Running title: Conflict as a driver of transformative change in agriculture

Sustainable agriculture: recognizing the potential of conflict as a positive driver for transformative change

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Abstract

Transformative changes in agriculture at multiple scales are needed to ensure sustainability, i.e. achieving food security while fostering social justice and environmental integrity. These transformations go beyond technological fixes and require fundamental changes in cognitive, relational, structural and functional aspects of agricultural systems. However, research on agricultural transformations fails to engage deeply with underlying social aspects such as differing perceptions of sustainability, uncertainties and ambiguities, politics of knowledge, power imbalances and deficits in democracy. In this paper, we suggest that conflict is one manifestation of such underlying social aspects. We present an original conceptualization and analytical framework, wherein conflict is recognized as an important motor for redistribution of power and leverage for social learning that – if addressed through a conflict transformation process – could potentially create a step-change in agricultural transformation towards greater sustainability. Our analysis, building on an extensive literature review and empirical case studies from around the world, suggests a novel approach to guide future transdisciplinary research that can support agricultural transformations towards sustainability.

Keywords: Agriculture, conflict, transformation, sustainability, food systems, agroecology

1. Introduction

Agriculture is the most dominant land use on Earth, providing valuable services to society (IPBES, 2019). However, these services incur costs such as a major carbon footprint (IPCC, 2019), significant pressure on the natural environments (IPBES, 2019), increasing social-ecological vulnerabilities (Bennett et al. this issue; Rasmussen et al., 2018), and social and cultural exclusion and marginalization (Pimbert, 2018). Within the context of global social and environmental change, conventional intensive agriculture is being contested and current agricultural systems are seen by some as untenable (Caron et al., 2018; IAASTD, 2009; IPBES, 2019; Vanbergen et al. this issue). Governing bodies, policy makers, non-governmental organizations, citizens, producers and other actors are debating what a more 'sustainable agriculture' entails and the ways to navigate towards more sustainable pathways (Struik & Kuyper, 2017; IPBES, 2019).

A growing policy, practice and research focus is on the need to complement incremental changes in agricultural systems with profound changes of agricultural systems (Feola, 2013). Incremental changes rely on applying current thinking and governance structures to modify agricultural systems (e.g., by optimising agricultural efficiency – see Vanbergen et al. this volume and citations therein). In contrast, profound change requires deep shifts that challenge established assumptions, beliefs, and values, along with institutional arrangements, development paradigms, and power relations at multiple scales (Bennett et al., 2019; Patterson et al., 2017; Pelling et al., 2015). These profound changes constitute what are termed (sustainable) 'transformations'. Sustainable agricultural transformations imply changes in cognitive, relational, structural and/or functional aspects of agricultural systems aiming at new qualitative and/or physical outcomes that contribute to social justice and environmental

integrity in agriculture and beyond (Future Earth, 2014; Gliessman, 2015; IPBES, 2019; O' Brien, 2012; Patterson et al., 2017; UN, 2015).

Transformations often entail differing perceptions of sustainability and change processes, contested uncertainties and ambiguities, the politics of knowledge, and power imbalances and deficits in democracy (Anderson et al., 2019; O'Brien, 2012; Patterson et al., 2017). All these can generate and/or involve conflicts among different actors and/or groups. Here, we define conflict as the pursuit of incompatible goals (or different views on how to reach a common goal) by different parties, where one party is perceived to assert its interests, values and needs at the expense of another (Redpath et al., 2013; Young et al., 2016). Conflict is often related to structural causes such as the specific context in which it occurs, culture and power dynamics, and manifests itself through people's behaviour, with individuals and groups adopting positional and adversarial negotiation tactics (Pound, 2015; Redpath et al., 2013; Rodriguez et al., 2019; Young et al., 2016). Research on agricultural transformations tends to focus on physical inputs and outputs, failing to engage deeply with possible conflicts and related social aspects involved in the transformation process (Panda, 2018; Rickards & Howden, 2012; Vermeulen et al., 2018). Moreover, the broader sustainable transformations research often views conflict as a problem that needs to be resolved through compromise and consensus (Kenis et al., 2016). However, ignoring conflicts or resolving them superficially through a technical or managerial solution may lead to reproducing inequitable social-ecological outcomes across society, time and space (Bennett et al., 2019; Blythe et al., 2018; Kenis et al., 2016; Mouffe, 2006). We suggest that, when conflicts constitute a feature of agricultural transformations, deeply understanding and proactively addressing them must lie at the core of achieving a transformed and sustainable agriculture.

In this paper, we offer an integrative approach to analyse and support sustainable agricultural transformations, highlighting the role of conflicts and suggesting a 'conflict

100 transformation' approach. Conflict transformation is a theoretical lens and an applied
101 participatory approach to conflict, drawing heavily on peace studies, where the paradigm shifts
102 from conflict resolution to a longer-term process aiming at inducing profound changes
103 (Lederach, 2003), in this case in the social and ecological structure of agricultural systems.
104 Central to our view of conflict transformation is that conflict itself is a dynamic, continuously
105 evolving phenomena, where incidental disputes are expressions of more deep-rooted, systemic
106 issues and symptoms of unsatisfied needs and marginalisation (Lederach, 1995; Madden &
107 McQuinn, 2014; Rodríguez & Inturias, 2018). Furthermore, we see conflict as a potential
108 catalyst for constructive social change provided that antagonistic positions 'between enemies'
109 are transformed into more productive agonistic positions 'between adversaries' (Mouffe, 2013;
110 Rodríguez & Inturias, 2018). In the case of agricultural transformations, the 'adversaries' are
111 beneficiaries and/or co-producers of ecosystem services in agricultural systems and relate at
112 multiple spatiotemporal scales (Kovács et al., 2014; Vialatte et al., 2019) – as such conflict
113 transformation cannot be separated from the ecological problem.
114 Our proposed framework contributes to the current research on transformation by
115 presenting a novel process and outcomes-based understanding of agricultural transformations
116 through the conceptualisation of conflicts in agriculture, a missing feature to date. In this way,
117 the framework shifts research on agricultural transformations around issues of democracy,
118 justice, and development, moving beyond the usual problem-centred frameworks that focus on
119 technological diagnoses and solutions (Feola, 2013, 2015; Mapfumo et al., 2017; Pereira et al.,
120 2020; UN, 2015; Vermeulen et al., 2018). To capture these dimensions, our framework is place-
121 centred at the territorial level, to recognize and involve economically and/or politically less
122 powerful and marginalised actors in agricultural transformation processes at all relevant scales
123 (multi-scalar). In this respect, farmers are recognized as key actors, being the most direct
124 beneficiaries and co-producers of agricultural systems at the territorial level (Kovács et al.,

125 2014; Vialatte et al., 2019). Importantly, the analytical framework is designed to guide future
126 transdisciplinary research, thereby responding to the calls for empirical grounding of
127 sustainable transformations theories (Fazey et al., 2018; Feola, 2015). The framework therefore
128 includes both a diagnostic and an action research perspective: i) integrating conflict and conflict
129 transformation processes within the agricultural transformation processes; and, ii) providing
130 practical guidance on understanding and addressing conflicts and their transformation to
131 support or enable agricultural transformation. Finally, to be successful, agricultural
132 transformations are essentially an interdisciplinary and transdisciplinary endeavour and so this
133 analytical framework represents a theoretical and methodological contribution from social
134 science complementing those from ecological and agronomic research (e.g. Kovács et al., 2014,
135 Vialatte et al. 2019).

136 Section 2 highlights the relevance of our approach within the broader discussion on
137 sustainable pathways for food systems, and defines the main concepts used in the paper.
138 Section 3 provides the theoretical underpinnings of our framework, based on an in-depth
139 interdisciplinary analysis of the literature on sustainable transformations and pathways
140 research, agricultural alternatives using the example of (political) agroecology, and conflict
141 transformation. We illustrate our theoretical considerations using case studies from across the
142 world (Boxes 1-5), previously analysed by co-authors of this paper for the needs of other
143 research projects and revisited here to test the empirical basis for our framework, which is
144 presented in Section 4. In Box 6, we outline guidelines for the application of the framework.
145 In Table 2, we provide a glossary with definitions of main concepts mentioned throughout the
146 paper and constitute the components of the framework. Finally, we present our findings and
147 the potential for future research (Section 5) and provide concluding remarks (Section 6).

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2. Agricultural and food systems change, conflicts, and the pathways of agricultural transformations

The linkages between food, agriculture and global environmental changes have become more apparent, leading to greater focus on entire food systems, i.e. all processes and infrastructure involved in food production, to consumption and waste disposal (Béné et al., 2019; Caron et al., 2018; Foran et al., 2014; IPBES, 2019; Oliver et al., 2018; Van Bers et al., 2019). While the primary focus in the 20th century had been to increase yield to respond to the demand for food, staples and luxuries, and biofuel crops, this seems to be gradually shifting towards multiple concerns including human health, diets and ecosystems as well as fairness, power, and trade in a globalized world (Béné et al., 2019; HLPE, 2016).

Agricultural systems must play a crucial role in future sustainable food systems (Caron et al., 2018). In this paper, agricultural systems are defined as social-ecological systems that comprise social and biotechnical components, and fulfil agricultural objectives (e.g. production of food and fibre, renewable natural resources management, contribution to the socio-economic viability of rural areas) but that have additional environmental, economic and social implications (Urruty et al., 2016). This definition includes the interactions between agricultural systems and systems 'external' to them that act as drivers of change operating at multiple scales such as agricultural systems with different agricultural objectives, the broader local and/or global environment, policies, institutions, markets and thus food systems (Stephens et al., 2018).

One of the dominant pathways discussed for future sustainable agricultural systems refers to the 'sustainable intensification of agriculture' (FAO, 2011; Helfenstein et al. this issue). The approach has been accused of becoming overly focussed on increasing efficiencies but failing to address social values, human well-being and justice, and other issues relevant to sustainability (Bennett et al. this issue; Struik & Kuyper, 2017; Tittonell, 2014). Similar

criticisms have been raised about other alternatives to conventional intensive agriculture, such as integrated pest management or organic agriculture, which tend to result in business-as-usual pathways (Altieri, 2012; Pimbert, 2015). More recently, ecological intensification of agriculture has gained prominence, including agroecological farming, a nature-based approach that aims towards sustainable management, food security and the broader goal of societal transformation (Vanbergen et al. this issue and Section 3.2 in this paper). Nevertheless, there remains a mismatch between scientific understanding of alternative approaches to conventional intensive agriculture and the concerns of people working in and living with agriculture (Kleijn et al., 2019; Velten et al., 2015).

Agricultural systems and farmers are diverse and may refer from agribusinesses to small-scale farmers with varied socio-economic status and often diverging values, interests, alliances, and power (Coolsaet, 2015; Hervieu & Puseigle, 2013; Box 1). Many farmers, particularly those managing small and medium-scale farms and indigenous land users, face challenges related to competition for and appropriation of land and water resources by other actors/sectors, market forces, and external factors such as climate change and disease (Caron et al. 2018). A broader social malaise within the profession is reflected through suicide rates (Bryant & Garnham, 2015; Deffontaines, 2017; Merriott, 2016), protests (Van der Ploeg, 2020), the low number of young farmers (White, 2012) and more hidden struggles related to knowledge and recognition (Coolsaet, 2016; Pimbert, 2018). This calls for more attention on rural impoverishment and on those farmers, who see their agency being restricted by more powerful farmers, agribusinesses etc. (Chandra et al., 2019).

The above highlights the linkages but also the conflicts that can arise within and among agricultural and food systems worldwide. These conflicts often emerge from social-ecological changes and power imbalances, as well as from the unavoidable trade-offs between local systems and global priorities (Caron et al., 2018). Indeed, conflicts related to agriculture are

200 often triggered by conflicting agricultural objectives as well as multi-scalar changes in the
201 environment, economy or policy (Chapron et al., 2014; Crescenzi et al., 2015; Gevers et al.,
202 2019). For instance, they may refer to the impacts on and management of biodiversity, multiple
203 uses of the landscape, the access or distribution of resources, and health concerns from the use
204 of agrochemicals (Martinez-Alier, 2013; Niemelä et al., 2005; Tanentzap et al., 2015). Such
205 conflicts should be expected to occur during agricultural transformations, even if the goal is
206 the pursuit of (an often contested) sustainability (Dentoni et al., 2017; Hassanein, 2003).

207 The way in which we understand or frame conflicts affects the type of conflict
208 engagement process and its outcomes (Pound et al., 2016; Rodríguez & Inturias, 2018). We
209 suggest that conflicts around agricultural transformations should be framed as symptoms of
210 deep-rooted systemic issues that can be identified and proactively addressed to generate more
211 sustainable agricultural transformations. In this sense, an agricultural transformation that
212 neglects or only superficially resolves conflicts could result in making the same mistakes again,
213 reproducing existing patterns of inequitable outcomes across society, time and space, and
214 undermining the sustainability of agricultural transformations (Bennett et al., 2019; Figure 1;
215 Box 2). Such a process would then refer to pathways of agricultural transformation of increased
216 but 'bounded' sustainability as they have not capitalized on the window of opportunity a
217 proactive engagement with conflict could provide.

218

219 [ADD FIGURE 1 HERE]

220

221 In this paper, we argue for pathways that take advantage of the window of opportunity to
222 engage more deeply with conflict and power imbalances through conflict transformation
223 (Figure 1 – orange top pathway and see Box 1 for an example of conflict as a result of
224 agricultural change, and the potential for agricultural transformation; see also Dentoni et al.,

225 2017). In this latter pathway, it is important to clarify how we understand the 'sustainable
226 agricultural transformations' and their potential outcomes, which we fully expect to be context-
227 dependent, co-created by the different actors involved, and, although probably contested, they
228 will represent the different parties in a more balanced way than if conflict transformation was
229 absent from the agricultural transformation process. Building on previous work (e.g. Béné et
230 al., 2019; Caron et al., 2018; Chandra et al., 2019, Rodríguez et al., 2019; Van Bers et al.,
231 2019), sustainable pathways of agricultural transformations that acknowledge and address
232 conflict could include the following outcomes:

233 i. Farmers are better recognized for their contributions to society, through improved
234 livelihood, a revitalized identity and more recognition of their knowledge by science,
235 policy and others;

236 ii. Inter-group interactions are more balanced in terms of power and agency with
237 consumers more aware of their consumption choices and farmers able to choose if, how,
238 and when to change; more supportive companies produce inputs for farmers, as well as
239 those involved in food distribution.

240 iii. Multi-level governance supports more dialogue among actors, territorial cohesion,
241 rural development, and ensures more sustainable interactions among agricultural systems
242 (from agribusiness to small-scale farmers) from local to global scales;

243 iv. Agriculture does not harm ecosystems (locally or globally) but potentially goes further
244 by contributing to environmental integrity and resilience (e.g., to social-ecological
245 changes, climate change).

246

247

248 **Box 1: The Way of Mals – Jutta Staffler & Carolin Holtkamp**

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Background

Mals is situated in the Vinschgau inner-alpine valley in South Tyrol, Italy. Since 2010 intensive fruit growing has expanded in an agricultural landscape that had previously been dominated by grassland and crop farming. The intensification and change in agricultural land use implied not only a change of the traditionally open landscape but also an increase in the use of synthetic pesticides. Very small sizes of land parcels and regularly occurring winds make it difficult to use pesticides without significant drift. Organic farmers found pesticide residues on their hay fields as soon as the first apple orchards had been planted. Farmers and consumers in Mals organized a resistance against the spreading of pesticides through 'The Way of Mals', a local, social movement engaged against the use of pesticides and for a transformation towards agroecological practices (Holtkamp & Staffler, 2020) (Figure 2).

[Insert here Figure 2]

The conflict

Due to climate change and modernised irrigation methods, land became suitable for fruit cultivation. Land prices increased by 500% and leased land become increasingly unaffordable for the previous tenants, mainly livestock farmers, because fruit growers from communities further down the valley are more financially solvent buyers or tenants (Figure 3). This small-scale 'land grabbing' gradually deprived local livestock farmers of the land. Moreover, studies of grass samples in playgrounds near orchards show that 45% of the samples are contaminated with at least one pesticide, and 24% have multiple contaminations (Linhart et al., 2019). Concerns about the negative effects on livelihoods, health, nature, and environment caused by pesticides are growing.

[Insert here Figure 3]

A conflict that takes place within agriculture (organic vs. conventional farmers; fruit growers vs. livestock farmers), and also between agriculture and the wider population has developed. Behind the group of fruit growers, there are other interest groups, who stand up for the interests of intensive fruit farming. At the same time, the sympathizers of the Malser Way can now be found globally. This international solidarity represents the greatest means of pressure from the opponents of pesticides, since South Tyrol, as a tourist destination, fears that negative press will damage its marketed image.

How the conflict has been addressed

In a first dialogue, all parties concerned reached an agreement on measures to prevent pesticide drift, but these were not implemented. Critics defended their interests. In 2013, an organizing committee prepared a referendum on a ban of synthetic pesticides, causing high disagreement from the apple industry, which had to that point remained outside of the conflict. The subsequent referendum, in 2014, resulted in a strong electoral mandate for a pesticide-free community. However, the Administrative Court of Bolzano prohibited the implementation of the municipal council resolution, and the provincial government and farmers association responded with superficial reforms. The parties in conflict are currently discussing the proposal of an 'organic-model-region' that could enable profound change.

Reflection on a possible conflict transformation process

The Mals conflict involves ecological, sociocultural, technological, economic and political dimensions of the agricultural and food system and consequently, we argue, only a multidimensional approach will lead to a long-term solution. Although the conflict has not been

solved yet due to opposing values like health vs. freedom of choice, it has already pushed positive and profound transformations for South Tyrol. The spread of intensive apple cultivation in the Upper Vinschgau has been slowed, farmers use pesticides more carefully and the farming community is aware that it must face up to the criticism of the citizens.

Changing relational networks in Mals manifested, for instance, by newly-established citizen cooperatives, social cooperatives and farmers' markets, can be seen as signs of an evolving process towards a sustainable transformation of agriculture (Figure 4). The persistence and intensity of the civil resistance has led to a shift in the balance of power in favor of the previously weaker parties. A conflict transformation process may help to lead from opposition to coexistence.

[Insert here Figure 4]

Box 2: The Sorme lake and cattle breeding, conflicts over a time perspective– Sandrine Petit

Background

The Sorme lake was created in 1970 by damming the Sorme River, a tributary of the Loire, located in the Saône-et-Loire, central-eastern France. The lake has an extent of 230 hectares, damming some 10 million cubic metres of water from a catchment basin of 6,000 hectares. The lake was the result of a major development project designed to create a large water reservoir for the nearby towns of Montceau-les-Mines and Le Creusot (both joint in an Urban Community). The lake: i) provides raw water to the Michelin tyre factory at Montceau-les-Mines; ii) reduces flood peaks in the Sorme tributaries; and, iii) provides a reservoir for

drinking water in an area where underground water resources are limited. Today, the lake provides 80% of the Urban Communities drinking water.

The lake lies in a grassy landscape criss-crossed by hedgerows. There are 46 farms that practice extensive livestock farming, predominantly with Charolais cattle for beef, which has been credited with improving water quality. An eutrophication event in the lake during the 1980s degraded the water quality due to high levels of organics and phosphorus excesses in leachates, resulting in costly treatment to render the water of sufficient quality for drinking. Farming is considered as responsible for the situation (Figure 5).

[Insert here Figure 5]

The conflict

The first conflict dates back to the lake creation. The filling of the reservoir was a success but also difficult as farmlands, roads and farm buildings were engulfed by the water. Twelve farms were expropriated by compulsory purchase. Farming interests weighed little in the face of the municipalities and industry advancing arguments of economic development. A ‘group for the defense of landowners and farmers’ was able to obtain compensation for the loss of land. The second conflict between the urban community and the farmers arose in the 1990s. A report from 1989 concluded that livestock dunghills were sources of nitrate and phosphorus leaching into the lake. Consequently, the farmers around the catchment had to adapt their management of livestock effluent to bring their farms up to the required standards (EU Nitrates Directive of 1991). However, in 2009, the Sorme was again identified as one of 500 drinking water catchments in France threatened by diffuse pollution (French Grenelle Acts). Farmers’ concerns about further measures to prevent cattle from watering in streams was the genesis of

a third round of conflict. In 2020, a fourth conflict arose linked to the revision of the extent of the protection zone for the water catchment (Figure 6).

[Insert here Figure 6]

How the conflict has been addressed

The local agents to address the conflict were the Urban Community and the Chamber of Agriculture. As the owner of the lake, the Urban Community provided funds to help farmers. The Chamber of Agriculture took up a mediation role and provided advice to farmers on how to adapt their farm management. Scientists and experts from various firms are key actors in dominating the discourse and defining the problem while water quality remains at a fragile state. In 2009, when tensions emerged from the Grenelle Act, farmers recalled the trees, buildings and roads lost to the lake. For farmers, the poor quality of the water is due to lake sediments. The farmers liken the lake to the ponds in their meadows, which have to be dredged to regain depth and clear water, and argue that the lake sediments should similarly be removed to restore water quality. For them, the lake's stagnant and turbid water contrasts with the clean water of local streams and springs that they channel to tanks to water their cattle. However, their knowledge about these water flows and the erosive dynamics of river has not been considered in any debate on water management.

This conflict is based on contrasted 'social representations'. Managers from the urban community, public services and scientists would like to introduce an ecologically-based management regime perceiving the lake and its catchment basin, as an ecosystem with strong interactions and, thus, as the ecosystem of interest (horizontal perspective). Farmers, on the other hand, perceived the lake and its sediments as the sole ecosystem of interest, excluding many of these interactions (vertical perspective). Changing pasture management and practices

of watering animals were difficult to accept by the farmers. Through a long process of dialogue, actions that target specific hot-spots of phosphorus input are being implemented, rather than applying standard measures across the 6,000 hectares of the catchment.

Reflection on a possible conflict transformation process

Over the last 50 years, conflict engagement processes have been iterative: conflicts have emerged, they have been solved, evolved and then reemerged. Conflict transformation would address underlying issues apparent in the different phases of the conflict. For example, from 1970 to 2020, the narrative shifted from the economic development of an industry to environmental management of a natural resource. Farmers in the Sorme catchment were first marginalized in 1970 but since 1990 agricultural change has become the center of public action. Public policies and the Urban Community place the question of management at the scale of the lake catchment and farmers' use of land. Farmers have a counter-argument that locates the pollution within the lake sediments. Farmer knowledge and values seem to be poorly integrated into the debate. This could be one reason for the reemergence of conflict over time. Scientific and expert explanations of the problem of phosphorus flow, for instance, are complex and further marginalize farmers and exclude co-production of knowledge. Farmers also demand justice, particularly as they believe that it is falsely only agriculture – no other stakeholders – that is required to change, feeling more 'vulnerable' than water in a context of economic crisis for beef production.

3. Building the analytical framework

In this section we provide an analysis of the theoretical foundations of the framework, namely sustainable transformations, alternative agricultural approaches (using agroecology as an example) and conflict transformation. Sustainable transformation theories provide the

399 conceptualisation of ‘pathways’ of agricultural transformation and social parameters that
400 enable or disable sustainable transformation. Here, we have limited our research to papers that
401 explicitly refer to transformations, rather than considering the entirety of the literature on
402 sustainability ‘transitions’ (see for instance Ingram, 2015; Lamine et al., 2019). We
403 differentiate between ‘transformations’, which imply more radical, emergent and long term
404 social-ecological changes (either top-down and/or bottom-up), and ‘transitions’ that tend to be
405 politically top-down and technocratic (e.g., Hölscher et al., 2018; Stirling, 2014). We
406 acknowledge, however, that the two concepts are not mutually exclusive and certain insights
407 from the sustainability transitions research could be valid here and *vice versa*. We focus on
408 agroecology not because it constitutes the desired endpoint of every agricultural transformation
409 but as an example of an alternative agricultural system that integrates biological, technical and
410 socio-political dimensions connected to broader food system challenges. In this respect,
411 agroecology is used here to provide specific lessons learnt to feed into the analytical
412 framework. Finally, the literature used from conflict transformation emphasizes the role of
413 power and additional aspects of conflict that need to be addressed when analysing and
414 transforming conflict.
415
416
417 **3.1 Adaptation pathways to sustainable transformations in agriculture**
418 Transformative changes in agricultural systems are usually analysed in terms of their depth,
419 scope/breadth and speed of change (Linnér & Wibeck, 2020; Panda, 2018; Termeer et al., 2017;
420 Fazey et al., 2018; Feola, 2015). The change can range from incremental to radical change
421 (depth), a narrow scope that addresses specific elements to large-scale, system-wide change
422 (scope/breadth) and timescale (speed of change). This outcomes-based approach is reasonable
423 insofar as it requires users to be explicit about their approaches and about what they perceived

424 is being transformed from and to (Fazey et al., 2018). However, a focus solely on the outcomes
425 fails to shed light on dynamic social processes, including conflict (Vermeulen et al., 2018). As
426 such, we echo the calls for combining the focus on depth, scope/breadth and speed of change
427 with a process-based analysis of transformations (Mapfumo et al., 2015).

428 To better understand the process, we follow the 'pathways' approach to transformations,
429 according to which the system is perceived to be in constant change over time to adapt to
430 multiple social-ecological changes (Fazey et al., 2016; Stringer et al., 2019; Wise et al., 2014;
431 Section 2). Within such approaches, ethical and procedural questions are raised about who and
432 what processes enable or disable transformations, who and what determines the multiple
433 emerging potential pathways and which pathway is considered sustainable (Fazey et al., 2018;
434 Pelling et al., 2015). In this regard, a number of enablers and disablers of sustainable
435 transformations have been identified, including vulnerability, history, the Values-Rules-
436 Knowledge interactions, uncertainty and ambiguity (for definitions on all the main concepts in
437 the paper please see Table 2).

438 The role of vulnerability is a central underlying factor necessary to understand
439 transformative change, which highlights the root causes that render a system susceptible to the
440 adverse effects of certain drivers of change (O'Brien & Wolf, 2010; Panda, 2018, Adger, 2006).
441 Vulnerability relates to what people value in terms of survival, security and identity and can
442 thus determine which adaptation or transformation pathways are perceived to be desirable,
443 effective, and legitimate (O'Brien & Wolf, 2010). Moreover, 'vulnerability is driven by
444 inadvertent or deliberate human actions that reinforce self-interest and the distribution of
445 power' (Adger, 2006, pp.270), making also power and agency central to sustainable
446 transformations, potentially blocking, distorting or directing them (for more on power and
447 agency see Section 3.3 – Scoones et al., 2020). For example, Box 1, illustrates how apple
448 farmers feel vulnerable within their economic success, fearing restrictions in terms of their

choice of production methods and potential changes in power structures that could block transformative change. Box 2 showcases trade-offs in social-ecological vulnerability that can interfere in transformation processes.

The history of the system including political, institutional, economic, cultural and other legacies filters future trajectories and hinders the potential to change direction along a given pathway (path-breaking). The evolution of the system is thus bounded by history in that certain alternative configurations become unthinkable (Olsson et al., 2017; Wilson, 2014). Understanding how this bounded system was formed and how a path-breaking moment could take place requires a clear mapping of the social landscape in which transformation may/should occur. Colloff et al. (2017) argue that processes that enable, hinder or direct transformations can be revealed through an analysis of the interactions among: i) societal values (O'Brien & Wolf, 2010); ii) rules, including informal norms and practices, and formal regulations legislation (Gorddard et al., 2016; Ostrom, 2011); and, iii) knowledge of the individuals and structures involved (Gorddard et al., 2016). During participatory decision making processes for deliberate transformations, the explicit consideration of these components promotes reflexive inquiry, new collective knowledge and perspectives, and can potentially augment double-loop social learning (i.e. to fundamentally revisit and reshape certain underlying assumptions, values and patterns of thinking and behaviours) and triple-loop social learning (i.e. institutional changes, such as changes in structures, policies, programs, rules and decision making procedures – Colloff et al., 2017). This is particularly necessary in developing country contexts where asymmetries between the values, rules, knowledge and power of the actors are highly complex and acute (Butler et al., 2014; 2015; 2016a; b; Box 3).

The adaptation pathways approach originally focused on the challenges related to uncertainty in scientific knowledge (Fazey et al., 2016). Considering that transformations are nested within complex social-ecological systems, this kind of uncertainty is a potential disabler

that could be addressed to some extent through sound ecological knowledge, for instance, on the identification of trade-offs and tipping points (Kovács et al., 2014; Pereira et al., 2020). The Values-Rules-Knowledge approach addresses ambiguity as a form of uncertainty. The processes of transformation usually involve many agents of change (Westley et al., 2013) who hold multiple legitimate viewpoints based on diverse ways of understanding and interpreting the same issue (Bosomworth & Gaillard, 2019; Renn et al., 2011). This ambiguity can often bring up conflicts that 'entail a radical choice for one or another type of society, based on specific values' and demand the active participation and engagement of citizens and decision makers (Ainsworth et al., 2020, Hassanein, 2003; Kenis et al., 2016, pp. 10; Box 1). This could explain, to a large extent, why sustainability and sustainable agriculture are contested concepts and as such need to be socially and politically defined through the co-production of solution spaces (Hassanein, 2003; Box 3).

Box 3: Oil palm development in East New Britain, Papua New Guinea (PNG) – James Butler

Background

Oil palm is a monoculture which performs well in humid coastal Papua New Guinea (PNG). Wherever it has been introduced the production system transforms landscapes and livelihoods (Sayer et al., 2012). The industry is PNG's most valuable agricultural export and the largest non-government employer (Cramb & Curry, 2012). However, its expansion has raised growing concerns about social and environmental impacts (Wakker et al., 2004; Koczberski et al., 2006).

The conflict

Most land in PNG is under customary ownership, which requires collective agreement amongst communities about land conversion. To accelerate oil palm development and national export earnings, the PNG Government introduced Special Agricultural and Business Leases (SABL) in which land tenure can be converted from customary ownership to long-term corporate leases in partnership with local landowners. However, this policy and its implementation has led to conflict amongst community members who support or oppose oil palm development, and tensions between developers, government and landowners (Nelson et al., 2013).

This case study focusses on two oil palm developments in East New Britain (ENB), both involving a Malaysian company that had been granted SABLs. The first was initiated in 2010 in East Pomio which converted 11,000 ha into oil palm. The second was Lassul Baining, where the company planted 5,500 ha in 2016 (Figure 7) and terraced steeper slopes, causing erosion and sediment run-off (Figure 8).

[Insert here Figure 7]

[Insert here Figure 8]

In East Pomio, some landowners converted their land and grew oil palm in a joint venture agreement with the company, while others chose to maintain their traditional food gardens and other cash crops. Although the company had initiated a community development program, those outside the agreement were excluded from this program. This asymmetry was illustrated by stakeholders in a pilot planning workshop (Figure 9). In Lassul Baining, the land clearance had only recently occurred and conflict was escalating. There remained confusion and

suspicion amongst landowners about the approval process, and the displacement of households and food gardens.

[Insert here Figure 9]

Conflict transformation process

In 2015-2017 a project was initiated to develop a participatory approach that could encourage evidence-based and transparent decision making and catalyse climate resilient development pathways through conflict transformation. The process encouraged partnerships between important stakeholders, exposed and discussed conflict, empowered marginalised and included previously excluded actors, facilitated linkages and coordination, and enhanced stakeholders' understanding of information and their skills to apply it (Butler et al., in review). The project created a 'social learning loop' with six steps amongst stakeholders around the oil palm developments:

Step 1: Understand the decision making process, politics and conflict

Step 2: Identify and map natural resource values in the area

Step 3: Develop decision-support tools to assess the potential 'footprint' of the development, and future change (e.g., climate change, population growth)

Step 4: Pilot planning workshops with decision makers to agree a vision for the community, explore future uncertainty and actions required to achieve the vision

Step 5: Training for decision makers to use the tools and information

Step 6: Evaluation to inform the subsequent social learning loop.

Step 1 carried out decision mapping exercises to understand the statutory approvals process for oil palm, and the power relations between the developers, communities and government. Interviews and focus groups revealed jurisdictional overlaps, acute power

asymmetries between actors, and low capacity amongst decision makers. This caused high transaction costs for developers, creating an incentive for corruption and mistrust between stakeholders (Meharg et al., 2016).

In Step 4, a 2-day workshop was held for each development, including key decision makers and non-oil palm growing landowners. Workshops were facilitated by the research team who acted as change agents, and also fostered other change agents to emerge amongst local stakeholders. The process was designed to catalyse social learning amongst participants, the development of new networks and partnerships and to co-produce knowledge, perspectives and solutions. The activities also aimed to trigger double-loop learning (i.e. testing assumptions) and triple-loop social learning (i.e. challenging underlying values, beliefs and institutional norms – Table 2).

Subsequent evaluation demonstrated that the process had produced significant change, including land use zoning to preserve food gardens and food security, a 'stop work order' on oil palm planting pending completion of the land use zoning, and a review of oil palm licensing. Hence, although the landscape transformation initiated by the oil palm had triggered conflict, it had also presented a window of opportunity to draw actors together to agree a future vision for their communities, and development pathways that addressed equity, sustainable livelihoods, food security, climate resilience and population growth (Butler et al., in review).

3.2 Solution spaces through collective actions: lessons from agroecology

Probably the most radical transformation pathways for future sustainable agriculture refer to the 'ecological intensification of agriculture' or agroecology (Tittonell, 2014; Petit et al., this issue; Vanbergen et al. this issue). Starting as an ecological science for sustainable agriculture, agroecology is by many now perceived both a science and practice that reconfigures and

establishes new linkages between knowledge, practice and power (Wezel et al., 2009, Pimbert, 2015). The aspired outcomes or 'solution spaces' of an agroecological transformation encompass the cognitive, social, technological and social-ecological aspects of agriculture (Toledo & Barrera-Bassols, 2017). In the agroecological perspective, food producers and citizens are knowledgeable and active agents that cooperate with scientists in a process of mutual learning (Box 3). The co-produced knowledge provides agroecological innovations as well as visibility and legitimacy to local actors (Box 2; Pimbert, 2015; Toledo & Barrera-Bassols, 2017), creating local 'bridgeheads' for adaptive co-management and wider transformation (Butler et al., 2016b). These innovations translate into a practice based on the sustainable use of local renewable resources and solutions that value the non-commodity outputs of agriculture as much as the commodities (Silici, 2014; Wezel et al., 2018).

Political agroecology emphasizes social and political aspects including autonomy, self-sufficiency, bottom-up place-based organisation, and equal access to decision making, to ultimately achieve social-ecological innovations and sustainable food systems (Anderson et al., 2019; Olsson et al., 2017). In this sense, the democratization or sovereignty of the food systems lies at the heart of the solution space sought by (political) agroecology. Hence, political agroecology calls on social movements and a wider range of 'agents of change' to reverse exclusionary processes that often favour the values, rules, and knowledge of the most powerful actors (Pimbert, 2015).

For agroecology to become accepted and grow, alternative agri-food movements often have to develop within a dominant institutional environment (Anderson et al., 2019; Bacon et al., 2012; Caron et al., 2018; Castro-Arce & Vanclay, 2020). Formal institutions can, however, enable agroecological transformations and lead to wider and multilevel transformations by supporting participatory governance processes, co-production of knowledge and agroecological, individual and collective, initiatives (Anderson et al., 2019). Institutions can

598 also promote agroecology by ensuring equitable access to natural resources (Castro-Arce &
599 Vanclay, 2020), which is an important incentive for farmers, communities, and territorial
600 networks to engage in long-term agroecological approaches (Anderson et al., 2019). In many
601 places of the world, multiple factors have contributed to a highly unequal land distribution and
602 difficult land access. Policies to counter the growing trend of land grabbing and land
603 restructuring may enable agroecological transformations to take place (Wezel et al., 2018; Box
604 1).

605 Considering the need to bridge top-down policies with bottom-up initiatives (Box 4), the
606 'territory' level is increasingly viewed as the decisive scale for fostering agroecological
607 transformations (Anderson et al., 2019; Caron et al., 2018; Oteros-rozas et al., 2019). The
608 territorial level is similar to the landscape approach in ecological research (Helfenstein et al.
609 this issue; Kleijn et al. this issue) moving beyond farm level management to collective action
610 through the connection between agricultural systems and institutions (Vialatte et al., 2019).
611 Agroecology at the territorial level, should lead to a recognition of the potential of conflict as
612 well as of resistance and creativity for actors to govern and shape their relationships with
613 agricultural and food systems and debate the benefits and trade-offs of different landscape
614 management options (Hassanein, 2003, pp. 79; Vialatte et al., 2019). To 'harvest' the energy
615 of conflict, formal and informal territory-based institutions need to empower the actors of
616 agroecological territories. To achieve this, inclusive and safe processes for deliberation and
617 action that enhance people's capacity for agency are needed (Holtkamp & Staffler, 2020;
618 Pimbert, 2015). Box 3 illustrates how processes can identify this 'territory' and cultivate a
619 solution space for actors, facilitated by external agents of change, while Box 2 illustrates how
620 the lack of co-production of knowledge and solution spaces has resulted in a vicious circle of
621 conflict, which is constantly re-emerging.
622

Box 4: Nature conservation struggles against agribusiness in Chaparri – Constanza Parra & Pieter Van den Broeck

Background

The Chaparri Ecological Reserve is a mountainous, protected area covered by sub-tropical dry forest, covering over 34000 hectares and containing a variety of ecosystems and fauna in danger of extinction (Figure 10). Chaparri is located in the Peruvian region of Lambayeque, at the intersection between the arid coastal plane and the Andes. Lambayeque experiences almost zero annual precipitation, with the exception of 'El Niño' years that bring severe precipitation and flooding to the Pacific coast (Vos & Vincent, 2011). The Chaparri Reserve was created in 2001, after the rural community Muchik Santa Catalina de Chongoyape decided to convert 80% of their communal land into the first, privately-protected area in Peru.

[Insert here Figure 10]

The conflict

The deep disconnection between the goals, needs and values of nature conservation and those of industrial agriculture was the starting point of the ongoing conflict in Chaparri. At the local and regional levels, the struggle for water and land are core issues (Figure 11). From a macro perspective, this conflict is fuelled by the capitalist, neo-extractive model of Peru (Svampa, 2019; Parra & Moulaert, 2016). Agriculture, mining and oil extraction have generated economic growth and employment at the expense of the degradation of multiple ecosystems, over-exploitation of natural resources, displacement of communities and violation of human rights. The establishment of the conservation project of Chaparri sought to redress this unsustainable model.

The conflict in Chaparri has its origin in the decision of the local community to convert most of their communal territory into a reserve. This decision restricted certain land uses – intensive agriculture, illegal mining, and clearcutting of forests – and favoured sustainable development through ecotourism and agroecology. The determination of the Chaparri community generates both acclaim and contestation. A very violent conflict opposing conservationist voices to powerful agroindustry companies operating in the immediate vicinity of the reserve started four years ago. Access to water and land initiated this conflict. Most of the water to irrigate the planes and crops covering the dry Chancay Valley emanate from the sources and rivers of the protected Chaparri mountains (Figure 11). The Chancay-Lambayeque irrigation system, set up to serve the hydraulic needs of the agricultural modernisation program pursued by Peru (Delgado, 2015), is at the centre of this conflict. The canals, dam and reservoir of Tinajones are an important part of the Chancay-Lambayeque system, supplying water to the neighbouring agricultural lands producing sugar cane, rice and corn (Garcés-Restrepo & Guerra Tovar, 1999). The current conflictive state of affairs in Chaparri results from the imminent implementation of a new phase of the Hydraulic Development Plan in Lambayeque, aiming to expand the water storage capacity of Tinajones. This would open up additional lands in the Chaparri reserve to expand industrial agriculture.

[Insert here Figure 11]

How the conflict has been addressed

The conflict has been partially addressed through bottom-up mobilisation. The local community's activism opposing powerful players counts on the support of judges, the media and other actors to raise awareness of the violent situation. Attracting eco-/agro-tourism to the

reserve and expanding conservation-related activities is also a way to reinforce the local means of addressing the conflict. Broader participation and involvement of different community members has been stimulated to increase the capacities and engagement with Chaparri (Figures 12 and 13). Nevertheless, despite these efforts, the conflict persists.

[Insert here Figure 12]

[Insert here Figure 13]

Reflection on a possible conflict transformation process

A conflict transformation process started with the self-organisation of the community and the creation of the reserve. The trigger was a shared view of a rural world in which the imperatives of social justice and environmental integrity merged. The community envisioned a mix of nature conservation and sustainable development, and identified eco-/agro-tourism, agroecology and local cultural revitalisation as the way to further empower their agency towards their transformation goal. The socio-environmental commitment of Chaparri provides inspiration but also clashes with the Peruvian socio-political and economic reality. Chaparri shows how power asymmetries reproduce extractive logics at the expense of humans and ecology. Bottom-linking (Spijker & Parra, 2018) Chaparri's agency with the powers and institutions that could further enable its mission could be a way to recalibrate power relationships and enhance the sustainability chances of Chaparri's transformation process (Van den Broeck et al., 2019; Figure 14).

[Insert here Figure 14]

3.3 Reinforcing agricultural transformations through conflict transformation

While certain conflicts are perceived as being between people and nature, agricultural conflicts are increasingly acknowledged in the ecological and conservation literatures as conflicts among different societal actors with competing goals and values over nature (Mann & Jeanneaux, 2009; Torre et al., 2014; Young et al., 2016). Conflict transformation recognizes conflict as a potentially constructive and creative part of human interaction and catalyst for change (Mouffe, 2013). According to this view, conflict is an inherent part of life, and while it can create stress and tension, it allows for the identification of potential injustices and deep-rooted systemic issues (Mitchell, 2002). Without ignoring the short term needs and actions (e.g., referring to conflict resolution processes), conflict transformation proposes a long-term process that can generate greater justice and reduce the negative impacts of conflict in relationships and society by understanding and addressing the relational and historical patterns in which conflict is embedded (Box 5; Lederach, 2003; Miall, 2004; Rodríguez & Inturias, 2018). Transformations towards sustainability via conflict transformation would address issues of desired change across four dimensions: personal, relational, structural and cultural (Lederach, 2003; see Table 1).

[Insert here Table 1]

Conflict transformation has mainly been applied to violent conflict and marginalized groups such as indigenous communities and ethnically discriminated groups (Rodríguez & Inturias, 2018; Smith, 2008; Temper et al., 2018), although it has also been applied to conservation conflicts (Madden & McQuinn, 2014). As seen in the case of agricultural changes and transformations, however, marginalization can be considered in a broader way, formulated

by prevailing values, rules and knowledge often expressed through hegemonic power perceptible through dominant paradigms and discourses. As such, marginalization can refer to the neglected needs of farmers in small and medium-scale agriculture (Boxes 1 and 2), to landowners with less popular interests (Box 3) or to communities' values and demands opposing powerful agroindustries (Box 4). Marginalization in conflict is contextual and dynamic with a societal group marginalized in one context or time becoming dominant in another situation.

A key component in conflict transformation in agriculture is the emphasis on understanding power dynamics as an underlying cause of conflict (Rodriguez et al., 2014). Rodríguez and Inturias (2018) identify three dimensions of hegemonic power: i) structural power, when it is applied visibly through the decision making structure; ii) network power, when it is obscure but occurs through manipulation; and, iii) cultural power, corresponding to the invisible way that power appears through discourses, narratives and worldviews assimilated by society as true without questioning. They propose that to achieve the transformation toward sustainability in agriculture, we must overcome these power asymmetries and reposition power as a force for conflict transformation.

Rodríguez and Inturias (2018) also mention the 'power of agency'. Power in this context is a positive notion that depicts the ability of actors to define problems and political issues and mobilize resources to formulate and carry out the desired solution (Arts & Van Tatenhove, 2004). Therefore, transformative power and agency allow thinking about what material (money), information (access and control) and cognitive (moral support) resources can be used to make a difference (Rodríguez et al, 2019). Agency is central in agricultural transformations, whether it is for a community of small-scale farmers against powerful agribusiness companies (Box 4) or for local organic farmers joining with local consumers against industrial fruit farming (Box 1). However, conflict transformation refocuses the

748 question of agency by recognizing that in situations of domination, the problem is not that some
749 have more power than others, but how the excluded make use of resources to change their
750 circumstances (Rodríguez & Inturias, 2018).

751 Rodríguez and Inturias' (2018) 'Socio-environmental Conflict Transformation'
752 framework aims to strengthen the capacity of vulnerable actors to transform conflict and create
753 the conditions for more symmetrical and horizontal intercultural dialogue. They do so by
754 acknowledging the importance of the 'intracultural' local level, which focusses on
755 communities' internal differences related to changing identities and contested visions of culture
756 (Box 5). They emphasize the need to create opportunities for negotiation, where social,
757 economic and political inequalities are made visible and confronted. Regarding conflict in
758 agriculture, for example, building capacity to overcome internal differences among farmers by
759 facilitating intracultural dialogue would be an important step to clarify local perspectives and
760 knowledge and strengthen local actors' capacity to confront future conflicts. The power of
761 agency should not only influence change and empowerment at the personal and relational level,
762 but also impact power asymmetries at the cultural and structural level (Rodríguez & Inturias,
763 2018).

764 Narratives play an important role in the abovementioned processes as they can influence
765 power at different levels. Narratives are related to how people interpret the reality surrounding
766 them, including past events and future expectations (Strömbom, 2001). By constructing
767 narrative identities, both collectively and individually, some of which become dominant,
768 people shape the interpretation of the past, present and potential futures. Some work on
769 transformation to sustainability emphasizes the need to create positive narratives from diverse
770 perspectives that could act on the status quo and enable transformation (Pereira et al., 2018;
771 Raudsepp-Hearne et al., 2019). However, conflict transformation focuses on the social groups
772 that do not see themselves recognized in the dominant worldview and will try then to alter the

realm of social representation (Rodríguez & Inturias, 2018). One suggestion is then to reconnect with the past to restore narratives and peoples' place in history, to revitalize and renegotiate identities to be in a much stronger position to visualize a desired future. By creating new meanings, norms, and values, those social groups offer counter-narratives that if reaffirmed by enough people, can allow for profound changes. The use of such counter-narratives is illustrated in the context of lake and sediment management (Box 2), of developing a strong environmental identity (Box 3) and of empowering marginalized, indigenous people based on social and ecological scientific research (Box 5).

Finally, conflict transformation also explores the type of social movement necessary to engage with transformation and rebalance power asymmetries. Authors working on conflict transformation highlight resistance, often expressed as oppositional action as important processes in the creation of alternative approaches (Pelenc et al., 2019; Temper et al., 2018). Alternative processes that do not involve concrete expression of opposition are also presented as a way of resisting and proposing some form of sustainable transformation (Pelenc et al., 2019; Temper et al., 2018). These interlinked processes allow an understanding of how to influence power dynamics, recognizing that resistance is not just a movement 'against' but also an opportunity to innovate and create energy to propose new alternatives (Pelenc et al., 2019; Temper et al., 2018). For example, Box 3 describes how opposition to oil palm development resulted in a 'stop work order' implemented by the provincial government, but also collective solutions such as land use zoning. Through a conflict transformation approach, we can question how those resistance and alternatives movements in agriculture navigate through different power and agency arrangements and narratives, eventually supporting profound changes at the personal, relational, structural and cultural levels.

Box 5: Conflict transformation through the emergence of a counter narrative of fire in Canaima National Park, Venezuela- Iokiñe Rodriguez

Background

Canaima National Park (CNP) is located in south-eastern Venezuela, within the ancestral territory of the Pemon Indigenous Peoples. Since the park was established in 1962, the Pemon have been in conflict with environmental authorities due to conflicting land use demands and because the park was established on ancestral territory without consultation or local consent. With an estimated population of 20,000, many Pemon still live a lifestyle based largely on traditional activities including agriculture, fishing, hunting and gathering, and more recently many have turned to mining.

The conflict

In terms of the CNP's conservation objectives, one of the most contentious issues has been the extensive use of fire by the Pemon in conucos (slash and burn) agriculture and in savannah burning; both indigenous practices that are considered by environmental managers as a threat to the watershed conservation functions of the CNP. Despite a variety of strategies developed by the government, many Pemon, especially the elders and those living in more isolated communities, have continued using fire extensively. Younger Pemon have become more critical of the use of fire and, as a result, inter-generational tensions are increasingly common on this topic.

The dominant view of fire in CNP is product of more than a century of misinterpretation, by non-indigenous people, of the Pemon's use of fire (Rodriguez et al., 2013). Since colonial contact, fire has been highlighted as a cause of the systematic reduction in the forests and conversion to grassland. Underlying the way traditional burning practices were and are seen is

822 the perception that the Pemon lack the necessary knowledge to use fire or manage the land. Up
823 until recently, such a view of fire among managers in the Park prevailed, and created a strong
824 clash between two different knowledge systems about fire.
825
826 **How the conflict has been addressed**
827 In the late 1990s, socio-ecological researchers began studying existing conflicts over the use
828 of fire, while supporting the development of Life Plans for the Pemon (Perez, 2009). Assisting
829 in the development of Life Plans, through participatory historical reconstructions, territorial
830 self-demarcation processes and facilitating community reflexivity was decisive for the Pemon
831 revealing fire management knowledge that challenges conventional explanations of landscape
832 change (Rodriguez, 2017). According to Pemon knowledge, the key to avoiding large
833 destructive fires is maintaining a prescribed patch-burning fire management regime, which
834 park managers had entirely overlooked for more than four decades (Rodriguez, 2004, Sletto &
835 Rodriguez, 2013). This was confirmed by fire behaviour studies, which supported Pemon
836 prescribed burning as an appropriate technique for biodiversity conservation and suggested that
837 the Pemon burning system is key in preventing potentially large destructive fires in critical
838 conservation areas. Paleoecological studies also showed that fire had been present in the
839 landscape for over 7,000 years (Leal, 2010; Leal et al., 2016). As a result, a counter narrative
840 of the role of fire in the park started to emerge, emphasising four points:
841 - Fire and burning is an integral component of the landscape.
842 - The Pemon have an ancestral system of fire management that could help reduce fires in high-
843 risk areas.
844 - Fire has to be considered one of a variety of factors that could be contributing to vegetation
845 change in the area.

- Fire policies must change from a focus on suppression to an emphasis on management (prescribed burning) based on greater integration of different knowledge systems.

Reflection on the conflict transformation process

As a result of the new fire narrative, the fire conflict in CNP has started to evolve from a state of latency, which made addressing its root causes very difficult, to one of open and manifest conflict, in which social awareness of the causes of the conflict has increased and a confrontation of views and perspectives has started to take place.

[Insert here Figure 15]

Figure 15 illustrated new knowledge networks that have begun to craft a counter-narrative of fire that exposes the weak points and illogicalities of the dominant narrative and suggests a more socially just and environmentally consistent approach to fire policies. Through these new knowledge networks, the Pemon have started clarifying and articulating their views of fire so as to be in a stronger position to engage in dialogue with resource managers and scientists. By grounding the discussion within their own cultural politics, Pemon from different generations have started to openly discuss complex issues related to land use, environmental change and shifting local identities. The counter-narrative of fire has started timidly to find its way into the institutional discourse (Sanchez et al., 2007). Thus, through this new counter-narrative of fire, a systemic transformation of the conflict has started to take place in all its dimensions: cultural, personal, relational, structural.

4. A conflict-centred framework for sustainable agricultural transformations

Based on the above theoretical foundations, we propose an analytical framework with an integrated view of the major components of agricultural transformations, particularly highlighting conflict transformation and how it can enhance sustainability.

Figure 16 details the point at which a window of opportunity for an agricultural transformation occurs. In Figure 16, the blue arrow describes a process that may involve conflict, but neglects it or attempts to superficially resolve it without deeply engaging with it through conflict transformation. This process tends to reproduce existing patterns of inequitable outcomes feeding back to changes in agriculture, neglecting the root-causes of the social-ecological crisis that either imposed or called for the agricultural transformation in the first place. In contrast, the orange arrow describes the process where conflict is made explicit and is recognized as an important motor for redistribution of power and leverage for social learning that – if addressed through a conflict transformation process – could potentially create a step-change in agricultural transformation towards greater sustainability that addresses aspects of the socio-ecological crisis (orange dotted arrow). We will now focus on this second case where conflict transformation refers to participatory processes attributed specifically to the conflicts involved and thus the agricultural transformation capitalizes upon the window of opportunity.

[Insert here Figure 16]

The ‘Enablers and Disablers of Transformation’ are derived mainly from the sustainable transformations literature (Section 3.1) and initially define the ‘solution spaces’ that can be sought and created (Section 3.2). At this first stage some agricultural transformation pathways

seem more possible and feasible than others due to prevailing Values-Rules-Knowledge and other aspects such as historical issues, vulnerability, uncertainty and ambiguity (Section 3.1 and Table 2). This first step can be used to help describe social systems that can often restrict agency, deepen conflicts and limit the 'solution spaces', possibly hindering social and technological innovation. It can also be used to investigate the potential of the dominant institutional environment to enhance bottom-up agricultural transformations such as agroecology (Section 3.2).

In the 'Conflict Transformation' component (Section 3.3), conflict and contestation are made visible and highlight profound debates and oppositions. Conflict transformation reinforces the capacity of the agricultural transformations by challenging the dominant pathways (Section 2). Conflict transformation acknowledges conflict and possible acts of resistance as manifestations of the need to reconfigure the power dynamics that marginalise certain actors (and thus Values-Rules-Knowledges) over others, thereby promoting certain pathways over others. The process explicitly recognizes and works with agency, the multiplicity of narratives, and forms of resistance and alternatives aiming at a double-loop social learning process. In this way, 'Conflict Transformation' provides agency to actors and structures and includes the previously marginalised from the agricultural transformation process, thereby redistributing power and enlarging the pool of 'agents of change'.

The 'agents of change', i.e. actors and institutions who play a significant role in initiating, managing or implementing change (Section 3.2 and Table 2), are at the core of the agricultural transformation process. In the case of agroecology, our exemplar alternative agricultural system, the agents of change are drawn from the three activity spheres of science, practice, and social movements. They help in linking the top-down provisioning of formal institutions with bottom-up initiatives at the territorial level and enable 'seeds' of agricultural transformations relevant also at the national and international levels (Section 3.2). The agents of change are

920 highly context-dependent but the framework suggests the three activity spheres and the focus
921 on the territorial level as a first step for the identification of multi-scalar drivers of change as
922 well as actual and potential agents of change and the links among them. The capacity and
923 willingness of those agents to act, as well as the efficiency of their actions will be largely
924 defined both by the 'Enablers and Disablers of transformation' and 'Conflict transformation'.

925 The 'Solution spaces' (Section 3.2) refer to the potential outcomes of the agricultural
926 transformation process that will eventually define the outputs. Here, the exact outcomes will
927 depend on the aspirations and aims of each agricultural transformation. In general, the diverse
928 actors co-produce new knowledge that provides visibility and legitimacy to previously
929 marginalised actors, who are now recognized and empowered. This process also supports
930 social, technological, and social-ecological innovation. Bringing structure and agency together,
931 the 'solution spaces' aim at achieving triple-loop social learning. Overall, the process includes
932 trade-offs, which are recognized, openly discussed and negotiated feeding to a continuous
933 learning process for the agricultural transformations to follow.

934 Finally, to describe and assess the outputs of the entire process we refer to the dimensions
935 of agricultural transformation, namely depth, scope/breadth, and timeframe of change (Section
936 3.1). Instead of the 'speed of change', as defined in Section 3.1, here we use the 'timeframe of
937 change'. This concerns both the time needed for the agricultural transformation process to
938 occur and the lasting effects of the transformation into the future (Section 5 for a reflection on
939 the time dimension of the agricultural transformation conceptualised in this paper). According
940 to our framework, the impact of the agricultural transformation measured in terms of these
941 dimensions will be generally more substantial when conflict transformation has been part of
942 the agricultural transformation process.

943

944 [Insert here Table 2]

Box 6: Putting the analytical framework into practice – Lou Lecuyer, Thomas Fickel, Nils Bunnefeld and Isla Hodgson

For our next steps, we aim at applying the analytical framework in three different European agricultural conflicts in Scotland, Germany, and France. Below we provide a brief introduction to the three case studies and we then outline the methods we plan to use for applying the framework. We suggest that these methods, appropriately fine-tuned and adapted according to the specificities of different contexts and research interests, could be used for the investigation of other cases as well.

Introduction to the three cases

In Scotland, geese populations are increasing due to increased protection status and improved agricultural management, which has provided higher-quality forage for geese in the form of more productive grassland (Mason et al., 2018a). However, geese cause significant agricultural damage to grasses and arable crops, which has led to conflicts between conservation and farming interests (Fox et al., 2017; MacKenzie & Shaw, 2017). Geese management is a contested issue where conflicts arise regarding knowledge holders, capacity building and funding repartition (Mason et al., 2018b; Pollard et al., 2019).

In France, large institutional discussions are taking place regarding the use of pesticides, creating pressure on different farmers and their practices (Sud, 2020; Hossard et al., 2017). Three cases will be explored in more detail: water management and agriculture practices in a water catchment (Petit et al., 2016), honey producers and farmer herbicide use (Lambert, 2013) and wine growers/community relationships around pesticide use (Garrigou, 2012).

In Germany, the question of insect biodiversity protection has become central after insect decline and its causes became public following a scientific study that revealed a 75% decline

of total flying insect biomass in protected areas (Hallmann et al., 2017). A federal program was put forward in September 2019 to provide 100 million euros more in funding for insect protection and seeks to have stricter regulations on pesticide and fertilizer use. However, farmers' organizations point out the lack of scientific data to provide clear evidence of causal relations between insect decline and intensive farming, and in general complain of a lack of societal acknowledgement of their work.

How to apply the analytical framework

To investigate the different components of the framework in the three conflict contexts outlined above, we plan to apply the analytical framework using a Transformation Labs (T-labs) approach. A T-Lab is described as 'a process involving research and transdisciplinary engagement to address a complex problem or challenge' (Pathways network, 2018: 6). For a deeper understanding of the methodology proposed, see Ely et al. (2020), Pathways network (2018) and Rodríguez et al (2019).

During the first phase of empirical research in each case study we will focus on investigating the enablers and disablers of transformation through methodologies that elicit a deep understanding of the situation. This phase privileges qualitative methods such as semi-structured interviews, focus groups or discourse analysis, to understand how history, vulnerability, uncertainty, and ambiguity but also values-rules-knowledge set-up the context and possibility for transformation. Previous research in Scotland (30 in-depth semi-structured interviews) has already showcased the effectiveness of semi-structured interviews in eliciting the perspectives of farmers in relation to goose management methods. This diagnostic stage can be complemented by ecological research and possibly models (Poggi et al. this issue) on the interdependencies, synergies and trade-offs among the ecosystem services involved in the territories of reference in order to triangulate the actors' perceptions and better understand

aspects of conflict such as the role of scale and land teleconnections to inform the subsequent deliberative approaches of the T-labs (Kovács et al., 2014; Vialatte et al., 2019).

In the second phase, to accompany conflict transformation, research can be implemented to better understand the power relationships in different dimensions. For example, in the French case study on pesticides it will be important to understand policy coherency through policy analysis. In this case, we plan to carry out social network analysis to understand agency and power, and to identify agents of change. Conflict transformation should also be pursued through more active participation of the relevant actors. Previous experience has shown the benefits of workshops focusing on power and the different views within group to create more intracultural exchanges and empower marginalized actors, prior to entering into dialogue with external actors (Rodríguez et al., 2013; Ainsworth et al, 2020). Regarding the agents of change, we will try to understand how they act toward the integration of science, policy, practice and social movements but also create bridges between bottom up and top down initiatives at a territorial level.

Finally, we plan to conduct workshops, also called T-labs, aiming at bringing together different actors involved in the issues, including particularly marginal actors as they can be a powerful enabler of innovation (Pathways, 2018). These T-Labs or workshops should be facilitated by professionals to allow the creation of an environment to think about transformation in a new way (Pereira et al., 2020). Professional facilitators manage this by structuring dialogue and enabling participants to shift from adversarial to cooperative behavior (Pound, 2015; Pound et al., 2016). This allows the researcher to use this time to continue investigating the process and measure how those workshops can support elements such as innovation, empowerment, knowledge co-production, and social learning. At this stage, the preparatory work is valuable and is presented to the actors with the aim at eliciting different and common values and perceptions but also misconceptions and miscommunication. For

instance, studies have shown that farmers and other actors often have distorted perceptions of social and ecological interdependencies and trade offs and that increasing awareness through the result of sound scientific research can be the first step in supporting effective collective action in efforts such as the T-labs (Kovács et al., 2014; Vialatte et al., 2019). One important initial step of the workshops will be to agree on a shared goal (for example see the Step 4 pilot planning workshop process in the PNG case study, Box 2) and to develop a mutual base of information on cause and effect of insect losses, to support social learning and knowledge co-production.

By following this analytical framework, researchers will be able to better understand the process of transformation and support it. However, the process described here is unpredictable and emergent. As such, no result or pathways direction can be guaranteed. We will also be evaluating the expected long-term outcomes, which should not be limited to environmental integrity, but should encompass all the pillars described in Section 2. In order to evaluate the solution spaces, we propose that indicators of sustainable agricultural transformation should be collectively developed with the participants before or at the beginning of the T-labs (see for instance the transdisciplinary sustainability assessment tool of Wiek & Binder, 2005 and the sustainability solution space of Binder et al., 2012, already applied to the agricultural sector of Switzerland).

5. Discussion

Sustainable transformations in agriculture are more likely to arise from contexts with many knowledges, norms and values (Dentoni et al. 2017; Patterson et al., 2017; Marin et al., 2016). Conflict transformation, as defined and positioned within our analytical framework, aims at fostering this plurality and contestation. Conflict transformation can support marginalized

actors to engage in change and increase the range and roles of agents of change (Box 3 and Box 5). In this way, it opens up the solution spaces that are being produced and may even result in outcomes that may have been unthinkable before that process (Pereira et al., 2018). Conflict transformation could therefore support path-breaking processes, especially through the appropriate engagement with the most political aspects of conflicts, i.e. conflicts over values, and by empowering actors at an intracultural level (Rodriguez & Inturias, 2018). As such, conflict transformation can support agricultural systems, for instance, by revitalizing less powerful farmers' identity and role in the debate on the future of agriculture. Alternatives such as the renaissance of rural territories as proposed by Caron et al. (2018), which may be perceived as impossible due to deep-rooted assumptions and constraints, could then become legitimate scenarios of change, generated through the positive use of tensions and conflicts.

The case studies presented throughout this paper have been used to triangulate our theoretical findings, as well as for initial testing of the analytical framework's empirical applicability. For instance, the fundamental conflicts over differing values mentioned above are transversal throughout the case studies presented in Boxes 1-5. They are particularly evident in Boxes 1 and 4, which demonstrate how values formulate certain visions of agricultural sustainability as well as more organized social movements aiming at profound agricultural transformations. Boxes 2 and 5 emphasize the struggles for recognition of the empirical and experiential knowledge which has historically been marginalised by scientific and 'formal' knowledge during decision making processes. Box 3 shows conflicts resulting from the ambiguity formulated due to multiple and diverse Values-Rules-Knowledge that together with scientific uncertainty hindered the climate resilient development of the rural areas. All the case studies showcase different forms of marginalisation and power asymmetries, with conflicts manifesting a demand for agency, often expressed through different forms of resistance (e.g., social movement in Box 1) and the use of counter-narratives (e.g. Box 2, 4 and

5). Building on experience and analysis, the case studies support the potential for a conflict transformation process to contribute towards sustainable agricultural transformations. In the cases where such a process had already taken place (Boxes 3 and 5) there is already evidence of a systemic transformation of the conflict (cultural, personal, relational, structural) and triple-loop social learning reflected in novel institutional arrangements.

The abovementioned case studies, which refer to different world regions and contexts, reveal a broad applicability of the analytical framework. As described in Box 6, the framework constitutes part of a T-labs methodology that will be applied in three cases within Europe. By applying the process in different contexts and goals, future empirical research can bring new insights that can inform the theory and the main premises of our work. We expect the concepts mentioned in the framework to be of diverse importance according to specific cases, allowing us to acquire more in-depth understanding of agricultural transformation and its outcomes, and factors influencing these. For example, history is expected to be emphasized in cases from the Global South, such as in South Africa where previous research has revealed the particular influence of the historical tensions of race and land when attempting transformational change in agriculture and food systems (Pereira et al., 2020). The important role of agents of change may become a focus for future capacity-building initiatives in the Pacific region, where agricultural transformation is imperative but the skills of researchers to facilitate these processes are limited (Butler et al., 2020).

Schulz and Siriwardane (2015) argue that in the absence of a strong normative consensus on the 'what' and 'why' of social transformation, transformation risks becoming an empty concept amenable to any kind of political intervention. As such, in the application of the framework, we acknowledge that there should be an effort to define the what, why and how of social transformations. Based on the approaches described in the paper and others (Box 3 and Pereira et al., 2020) joint formulation of the aims, processes and indicators of transformation

1095 are possible, and can contribute to the sustainability of transformations. How the joint
1096 formulation is carried out can and should be questioned. For example, although we recognize
1097 the benefits of external facilitators in T-Labs helping agents of change jointly formulate aims
1098 and criteria for the evaluation of transformation (Box 6), reflection will be needed at each step
1099 of the process over the bias and roles of facilitators and researchers (Pereira et al., 2020).

1100 It is also important to reflect critically on the temporal dimension of the analytical
1101 framework. A potential critique of the current framework is the argument that a conflict
1102 transformation approach could take much longer than technical solutions or top down
1103 regulations, depending on how one defines the end of the process of 'transformation'. Some
1104 questions that emerge from this consideration are: 'How does procedural justice enable or
1105 disable transformations' (Fazey et al., 2018, pp. 211)? Also, is a longer timeframe beneficial
1106 and in which way? Or is time efficiency desirable for e.g., protection of insects, stopping the
1107 pollution of ground water, climate change adaptation? In the words of Fazey et al., (2018, pp.
1108 205), 'a 'good' process does not necessarily guarantee a 'good' decision particularly over the
1109 kinds of timeframes imposed by a rapidly changing climate'. The different trade-offs are
1110 essential considerations, especially in case studies where environmental integrity is an essential
1111 component of sustainability. Here, we can learn from other frameworks (e.g., the Sustainable
1112 Development Goals and Ecosystem Services Frameworks) to better understand, address, and
1113 manage such trade-offs (e.g., Kanter et al., 2018; Kovács et al., 2014; Morris et al., 2020; UN,
1114 2015; Vialatte et al., 2019).

1115 Connected to the transformation's outcomes and outputs, is the challenge of achieving a
1116 redistribution of power (Rodríguez & Inturias, 2018). For instance, while conflict
1117 transformation encourages intracultural dialogue among marginalised farmers to empower
1118 them to take part in the larger discussion of the future of agriculture, this may be difficult
1119 considering the variety of farming practices and goals. Furthermore, such a process will not

always guarantee more environmental integrity and some actors might not support such power redistribution for fear of aggravating consequences for the environment. In practice, this requires trust in transformation processes. It also requires the joint selection of indicators that can reveal relevant insights for the evaluation of transformations in terms of power dynamics (Rodríguez et al., 2019).

6. Conclusion

There is a clear shift, locally, nationally and internationally, occurring in agricultural policy making away from the prevailing paradigm of conventional agricultural intensification and towards various forms of a sustainable agriculture (Vanbergen et al. this issue), some of which demand transformative changes that could have profound consequences for agriculture, biodiversity and global change. Ignoring or underplaying the social and cultural dimensions of the current and possible future agricultural systems presents a substantial risk to the sustainability of those agricultural transformations. Building on the premise that agricultural transformations can often generate and/or involve conflicts, in our paper, we posit a potentially critical role of conflicts and their transformation to ensure that these elements are both recognised and harnessed as a positive motor for change. More particularly, we argue that a proactive understanding and engagement with those conflicts will create a step-change in the agricultural transformations towards greater sustainability. Conceptualising the process as a 'window of opportunity' for agricultural transformations, we follow an interdisciplinary approach based on sustainable transformations, agricultural and food systems, and conflict transformation research, and propose a novel conflict-centred analytical framework for transformations to sustainable agriculture. Our analytical framework offers a more integrative, process- and outcomes-based understanding of agricultural transformations. It also connects

the agricultural systems' technical considerations to their political dimensions and the role of the agents of change within the broader food systems' challenges. Most importantly, the framework recognizes conflicts as the symptom of deep-rooted systemic issues and as the potential motor for constructive social change that incorporate inclusive participatory processes for deliberation and action in the form of conflict transformation processes. In this way, conflict transformation represents an important tool that can help to ensure that the outcomes of transformative changes in agricultural systems are more acceptable and well adapted to assure the multiple contributions (e.g., food, materials, well-being, biodiversity ecosystem functions) that agriculture provides to humanity. Finally, the proposed analytical framework can support flexible and context-sensitive analyses of agricultural transformations through transdisciplinary research.

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1622 # TABLES

1623

1624 **Table 1.** Dimensions of conflict transformation (from Lederach, 2003)

Dimension of conflict transformation	Definitions	Examples
Personal level	Changes related to the cognitive, emotional, perceptual and spiritual dimensions of individuals	The self-esteem and sense of dignity of farmers is strengthened. Consumers' perception of the importance of food quality increase.
Relational level	Changes associated to face-to-face relationships with questions link to affection, power, interdependence, communication, and interaction	Improvement in communication, agency, political organization (for specific example, see Charli-Joseph et al 2018). Decision makers are more receptive to local views and knowledge (for specific example, see Bohensky et al., 2016; Butler et al., 2016c).
Structural level	Changes related to the underlying cause of conflict and the patterns and changes it brings about in social, political, and economic structures	Changes in levels of control that producers and consumers have over their local food systems.

		Economic policies are receptive to local economies.
Cultural level	Changes related to the broadest pattern of group life, including identity, knowledge, and the ways that culture affects patterns of response and conflict	Strengthening local, territorial identity to enhance the awareness for local, rural developments. Local knowledge is revitalized and strengthened (for specific example, see Pereira et al. 2019; Dolrenry et al., 2018)

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1629 **Table 2.** Glossary of concepts used in the framework

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Principal components of the framework	Definitions	References
Enablers/Disablers of transformation		
History (path-dependency)	The history of the system implies certain initial conditions and political, institutional, economic, cultural and other legacies that filter the system's future trajectories. The evolution of the system is then bounded by a "corridor of the possible" beyond which certain alternative configurations become unthinkable.	Olsson et a., 2017; Wilson, 2014
Vulnerability	The degree to which a system is susceptible to harm being unable to cope with adverse effects of certain drivers of change. Vulnerability is driven by inadvertent or deliberate human action that reinforces self-interest and the distribution of power in addition to interacting with physical and ecological systems. It often determines which types of adaptation or transformation pathways are perceived as most desirable, effective, and legitimate by individuals and communities.	Adger, 2006; O'Brien & Wolf, 2010; Turner et al., 2003
Uncertainty and ambiguity	Both uncertainty and ambiguity translate to gaps in knowledge. Uncertainty refers to limitedness or absence of (often scientific) knowledge (data, information) that makes it difficult to exactly assess a situation, its evolution and the effects of interventions. Ambiguity refers to the existence of multiple legitimate viewpoints due to diverse ways of understanding and interpreting the same issue or challenge according to different values, interests and goals.	Bosomworth & Gaillard, 2019; Renn et al., 2011

Values	Ethical precepts that guide action, judgment, choice, behaviour, evaluation, argument, exhortation, rationalization. Values can be associated with individuals, groups, institutions, organizations, and cultures. They change over time, often gradually and over generations, but also within the lifespan of an individual.	O'Brien & Wolf, 2010
Rules	Rules are shared understandings among those involved that refer to enforced prescriptions about what actions (or states of the world) are required, prohibited, or permitted. All rules are the result of implicit or explicit efforts to achieve order and predictability among humans and in society. Rules-in-use include norms, practices, taboos, habits and rules-in-form include regulations, legislation, treaties and ordinances.	Gorddard et al., 2016; Ostrom, 2011
Knowledge	Evidence-based (scientific and technical) knowledge and empirical knowledge that together constitute the knowledge system of the (agricultural) system of reference. In the case of agroecology, empirical knowledge refers to experiential knowledge of "non-scientists" on local taxonomies, ecological knowledge, knowledge of farming practices, experimental knowledge.	Gorddard et al., 2016; Pimbert, 2015
VRK interactions	The interrelationships between values-knowledge, values-rules and knowledge-rules and those of all three elements and how one affects the other two in influencing the decision-making process.	Colloff et al., 2017; Gorddard et al., 2016
Conflict transformation components		

Power	Refers to the hegemonic power, where an idea or mandate is imposed. It can be divided by power exercised coercively such as structural power, or those form of power that go through subtle mechanisms, such as people and power networks, or cultural power.	Rodiguez & Inturias 2018, Rodriguez, 2015
Agency	Refers to the power of agency, which has been defined as 'the ability of social partners to define social problems and political issues and mobilize resources to formulate and carry out a desired solution'.	Arts & Van Tatenhove, 2004, in Rodiguez & Inturias 2018
Narratives	Refers to a way of presenting or understanding a situation or series of events that reflects and promotes a particular point of view or set of values.	Czarniawska, 2004
Resistance & Alternatives	Refers to movements (e.g., practices, performances, systems, structures, policies, processes, technologies, and concepts) which are confronting the structural reasons of unsustainability, inequity and injustice, such as capitalism, patriarchy, state- centrism, or other inequities in power resulting from caste, ethnic, racial, and other social characteristics. Resistance and alternatives are intertwined concepts: while resistance will actively oppose a particular issue, alternatives will be engaged in other practices without open opposition but can be both the result and the root of resistance processes.	Pelenc et al., 2019; Temper et al., 2018
Agents of change		

Integration of science, policy, practice and social movements	Science, practice and social movements have been recognized as the three main activity spheres advancing agroecological transformations. Policies and formal institutions have also been recognized to also play an important role in supporting agricultural transformations. The agents of change (i.e. actors who play a significant role in initiating or managing change) will be able to integrate the different domains and create bridges that support agricultural transformations by developing social networks and recognizing or creating and seizing windows of opportunity, among others.	Castro-Arce & Vanclay, 2020; Toledo & Barrera-Bassols, 2017; Westley et al., 2013
Top-down & Bottom-up	Top-down processes often involve decisions taken at higher institutional levels (national and international), based on long-term knowledge and larger picture, implemented through mandatory policies that can often be perceived as imposed. Bottom-up processes refer to the community-based or grassroots initiatives that express community priorities. Both have advantages and disadvantages but the agents of change will be able to find synergies that harvest the power of change of both.	Butler et al., 2015
Territorial level	A territory, which does not necessarily relate to an administrative area, is defined as 'a bounded space that has stood the test of time, is owned by a social group that identifies with it, and which accepts specific forms of governance and control'. It proposes an interface between collective	Anderson et al., 2019; p.9, Caron et al., 2018; Oteros-rozas et al., 2019

	action and public administration where agents of change can act to support agricultural transformation.	
Solution spaces components		
Knowledge co-production	Production of collective knowledge through transdisciplinary approaches. In the context of agroecology, instead of being passive beneficiaries, farmers and citizens are active producers of knowledge including in setting upstream strategic priorities for national research.	Pimbert, 2015; Ruiu et al., 2017
Empowerment	Political agroecology emphasizes the re-distribution of power dynamics and empowerment of actors focusing on promoting autonomy, self-sufficiency, bottom-up place-based organization, and equal access to decision-making.	Anderson et al., 2019; Guerrero Lara et al., 2019; Olsson et al., 2017
Innovation	May refer to technical and agroecological innovations and/or to social innovations. The latter refers to the 'actions, participatory processes and outcomes that provoke changes in social relations, collective empowerment, political arrangements and/or governance processes, and lead to improvements in the social system'.	Castro-Arce & Vanclay, 2020: 46; Moulaert et al., 2013
Social learning	Revolves around processes of multi-actor interactions and implies learning about the dynamics of change of the human system and the ecosystem, the mental frames that shape decision making, and the biophysical and social consequences of change. Learning may have different degrees of intensity and scope from single to triple-loop learning. Single-loop learning is the	Pahl-Wostl et al., 2007; Pahl-Wostl et al. 2010

	most common form of social learning based on error detection and correction in the context of established actions. Double-loop social learning refers to fundamentally revisiting and reshaping certain underlying assumptions, values and patterns of thinking and behaviors. Triple -loop social learning refers to institutional changes, such as changes in structures, policies, programs, rules and decision making procedures.	
Agricultural transformation dimensions		
Depth, scope/breadth, and timeframe of change	The intensity or quality of the change from incremental to radical, the distribution of change from a narrow scope to system-wide change, and the timeframe through which a change occurs. Highly case-specific and subjective dimensions, often used to assess whether a change is transformative and in which respect. We use them in combination with a consideration of the process of agricultural transformations.	Panda, 2018; Termeer et al., 2017; Fazey et al., 2018

FIGURE LEGENDS

Figure 1. The context-specific, multiple pathways of transformations to sustainable agriculture (building on IPCC, 2018 and Fazey et al., 2016). a. The green bottom pathway represents a situation in which no transformation occurs (business-as-usual pathway), b. The blue pathway shows a situation in which a window of opportunity for transformation occurs but is not taken as conflict is neglected or attempted to be resolved. c. The orange pathway occurs when the window of opportunity for transformation is taken and the agricultural transformation includes conflict transformation, leading to a step-change in sustainability. Within both the blue and orange pathways, incremental changes continue to occur, yielding a range of sustainability outcomes.

Figure 2. The community of Mals and its cultural landscape

Photo credits: Hanspeter Staffler

Figure 3. Covering orchards in the Vinschger valley floor near Tschengls with the view towards Mals

Photo credits: Jutta Staffler

Figure 4. Consumers and producers meet on the farmers market that has been organized only recently by the new citizens' cooperative

Photo credits: Martina Waldner

Figure 5. Location map of the Sorme lake in France

Source: S. Petit

Figure 6. Landscape of Sorme catchment basin, dominated by grasslands

Source: S. Petit

Figure 7. Coastal land converted to oil palm in Lassul Baining, ENB

Source: GoogleEarth

Figure 8. Recently cleared coastal forest, oil palm planted on terraces and run-off in Lassul Baining, ENB

Source: N. Peterson

Figure 9. The conflicts emerging in East Pomio, illustrated by stakeholders in a future scenario diagram entitled 'Fat Cats, Skinny Rats'

Source: J. Butler

Figure 10. Chaparri Sacred mountain covered by a highly biodiverse dry forest

Source: C. Parra, November 2018

Figure 11. Water, land and agriculture in the Chaparri Ecological Reserve area, Lambayeque, Peru

Source: P. Van den Broeck, November 2017

Figure 12. Socially innovative Agroecological Primary School Cesar Vallejo Mendoza and its proud children (Location: Paredones, Chaparri Ecological Reserve Region, Peru)

Source: C. Parra, November 2017

Figure 13. Agroecological produce by Primary School Cesar Vallejo Mendoza, Local fair at the Chaparri Ecological Reserve, Peru

Source: C. Parra, November 2018

Figure 14. Launch of the Contest "Todos por Chaparri" in view of the socio-ecological empowerment of Chaparri and within the framework of the VLIR-UOS transdisciplinary project Sustainable rural

development through socially innovative and community-based conservation in the Chaparri Reserve Region (https://www.vliruos.be/en/projects/project/22?pid=4252)

Source: Chaparri Ecological Reserve, January 2020

Figure 15. The evolution of the Fire Conflict 1999-2020

Source: Rodriguez et al 2013b

Figure 16. A conflict-centred framework for sustainable agricultural transformations. Whether agricultural transformation capitalises upon the window of opportunity (i.e. the orange arrow) or not (i.e. the blue arrow) depends on the conflict transformation process. The orange arrow represents a process where the energy of conflict is 'harvested' allowing a step-change in the agricultural transformation that expands outwards and spirals up towards greater sustainability. This is achieved through greater involvement of agents of change, more solution spaces and greater sustainable agricultural transformation than in a situation (blue arrow) where conflict is not addressed.

FOOTNOTES