paperwork to register, as well as from certification costs and the absence of incentives in terms of price and markets.

Regarding the wine market, France has experienced a drop in the domestic consumption of table wine over the last 40 years, but the production of PDO wines has substantially increased in value, and the country is still betting on its quality and terroir differentials to compete in the international market. France's strategy is hinged on producing terroir wines in a globalizing world that is following a trend towards standardization and the industrial production of wines (Garcia-Parpet, 2004). In 2015, for example, of the output of 46.7 billion hectolitres of wine, PDO wines accounted for 46%, while PGI wines accounted for 28%, thus representing more than 74% of total output (FranceAgriMer, 2016). Considering French exports of PDO and PGI products, wines accounted for 75% of the revenues in 2015. In the domestic market, even though consumption of wine has decreased in volume, quality wines enjoy a good reputation and are recognized and appreciated by consumers who can pay higher prices.

This context of quality markets benefits arrangements such as Montpeyroux,

whose quality-driven strategy caters to market at home and abroad. In our survey, we found out that the cooperative (Bettini and Sloop, 2014), with a larger scale and diversification of supply, channelled 71% of its production to foreign markets, whereas private wineries (Chever et al., 2012) were primarily focused on the domestic market, which takes 78.4% of their production (Table 3). As regards marketing strategies, positioning the wines rin terms of quality and price was overwhelmingly associated with 'a better product' for 'higher prices' or 'higher prices than those for wines from outside the terroir'.

In the context of institutional factors, public policies for the wine sector in France also favour quality strategies. Public policies and regulations governing the production of grapes and wines are distinct from those of other producing countries not only because of France's leadership as the world's largest wine producer but also because the country has been identified increasingly as a producer of quality wines from specific terroirs. Thus, France built a sound state regulatory framework for terroir-related wines, as well as specific standards designed to protect and enhance the quality of organic and traditional products (INAO, 2017).

Concerning technical/expert knowledge, this country has developed a broad and robust stock of knowledge about the production of grapes and wines, and a research, development and teaching structure dedicated to the sector. Institutions and structures were also developed and fostered to address the interests of the winemaking industry, as well as ancillary public policies such as particular credit lines and technical assistance (Boyer and Touzard, 2016).

Cultural Factors

In addition to the institutional factors influencing the construction of quality, cultural or cognitive factors have a crucial influence on actors' strategies in an arrangement. For the analysis of the Montpeyroux arrangement, we named them 'cultural factors'. In this ad hoc category, the proxies considered were local identity and reputation, personal motivations, tacit knowledge and the collective platforms focused on valorizing quality over productivity and distinguishing the local terroir.

Regarding the local identity and reputation, the ancient history of Montpeyroux, dating back to the medieval era, was cited by several respondents (Table 4) and is materialized in several local monuments and names of locations (medieval castle, church, name of city quarters) and in ceremonies and books that refer to the city's medieval past. As argued by Creissac (2011, p. 5), 'our landscape today, our customs, our uses and our Occitan language were slowly sculpted by a laborious, obscure and often anonymous people. These people deserve our attention.'[15] This history contributes to strengthening the sense of identity of the local grape growers and winemakers. A good feeling about the place was informed by 100% of the respondents (Table 4), who stated they were proud to live in the region, although only 15% of them were Montpeyroux born or came from the Montpeyroux region. A shared argument by almost all interviewed during the research was the need for unity of all around a common platform to defend the reputation of local wines. Such an argument was often reflected in the expression 'we are all in the same boat'. Another collective platform mentioned by the interviewees was the maintenance of Montpeyroux as a small village focused on the production of quality wines and terroir. This idea also has been supported by municipal administrators during the last five mandates.

Besides the actors' sense of belonging and identity with the territory, attitudes of

Table 4. Cultural factors influencing activity in the Montpeyroux wine arrangement, France, 2012.

Factor	Meaning	Performance
Local identity and reputation (c_ident)	Pride and joy of living in the place	100% of respondents claimed to have pride of living and producing in Montpeyroux; although only 15% of the wine producers came from Montpeyroux and region, 100% of respondents claimed to have pride of living and producing in Montpeyroux
Quality-driven production model (c_quality)	Prioritization of the production of quality wines	Local production focused on quality (%): Protected Designation of Origin (PDO) • cooperative: current: 50.0 planned: 43.0 • private vineyards: current: 66.0 planned: 78.0 Protected Geographical Indication (PGI): • cooperative: current: 47.0 planned: 49.0 • private vineyards: current: 27.4 planned: 18.0
Local terroir value enhancement (c_terroir)	Valorization for PDO/PGI strategies and mainly for Montpeyroux terroir appellation (Syndicat du Cru de Montpeyroux)	Actors' engagement in the process of recognizing the Montpeyroux terroir (%): • cooperative: 100.0 • private vineyards: 93.8
Personal motivations (c_motivat)	Motivations, views and plans from winemakers regarding enter, stay or leave the activity and about quality of their wines	Main motivations for joining a viticultural activity (%): Private vineyards: • change life/be a wine producer/own business: 46.7 • inheritance: 33.3 • search for specific wine quality: 13.3 • problems with the cooperative: 6.7 Cooperative: search for wine quality/cooperative ideal/cooperative as support for local viticulture and economy/economic sustenance for small wine grape growers Perspectives: Cooperative (%) • keep members' supply volume: 100.0 • product quality aligned with markets: 100.0 Private Vineyards (%) • continue/keep production at present level: 35.3 • improve quality of current wines: 23.5 • increase production: 17.6 • diversify types of wine produced: 17.6 • leave the activity: 5.9
Tacit knowledge (c_tacit)	On systems of production, wine assembling, and market strategies	Adaptation of practices in organic, biodynamic systems of production and the transition from conventional to raisonnée; personal know-how on wine production: 'the qualitative differential of (my) wine stems from' (%): • know-how (*savoir-faire*): 52.0 • wine blending (assemblage): 47.0 • quality of grape/terroir: 17.6

cooperation and competition also coexist. Cooperative behaviour occurs in the context of reaching the common goal of enhancing local reputation. As for the competitive attitudes, these occur at the individual level with the aim of differentiating one's own wine to secure quality markets. The territory is also the actors' stage for reciprocal observation of quality-scheme strategies and markets, which are learnt, imitated

or used to build differentiating elements (White, 1981; Chiffoleau et al., 2006).

Regarding personal motivations, 93.3% of respondents shared a positive and proactive feeling vis-à-vis their activity. Both the private wine producers and the cooperative strongly *identified* themselves with the production of quality wines. The actors' positive vision about local wine production was further clarified by the actors' views on the activity they perform – 86.6% regard it as 'art' or as 'exciting', despite its being considered difficult and complex. Complexity was mainly associated with the need for multiple forms of expertise in grape growing, wine production, business and marketing know-how (Table 4). When asked about their future (planned) strategies, the respondents expressed interest in continuing and expanding their activity.

Relatively to the collective platforms regarding quality, our survey detected that the production of quality wines or wines certified for their origin was shared by all actors, a fact demonstrated in practice by their option for the current production of PDO (50–66% of the producing areas) or PGI wines (47–49% of the vineyards). The proportion of PGI wines produced by the cooperative and the private vineyards reflects several causes. Among them is the absence, in some farms, of land areas that could be classified as PDO and strategies focused on the production of wines from a single variety of grape (*cépage*) or specific types of wine to meet market demand. The platform focused on valorizing Montpeyroux's terroir wines is evident from the massive support of the local winegrowers to the Syndicat du Cru de Montpeyroux, an association seeking to establish a PDO/appellation in Montpeyroux.

At the collective level, tacit knowledge of the climate, soil, landscape and organic and raisonnée models of production, in addition to know-how in winemaking, is shared via personal and affiliation networks, as we shall see below. Tacit knowledge is intertwined with expert knowledge in the construction of quality strategies and for differentiation (Arévalo et al., 2016). Thus, there is an isomorphic behaviour influenced by appellation rules, ordinary (albeit mandatory) tertiary degree, consulting by enologists, the belonging to collective institutions (PDO/PGI), adoption of organic or raisonnée models and mutual observation (benchmarking). These factors act as a mechanism of homogenization of the grape growing and winemaking process, to a certain extent. However, even in a context that favours such isomorphism, there are personal strategies targeting quality distinction through differentials in grape and wine production. These differentials were attributed to specific knowledge (52% of the cases), know-how in blending (assemblage) of the grapes in the vinification process (47%) or specific quality of grape production due to *micro-terroir* (17.6%) (Table 4).

Relational Factors

To analyse relational factors we used as proxies interpersonal (actor-by-actor) and affiliation (actor-by-event) networks as well as the agency and mobilization process from central actors in the creation, animation and maintenance of local collective platforms.[16]

Concerning the interpersonal networks based on trust and advice, and partnerships, we observed a distinct behaviour both in terms of the variables reflecting social capital (network density and reciprocity) power (centralization), and influence-based relations (influence, prestige). Trust-based networks showed higher densities than those addressing technical advice and partnership, thus reflecting higher social

Table 5. Relational factors influencing activity in the Montpeyroux wine arrangement, France, 2012.

Factor	Meaning	Performance	
Actor by actor-network (r_person)	(a) Trust (friendship and kinship)	no. of ties:	63
		density:	30.0
		influence:	36.7
		prestige:	21.4
		reciprocity:	28.5
	(b) Advice (interchange of technical information)	no. of ties:	30
		density:	14.3
		influence:	84.2
		prestige:	7.6
		reciprocity:	11.1
	(c) Partnership (in grape and wine production)	no. of ties:	35
		density:	16.7
		influence:	70.0
		reciprocity:	34.6
	Interpersonal networks (a + b + c)	no. of ties:	80
		density:	38.1
		influence:	62.0
		prestige:	11.4
		reciprocity:	40.3
Actor by finality network (r_affilia)	PDO in general (AOP_OUT)	no. of ties:	15/15
		centrality:	100.0
	PDO Montpeyroux (AOP_MONT)	no. of ties:	14/15
		centrality:	93.3
	PGI (IGP/VDP)	no. of ties:	10/15
		centrality:	66.7
	Raisonnée viticulture (RAISONNÉE)	no. of ties:	8/15
		centrality:	53.3
	Organic viticulture (ORGANIC)	no. of ties:	7/15
		centrality:	46.7
Actor-Network (r_ant)	Leading actor originating and influencing the process of quality wine production	The cooperative and two local private wine producers, acted as key actors-nurturing a quality driven network and supporting the proposal for the Montpeyroux' s terroir	

capital levels derived from personal relationships compared with strictly technical or productive relationships (Table 5, Figures 1–3). This finding was expected given the actors' competitive nature, despite their sharing collective platforms aimed at valorizing local wines. The advice-based network, mobilizing expert and tacit knowledges, showed a low level of reciprocity, thus demonstrating that there are certain actors with greater influence than others as regards know-how in viticulture and wine production. This network also exhibited lower density, reflecting the competitive nature of the activity (Chiffoleau and Touzard, 2014) and a tendency toward distinction-oriented behaviours in winemaking (DiMaggio and Powell, 1983). The higher influence of some actors in this network, as measured by an average centrality level of 84.2%, showed that some of them act as mentors for the others, as exemplified in Figure 2 by the actors VP03 and, to a lesser extent, by the coopera-

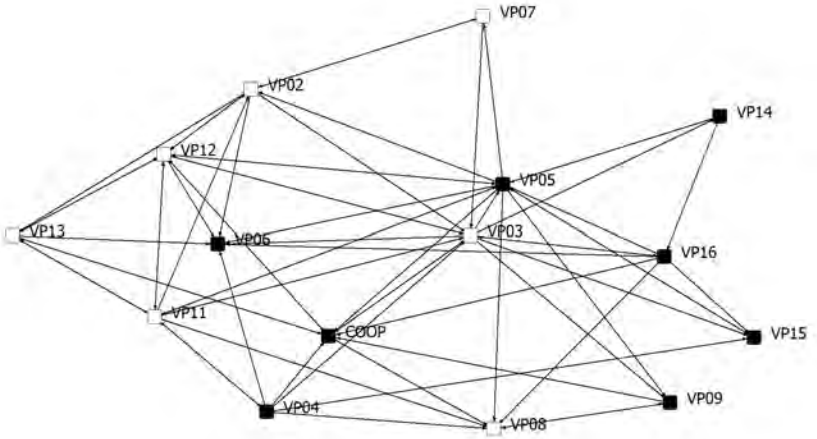

Figure 1. Network of trust among winemakers adopting models of grape production convergent with organic or raisonnée farming, in the Montpeyroux wine arrangement, France, 2012.
Notes: actors: VP: private vineyard, COOP: cooperative; production models: □: organic, ■: raisonnée.

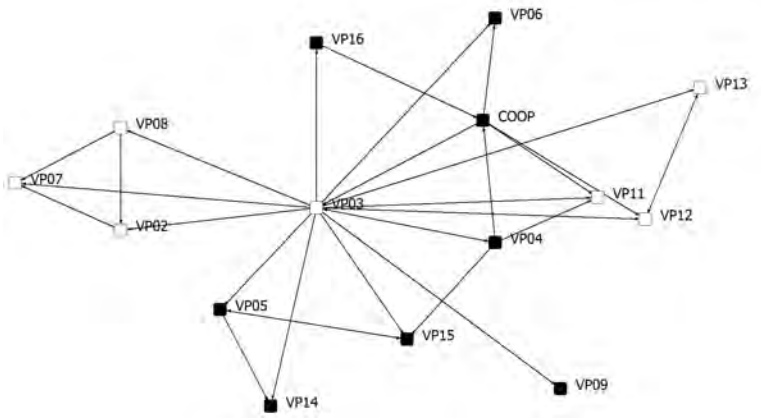

Figure 2. Network of advice among winemakers adopting models of grape production convergent with organic or raisonnée farming, in the Montpeyroux wine arrangement, France, 2012.
Notes: actors: VP: private vineyard, COOP: cooperative; production models: □: organic, ■: raisonnée.

tive (COOP). The partnership network, though exhibiting low density, showed more reciprocity because partnerships in grape and wine production require complementarities in terms of physical assets (facilities, machinery, packaging) and knowledge (in grape growing and winemaking).

For the whole set of interpersonal relations, now conforming a network based on the three kinds of ties, we noticed that this was not enough to characterize a higher level of social capital since the ties between actors only accounted for 38% of their potential. In small networks like these, one would expect higher density (above 50%), thus exhibiting higher levels of connectivity and reciprocity. What was found

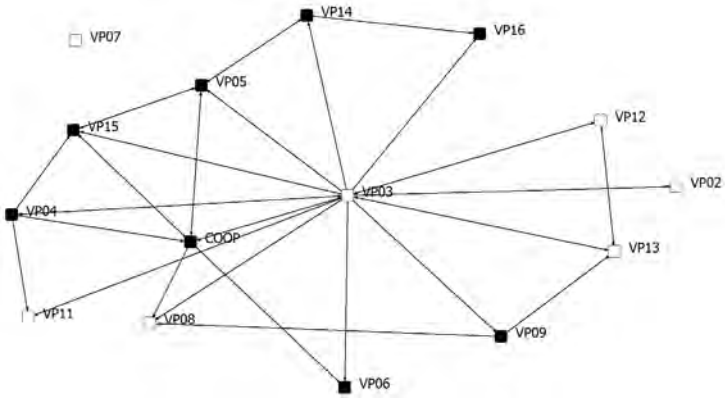

Figure 3. Network of partnership among winemakers adopting models of grape production convergent with organic or raisonnée farming, in the Montpeyroux wine arrangement, France, 2012.
Notes: actors: VP: private vineyard, COOP: cooperative; production models: □: organic, ■: raisonnée.

was that some actors (the cooperative, VP03 and VP05) wield greater power to influence the others, for the various kinds of ties analysed herein, but foremost regarding partnerships and the exchange of information. These actors' high levels of centrality do not mean, however, that they hold the information for themselves, since they are mostly sources (influence) rather than recipients (prestige), with the network showing a higher level of reciprocity, i.e. 40%. Another key aspect – which can be found in the interpersonal networks, yet is more salient in affiliation networks – is that advice-based networks and partnerships showed a greater number of ties among wine producers who adopt the same production model, whether organic or raisonnée.

In the context of the actor-by-event networks, we analysed an actor-affiliation network focused on quality-building strategies and models of production. This network encompassed actors from appellation wines in general (AOP_OUTR), the Montpeyroux appellation (AOP_MONT), PGI and other quality wines (IGP/VDP) and platforms focused on both the production models of raisonnée (RAISONNÉE) or organic (ORGANIC). For this network, we adopted metrics for quantifying actor engagement, as a number of ties and centrality. The platform of appellations wine in general (Montpeyroux included), had the higher degree of centrality and number of ties, scoring 100% (Table 5, Figure 5). That is, the goal of producing appellation wines, regardless of the appellation system (Montpeyroux or others), was supported unanimously by the actors in the arrangement. As for the platform advocating the valorization of wines made in the territory using a Montpeyroux appellation, the level of centralization and number of ties was close to that of the platform for appellation wines in general, corresponding to 93.3% of all the actors in the arrangement. The difference in percentages, in this case, is because at the time of the research one of the private winemakers did not belong to the Montpeyroux Cru Syndicat due to disagreements with the cooperative. Also, the PGI platform provided some significant levels of centrality (higher than 60%), yet still lower than the other two. This is because, for some actors in the arrangement, PGI and other quality wines are considered an alternative for soils that do not fit PDO requirements, while also intended to produce types of wine that follow specific qualification and market strategies.

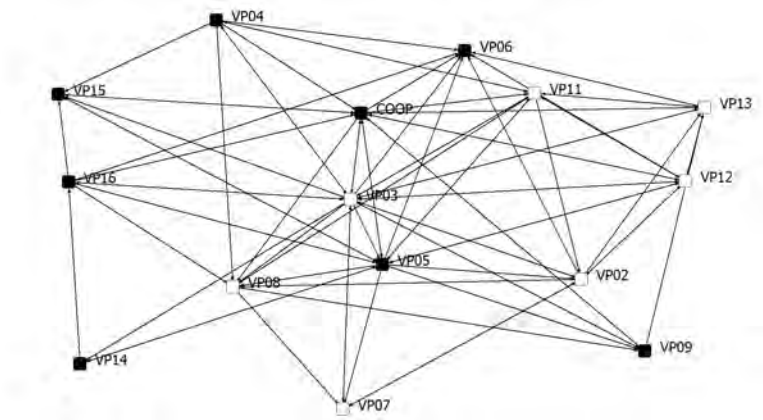

Figure 4. Network of trust, advice and partnership among winemakers adopting models of grape production convergent with organic or raisonnée farming, in the Montpeyroux wine arrangement, France, 2012.
Notes: actors: VP: private vineyard, COOP: cooperative; production models: □: organic, ■: raisonnée.

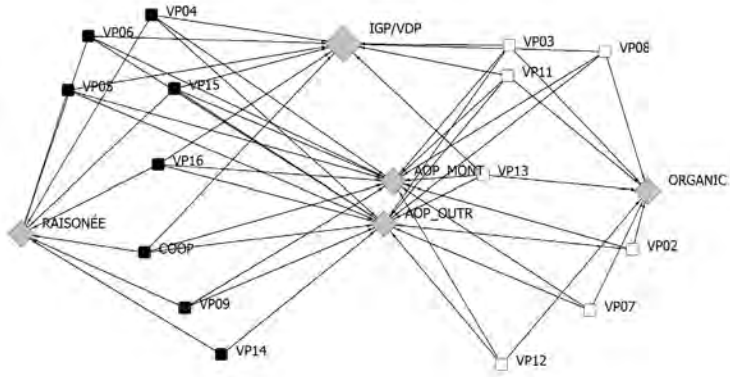

Figure 5. Network of actors' affiliation to production or qualification models in the Montpeyroux wine arrangement, France, 2012.
Notes: actors: VP: private vineyard, COOP: cooperative; production models: □: organic, ■: raisonnée; qualification models: AOP_OUTR: PDO in general, AOP_MONT: PDO Montpeyoux, IGP/VDP: PGI and other quality wines.

Considering the production models, both raisonnée and organic exhibited similar degrees of centrality, albeit lower than those of the three qualification models. Both production models not only divided the actors into two groups but also allowed a greater number of ties between their adopters, as shown in the figures of interpersonal and affiliation networks.

Hence, what we observe in analysing relational factors is that, even though personal ties of trust, advice and partnership do exist in this arrangement, their contribution to building denser network cohesion is minor. Affiliation networks linked to quality-building strategies, on the one hand, and to production models, on the other, prompted denser networks, thus they are more likely to strengthen collective

platforms that characterize the productive arrangement.

Therefore, in the context of relational factors, what stands out as the main ties uniting grape growers and winemakers are the proposals regarding quality wines and valorization of the local terroir. The latter was championed by the cooperative, through the support of two private wineries, setting up an actor-network strategy. This strategy was materialized through the creation of the Syndicat du Cru de Montpeyroux, a local association that brings together 95% of the private wineries and the cooperative, seeking the recognition of the Montpeyroux terroir as a 'village appellation'. Moreover, the cooperative was the actor that carried on the proposal for prioritizing quality over productivity that was started by one of its former presidents. The cooperative has continued to influence the local actors and to unite them around a collective goal.

The Interplay of Factors

The Montpeyroux arrangement is itself a laboratory where several factors were combined to meet the goals of the local people's collective platforms. The construction of quality was founded on shared values stemming from cognitive and relational factors translated into standards and conventions that influence the grape production and wine quality-building strategies. The negotiation over quality takes place in a context in which there is cooperation regarding shared collective values, on the one hand, and competition as regards personal differentiation strategies and markets, on the other. That is, regardless of a common territory and sense of identity, actors seek to differentiate their grapes and wine production while strengthening individual reputational strategies and market penetration (Chauvin, 2013). This differential is sought through organic and raisonnée vis-á-vis conventional production models, qualification strategies like PDO/PGI in contraposition to table wines, and individual know-how (*savoir-faire*) in selecting grape varieties, cultivating them, improving the quality of wines and developing strategies for market penetration.

Considering the variables associated with the four categories of factors analysed, some are more central and densely related to each other. From the perspective of network analysis, this became evident by their degree of centrality or the density of their relations with other equally central variables. Thus, out of the 18 variables associated with these factors, 10 variables stand out for their higher density and interrelation (core) in comparison with the less dense and with fewer interrelational ties (periphery) (Table 6, Figure 6).[17] Among the most relevant and interconnected variables, three refer to relational factors (r_affilia, r_ant e r_person), representing 100% of this category, three belong to cultural factors (c_quality, c_terroir e c_motivat), representing 60% of this category, three are related to institutional factors (i_market, i_qualif e i_tecnhic), representing 60%, and only one variable is related to physical factors (p_grape), representing 20% of the category.

Regarding the specific influence of the factors, the physical ones such as soil, climate, landscape and grape varieties influenced the construction of rules linked to quality standards. The low productivity of the soil limits the adoption of high-yield grape varieties, and allows, therefore, the establishment of rules for a specific appellation with a lower yield per hectare, which in turn values the local product in the market. The concentration of wineries (p_cluster) only became significant in association with collective platforms focused on improving local wine quality and the terroir's reputation. These platforms acted as a magnet to attract new quality wineries

Table 6. Influence and interplay of principal (core) and secondary (periphery) factors and their proxies in the construction of the quality in the Montpeyroux wine arrangement, France, 2012.

Factor proxies	Core											Periphery						Ties: 170/306		
	i_market	c_ident	c_quality	p_grape	c_motivat	i_qualif	r_person	r_affilia	i_technic	r_ant	c_terroir	p_landsc	p_localiz	p_soilcl	c_tacit	i_system	i_policy	p_cluster	Out	In	Total
i_market			X	X	X	X		X		X	X	X	X			X	X		11	8	19
c_ident			X		X		X	X		X	X	X		X		X		X	10	8	18
c_quality	X	X		X	X	X	X	X	X	X	X	X		X	X	X		X	15	12	27
p_grape	X		X			X	X	X	X	X	X	X		X	X		X		12	10	22
c_motivat	X	X	X			X	X	X		X	X				X			X	10	12	22
i_qualif	X		X	X	X			X	X	X	X			X	X	X			11	13	24
r_person		X	X	X	X	X			X		X				X	X		X	10	8	18
r_affilia		X	X			X			X	X	X			X		X	X	X	10	14	24
i_technic				X	X	X		X		X	X			X		X	X		9	9	18
r_ant		X		X	X	X	X		X		X	X		X				X	10	13	23
c_terroir		X	X	X	X	X		X		X				X	X				9	16	25
p_landsc	X	X								X	X							X	5	6	11
p_localiz	X		X		X			X		X	X							X	7	2	9
p_soilcl			X	X		X		X	X		X				X	X			8	8	16
c_tacit			X	X	X	X	X	X			X					X			8	9	17
i_system	X				X	X	X	X	X						X				7	10	17
i_policy			X	X		X		X	X	X	X					X			8	4	12
p_cluster	X	X			X		X	X		X	X	X	X		X				10	8	18

Notes: Factors: physical (p); institutional (i); cultural (c); relational (r). Proxies: physical: p_soilcl: soil, relief, water and climate; p_localiz: localization; p_landsc: landscape and monuments; p_grape: types of grape; p_cluster: concentration of enterprises. Institutional - i_qualif: qualification rules; i_system: production models; i_policy: public policies; i_technic: technical knowledge; i_market: market. Cultural - c_ident: local identity; c_quality: quality driven; c_terroir: terroir valorization; c_motivat: personal motivations; c_tacit: tacit knowledge. Relational - r_person: personal networks; r_affilia: affiliation networks; r_ant: actor-network. Fitness: 73.7%; network density: 55.6%; core density: 72.7%; periphery density: 23.8%

and to reinforce the local reputation. The variable localization (p_localiz), usually considered significant in cluster and industrial district studies, did not prove as relevant to achieve the goals of constructing local quality and reputation. An example of this is that several neighbouring municipalities that are even closer to Montpellier failed to form a concentration of wineries as in the case in question.

About institutional factors, qualification rules (PDO/PGI) stand out, together with the stock of expert knowledge available on the growing of grapes and wine production, quality markets and quality-certification policies. Qualification rules also reflected productivity constraints derived from local physical factors and contributed, in turn, to reinforcing and supporting collective strategies focused on product quality and valorisation of the terroir (Belletti et al., 2017). Cultural factors, in turn, acted as ongoing motivational elements, identity reinforcement and drivers of collective actions also focused on quality-building goals. These factors contributed

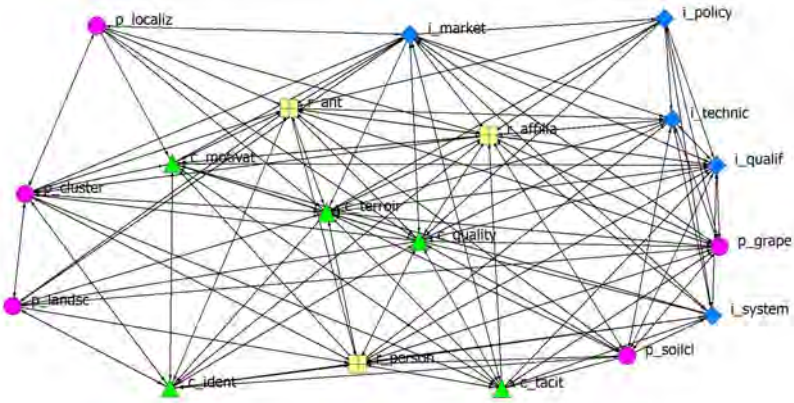

Figure 6. Interplay of factors in the construction of the quality in the Montpeyroux arrangement, France, 2012.
Notes: factor: ●: physical, ♦: institutional, ▲: cultural, ■: relational.

to compensating for the limitations relating to physical ones through the enhancement of a specific terroir, which in turn allowed the qualitative positioning of local wines in domestic and international markets.

Concerning relational factors, personal networks acted mostly in the form of partnerships for the cultivation of grapes and vinification (equipment sharing) and on the advice networks for exchanging tacit and expert knowledge on grape cultivation in the various systems of production. They were less dense than the networks of affiliation, reflecting that there are relations of cooperation and competition in an activity where personal reputation and individual know-how influence competition strategies in quality or niche markets. Affiliation networks refer to common platforms and standards and placed greater emphasis on general quality-related collective goals and so encompassed a major number of actors. Also within the scope of relational factors, the cooperative played a key role in maintaining the proposals focused on the quality of the wines and valorization of the local terroir. Here characterized as an actor network, it acts by reinforcing cultural factors, i.e. leading and stimulating the proposal of terroir and quality wines in general and local identity, nurturing interpersonal and affiliation networks and events designed to accomplish collective platforms.

Therefore, cultural and relational factors were the main drivers of the construction of quality in the Montpeyroux wine cluster. Both factors were instrumental in enabling negotiation and adaptation of quality and production standards (institutional factors) that considered local edaphic and climatic conditions (physical factors) in building collectively shared quality-driven proposals.

Conclusions

In light of the case, we verified that analysis of a productive arrangement based on the SYAL approach, through the integration of physical, institutional, cultural and relational factors, rendered it possible to shed light on the different facets of a research area whose complex nature would be incompletely addressed if analysed by

a unidimensional perspective by adopting only some of these factors. In the context of the factors examined, the actor's agency was reinforced by cultural or cognitive factors that contributed for the continuity of Montpeyroux as a quality and terroir arrangement. Also, under the influence of physical and institutional factors, which can act as drivers or constraints, collective goals linked to the construction of quality were further strengthened by a relational context, through interpersonal and affiliation networks.

The social construction of quality in Montpeyroux was prompted by collective platforms focusing on the production of quality wines and the establishment of a terroir negotiated by the actors through relational networks. Cultural and relational factors have acted to offset such local limitations as the low productivity of the soil, by building on valorizing the region's edaphic and climatic attributes favouring the establishment of a terroir (PDO) or a specific quality (PGI) and the cultivation of grape varieties (*cépages*) better adapted to the local conditions (physical factors). As regards the institutional factors, the strategic choices made by the Montpeyroux actors are in line with the French setting, characterised by a research and development environment focused on the production of quality wines. As for markets, the French bet to export terroir wines and the existence of a domestic market that appreciates these wines contributes to strengthening the arrangement's collective platforms further.

This process of construction of quality and local reputation has already enabled Montpeyroux actors to make some accomplishments. The main achievement has been the continuity of viticulture at a time when, in several regions in France and even in neighbouring municipalities, cooperatives have merged or are closed.[18] The demise of the activity, in a region where the opportunity cost for other activities is high, would bring about adverse effects not only on the socio-economic conditions of the population but also on the vineyard landscape, a principal local tourist attraction. As for the collective platforms, a remarkable accomplishment was the approval of the Montpeyroux sub-appellation, with a specific terroir within the Languedoc Appellation. This appellation has been recognized by INAO since 2011 and is now in the implementation phase. Another result was the quality enhancement of wines and production systems, over the last five years, in the local cooperative. The share of PDO wines has risen from 50% to 65%, while a line of wines made from organic grapes was also launched. As for the stability of the arrangement and the upholding of the shared goal of quality enhancement, in 2017 there were 22 private wineries in Montpeyroux, 21 of them, plus the cooperative, were members of the Syndicat du Cru de Montpeyroux.

Despite these results, the production of grapes and wine in Montpeyroux faces several challenges. In the international market, French terroir wines face fierce competition from the so-called New World wines (varietals or from other regions). In the domestic market, decreasing household income and competition from other beverages have reduced wine consumption over the last years. As for the cooperative, the ageing of grape growers jeopardizes the supply of grapes for vinification, since the new generations are not interested in continuing their parents' activity. Private wineries, in turn, are faced with the imperative of increasingly seeking other markets, especially the foreign market, yet their low scales of production and the need to meet specific regulations to enter these markets, limit their scope of action. There is also a greater complexity involved in running these, mostly, family businesses, given the fact that private wineries must work on several fronts, from growing the grapes and

producing the wine to develop market strategies. All this brings a relevant level of complexity to the management of this business.

From a theoretical and methodological perspective, the analysis of the Montpeyroux arrangement showed the importance of the coming together of actors' projects and motivations regarding coherent interaction nodes in the context of a quality-oriented model – terroir, appellations, valuing of the territory, continuing to be a village. The Montpeyroux case contributes to the debate focusing on productive arrangements in general, and reinforces the theoretical assumptions of localised agri-food systems (SYALs) in particular, building on the following findings:

1. the generation of territorial quality income is the result of the collective action by valorizing tangible and intangible assets through innovation designed to construct a specific and territorial quality;
2. innovations take place under conditions where collective action is rooted in robust collective platforms, based on social capital and territorial identity, and constantly reinforced by social networks, driven by common goals.

The study has also shown that a SYAL-based analysis, leveraging on multidisciplinary and multidimensional approaches, may shed light on such complex objects of study as productive clusters and the construction of quality. Hence, even though the SYAL approach is still a theoretical body in construction, adopting its assumptions for analysing its core objects or complementing other analytical frameworks – for instance, cluster, industrial district and value chain – may be of help in understanding socio-economic processes related to agri-food systems. As for analytical methodologies, due to sampling limitations typical of case studies, the adoption of research techniques such as content analysis, structured observation and, mostly, analysis of social networks proved useful in understanding our object of study.

The case study confirms the multidimensional assumptions of the SYAL approach, yet the validity of the integrated analysis used here still needs to be tested in other situations and in different types of arrangements to assess its generalization level. In future studies analysing networks, it would be advisable to use other interpersonal variables capable both of capturing the specific power and conflict relations within productive arrangements and of measuring the influence of actors and institutions on the outside. The inclusion of economic variables associated with pricing, production costs and negotiations within the value chain may also prove useful toward a better understanding of these arrangements. Finally, though not the primary goal in this article, longitudinal comparative analysis of secondary data concerning the human development indices among the arrangement and other cities in the same region may indicate potential shared benefits afforded by the quality-driven strategies implemented.

Notes

1. Platform collective is here defined as shared values or collective projects.
2. This research has also sought to assess how these factors influence the actors' market and quality-focused strategies, but for lack of space, this analysis will be published elsewhere.
3. There are several definitions of terroir, many of them referring to the influence of edaphic and climatic factors on the quality of a given product. However, the concept of terroir adopted here is of a more dynamic and procedural character, referring both to a combination of biophysical and cultural elements (Bérard and Marchenay, 2004), as a result of a production process (Teil, 2012).
4. Here, the institutional framework comprises the set of rules, laws, and (formal and informal) regula-

tions that influence and condition societal relations (North, 1991).

5. Defining variables more accurately for each factor would require other kinds of analyses prior to this study, such as a questionnaire-based survey of the local actors using, for instance, item response theory (Hambleton et al., 1991) or factorial analysis, which would require a range of cases, thus beyond the scope of this article, whose goal was to approach, on an exploratory basis, a categorization and the interplay between its factors, ultimately aiming to contribute some questions that might enrich SYAL research heuristics.
6. The relationships among factors are based on our field observations, on the literature, as well as on the analysis of the responses of local actors. Additionally, we have consulted colleagues who work on the topic. That is, these relations were established from a deliberative process. In later studies, using a higher number of observations, we suggest performing factor analysis using parametric methods.
7. In France, cities are called *villes*, and the smaller towns like Montpeyroux, *villages*.
8. The expressions 'private vineyards', 'private cellars', 'wineries', and 'private domains' have the same meaning and are used interchangeably to distinguish private wineries from the local cooperative.
9. In the network analysis, we considered the responses of 14 out of 15 private vineyards, since one of the producers was still in the initial stage of wine production.
10. Wines with appellation labels in France and the European Union abide by European regulations. For more details, see INAO (2017). The protected designation of origin (PDO) is a distinction awarded to products whose authenticity and typicality arise from their geographical origin. The distinctive features of a PDO product find their origin in several factors such as the geographical context, the conditions of production, and a close association between these factors and traditional knowledge (human factors). The distinction for the protected geographical indication (PGI) is mainly based on reputation and association with a particular territory. While the production phases of a PDO must take place in one's geographical zone, PGI wines may have some of their production phases carried out outside the geographical zone of reference. Table wines (vin de table) are considered mass consumption wines and have no distinction.
11. The designation 'Montpeyroux' is acknowledged as part of the Languedoc appellation (PDO), but the local actors' project is to turn it into a specific terroir appellation (a village appellation).
12. An example of an entry barrier was the refusing to grant authorization for a big US businessman to establish a vineyard in Aniane, a city near to Montpeyroux, in an episode known as the 'Mondavi case'.
13. Agriculture Raisonnée was established in France by Decree n° 2002-631 of 25 April 2002 to improve the quality of rural activities, defined as a set of agricultural practices that includes: respect for the environment, control of health risks, health and safety at work and the well-being of animals (France, 2002).
14. Information on the production models adopted, i.e. organic or raisonnée, was based on statements from winemakers interviewed. Concerning organics, for instance, we found that there were producers at various stages of certification. It included the already certified, those in the certification process and those who declared that even though adopting the procedures required by this model of production they avoided being certified due to excessive bureaucracy and paperwork that would be required each year. Therefore, both production models here cited could be classified more precisely into two groups: (i) organic, in conversion or similar; and (ii) raisonnée or with low use of chemical inputs. The quotes in raisonnée are due to the lack of proof, at the time of the research, of winemakers certified in this production model, but who declared themselves adopters of the procedures referred to it.
15. Free translation from the original in French: 'Notre paysage actuel, nos coutumes, nos usages et notre langue occitane, ont été lentement ciselés par un peuple laborieux, obscur et souvent anonyme. Ce peuple mérite nos attentions.' Yvon Creyssac is a local historian.
16. Networks of affiliation (actor/event) differ in terms of meaning and metrics in relation to adjacency networks (actor/actor). What we seek to measure in the first is the degree and form in which a given event or platform engages network actors, while in the latter the focus is on the relations between actors themselves. Through the networks of affiliation, we sought to analyse to what extent the different systems of production and qualification strategies centralize actor engagement and enable relationships.
17. The core–periphery analysis demonstrated that the network constituted by the interplay of factors is well connected – that is, the factors and their proxies presented a number of interrelationships (ties) consistent with their importance. In this sense, only a core–periphery analysis technique (Hamming) demonstrated an adequate level of fitness. The same network, if analysed by the most usual correlation procedure (CORR), would not present, for the proxies, a clear division between core and periphery, which shows that all the factors and proxies adopted were relevant to describe the studied phenomenon.
18. Over the last three years, two important grape and wine cooperatives in the region –St. Jean de Fos

(2015) and Gignac (2017) – stopped operating; both had been producing mostly table wines.

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Book Review

The Sugarcane Complex in Brazil: The Role of Innovation in a Dynamic Sector on Its Path Towards Sustainability
Felix Kaup, 2015
Basel: Springer International Publishing Switzerland
xxii + 280 pp., ISBN: 978-3-319-16582-0 [hbk]

There is great concern at present about obtaining energy for the development of humanity. Non-renewable energy resources are being depleted, and we are looking urgently to replace non-renewable rainforest wood and other slow-recovering energy resources, without the intensive use of fossil fuels. Recently, biofuels have appeared as a viable alternative due to their renewability, relative ease of production and low impact on the environment. One of the most important biofuels is ethanol, produced mainly from corn and sugarcane. The latter is used most, especially in developing countries, and Brazil is at the head of world producers of sugarcane. Brazil is the world's leading producer of sugar and second in ethanol from sugarcane. Generally, when Brazil is named, it is thought of in terms of sugarcane and its products, tropical climate and sustainability. Sustainability is the main concern for Brazil, and it is here that a question emerges: will sugarcane crops be sustainable in the future?

Around this main question revolve other questions about the relationships between agriculture, energy, rural development and food security. These relationships are not simple because some of them are mixed up in multiple relationships as well as in dualistic links. Sugarcane is a crop that involves numerous complex factors, and hence it is necessary to analyse each of the factors and connections to understand their dynamics, and to predict the sustainability of the sugarcane industry in Brazil.

Thus, in order to recognize the necessary steps for sustainable development it is indispensable to know the stakeholders, technologies, and markets, and it is precisely here that *The Sugarcane Complex in Brazil: The Role of Innovation in a Dynamic Sector on Its Path Towards Sustainability* offers a profound academic study of the Brazilian sugarcane complex, focusing on the role of innovation to make this agribusiness economically sustainable for the future without ignoring environmental issues.

Felix Kaup is an economist with extensive international experience in project development relating to renewable energies and energy efficiency. During the last five years leading up to the writing of this book he worked in international and interdisciplinary projects, mostly in Latin America countries and in Brazil in particular, where he finished the PhD thesis that is the origin of this book.

The book is about technology and innovations and how they contribute to the sustainability of ethanol in Brazil. Also, it analyses the links between ethanol and other sensible factors such as air quality, biodiversity, deforestation, and food security. There is an argument that the expansion of the ethanol agribusiness should be guided by technological innovation. In fact, the author says that this innovation

is responsible for the growth of the sugarcane industry without endangering its renewal and, even better, that technological innovation helps to make this crop a fundamental contributor to Brazilian development.

As I said before, this publication results from a PhD thesis, which is the reason for the book's unique academic rigor, and for its thorough study of the technological factors that directly affect the production of Brazilian sugarcane. However, social and human factors are not the main ingredients for the author, which is a weak point.

The book is divided into five chapters. The first is an introductory chapter that explains briefly the three main objectives in the author's research. The first is to document and to analyse important developments of the sugarcane complex through conducting semi-structured interviews with experts from the Brazilian sugarcane industry. The second objective is to assess to what extent the identified dynamics and developments affect the capability of the sugarcane complex to evolve into an innovative system. The third objective is to evaluate to what extent the identified and analysed technological and institutional developments and innovations might contribute to a transition towards sustainability.

The second chapter presents the theoretical framework that deals with the concept of sustainability and the transition towards sustainable mobility. Here mention is made of one of the main fears of the production of biofuels, its environmental impact. The author uses the Environmental Kuznets Curve (EKC) to explain that industrial innovation leads to excessive consumption, which generally has a negative impact on the environment. However, the curve also suggests that continuous economic development can also promote environmental protection. It is important to cite that the concept of sustainable development is very controversial as some environmental economists affirm that it maintains capital for future generations. But no attention is given to the power asymmetries along the ethanol value chain, inequalities spots where there are people without economic growth opportunities.

The third chapter gives a detailed explanation of the methodology used for the research. Thus, the research design process is explained, concluding that it is a case of methodological pluralism. Here, the concept of triangulation is introduced, which is to investigate through different methods and different points of view and perspectives the advantages of innovation and technology within the sugarcane industry. Also, it is explained that methodological pluralism occurs when quantitative and qualitative methods are used within the process of data collection, field interviews, and the literature review; thus, they complement and explain each other towards a holistic view of the work.

The fourth chapter is the most extensive because it is the empirical analysis of the compiled data. After the theories of sustainable transition and innovation systems have been explained in the previous chapters, semi-structured interviews conducted with industry experts are followed by an elaborated analysis using, among others, ATLAS.ti software. In this chapter it becomes possible to understand Brazilian state intervention through policies developed by the government to influence, control and supervise the entire productive chain of sugarcane and its products. In turn, it explains the different governmental and private institutions that determine the global value chain of sugarcane (GVC) in Brazil. Here, for example, UNICA (Brazilian Sugarcane Industry Association) appears as an organization controlling more than 50% of all Brazilian ethanol and 60% of overall sugar production. At this point, it is interesting to note that after processing the interviews the frequency of occurrence

of institutions that are mentioned is governed by private and foreign institutions that traditionally control the Brazilian ethanol industry; no social institutions appear from the interviews. I believe that this biases the social perspectives within the work, since it is a loss of realistic information about the social and economic impact on the rural and marginal communities that depend on this crop.

In chapter five the author draws conclusions based on his work; for example, ethanol production and its use in mobility have a positive impact by reducing Greenhouse Gas (GHG) emissions. Also, unrestrained expansion would result in palpable negative effects. Obviously, there are many valuable, amazing, and crucial results, but I will let to the reader discover this.

In conclusion, *The Sugarcane Complex in Brazil* is a valuable book for scholars who want to know more about the sustainable production of Brazilian ethanol, and it allows the reader to contrast the realities and possibilities of this crop as a social and economic responsible motor of development through innovation systems. For them I would recommend this book.

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