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Abstract: The Multi-Level Perspective (MLP) is an analytical framework developed to explain transitions towards sustainability. This article aims to contribute to enhancing the use of the MLP to understand the transitions towards sustainability in agriculture. We propose that MLP is an insightful framework to capture particular micro-level trajectories of adopting innovations. The Douro wine region in Northern Portugal, known worldwide for the wines that are produced there, was the study area of our empirical research. This region has become the stage for developing a complex agroecological innovation, the Ecological Infrastructures (EIs). These consist of a combination of techniques that aim to expand the ecosystem services of the vineyards. The uniqueness of its development at the farm level originates a multiplicity of innovation trajectories, which are the focus of this study. Content analysis of 20 interviews with winegrowers was performed, and the results were analysed through the MLP framework. This allowed us to conclude that a process of transition towards the sustainability of region-level winegrowing is underway, and that it can be explained by the overlapping of different paths of adopting innovation. Our research shows that in-depth analysis of qualitative data, done through content analysis, can be used to amplify the insightfulness of MLP by enabling it to uncover the microscale transition pathways that shape uneven region-level transitions.

Keywords: agroecological innovations; Multi-Level Perspective (MLP); sociotechnical transitions; sustainable development; winegrowing

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1. Introduction

In order to analyse empirical cases of sociotechnical transitions triggered by innovation, scientists have been using an approach called Multi-Level Perspective (MLP). The MLP approach was developed to explain transition in technological sectors, helping to understand radical innovation-related transition processes and providing guidelines for the strategic management of innovation niches [1], but it has also been used to study transition processes in agriculture [2]. According to this approach, there is a transition when new interactions are designed between the conceptual levels of a sociotechnical system—the niche, the regime, and the landscape [3,4].

Particularly in agriculture, transitions characterise themselves by being based on factors belonging to the sociotechnical system but, as stressed by Smith and Stirling [5], there are other factors like the socioecological dimension that must also be part of the equation. In 2015, Duru, Therond, and Fares [6] emphasised this type of approach, proposing that in order to understand transitions in agriculture, namely those of an agroecological nature, other dimensions rather than the sociotechnical and the socioecological should be taken into account, such as the characteristics of the agricultural system. Torre, Polge, and Wallet [7] have looked further into this matter, pointing out sociotechnical systems in agriculture evolve by the diversity that defines them, which is related to innovation models coexisting within the same territory. Torre et al. [7] have observed that farmers who apparently could have developed different innovation models do, in fact, collaborate with

each other partly because their farms are in close proximity but, above all, because they share the conditions of the same territory and partake in the same social logics.

Thus, in agriculture, transition processes depend on the interaction of three systems: the sociotechnical, socioecological, and agricultural systems [6]. In view of these interactions, transition processes become multisystemic and, therefore, complex, and each farmer manages and articulates the elements of the systems they have at their disposal. This suggests farmers can adopt the same innovation by resorting to a diversity of trajectories. In other words, a transition is made of the many individual transition pathways. An example of this is research that was conducted in the Douro wine region, in Northern Portugal, where farmers have been using an agroecological innovation called Ecological Infrastructures (EIs).

According to Landis et al. [8], EIs include several elements, such as hedges, natural pasture land, undergrowth, and forests along with crop growing areas which provide ecosystem services, like biological control of pests and diseases, and favourable microclimatic conditions. In the case of Douro's viticulture, EIs can be described as a number of elements, including the growing of native or exotic vegetable species that are sown or occur spontaneously between the vineyards or bordering them, which have several purposes, namely in attracting auxiliary insects, retaining soil moisture, and avoiding erosion, to name but a few [9].

The multi-systemic and complexity features of agroecological innovation comprised by EIs give rise to multiple transition paths in the same geographical area. Thus, understanding the underway agroecological transition at the Douro region-scale entails unravelling this diversity of trajectories at the farm microscale. In this research, we applied the MLP perspective focusing on the farmer level. The research design combined semi-structured interviews to capture farmer narratives of respective farm-level innovation paths with content analysis. Hence, the paper provides empirical evidence to answer its two goals. The first goal is to describe the ongoing agroecological transition in the Douro wine region through uncovering the transition patterns defined by the multiple farmer-level innovation pathways. The second goal of the paper is to show that MLP is able to provide an insightful understanding of microscale transition phenomena, refuting the criticism that it is just a general approach.

The article contributes to studies on the transition towards sustainability in agriculture, highlighting those cases in which that transition is prompted by agroecological innovation and where different trajectories can coexist. In addition, it introduces a methodological approach that enables applying the MLP at the microscale to identify and to systematise, into similar patterns (clusters), uneven microscale patterns underpinning sustainability transitions in the same geographical scale.

The present article is structured as follows: Sections 1.1 and 1.2 present the theoretical framework on which the empirical research is based; the former deals with the Multi-Level Perspective in more detail, and the latter focuses on the review of some studies regarding its application to understanding agroecological transition processes in agriculture. Section 2 presents the materials and methods used in the course of the research. Section 3 includes the results which are discussed in Section 4. Finally, Section 5 offers the conclusions.

1.1. Transition Phenomena in View of Multi-Level Perspective

The word transition comes from the Latin *transire*, meaning crossover. Hinrichs [10] claims that according to several dictionaries, transition means to go from a form, a state, a style, or a place to another, and that this notion has also been applied to studies on sustainability. Rotmans et al. [11] think that as gradual and continuous processes of change, transitions affect a significant part of society over one or more generations.

When studying transitions and transformations, Sovacool and Hess [12] came across 96 different theoretical and conceptual approaches to phenomena of technical and social change. This article explores the MLP approach, an explanatory scheme structured by Rip

and Kemp in 1998 [13], and by Geels in 2002 [14], to examine transition studies that occur when innovation is introduced in sociotechnical systems.

The MLP is represented by a three-level scheme—the niche, the regime, and the landscape—in a sociotechnical system; whenever innovation operates a change in that system by way of realigning its levels, it is possible to say we are in the presence of a transition, provided the innovation, which emerges from a niche, is robust enough to face and modify the regime in place [4,15].

As the first level of the scheme, the niche is where all innovation comes from; niches are protected environments, working as incubators, where innovations are provided with investments, resources, knowledge, and skills to structure themselves [16]. They also correspond to pilot-projects, small market segments, and research and development networks [17] that may arise informally and are not caused by commercial demand [10]. They allow for the development of new rules and practices around innovations, escaping market pressure [18].

When an innovation obtains some degree of success at niche level, it spreads, leading to a development and dissemination process. This way, innovation enters the regime, which represents the intermediate level of the sociotechnical system. The regime is composed of practices, technology rules, and institutions that guide and justify the way science and technology are produced [19]. It is also composed of groups of actors and infrastructures that enable innovation [20]; actually, it is inside the regime that innovation can be exerted and stabilised [21].

Finally, the landscape is the exogenous sociotechnical scenario, the broadest context made of ideologies, macroeconomic patterns, climate changes, cultural changes, and demographic trends that influence both niches and regimes [4,21]. Seoane and Marín [22] call it "context variables". Any change affecting its composition causes pressure on sociotechnical niches and regimes and this is how there is room and opportunity for niches to feed each other on innovation [3]. It should be pointed out, though, that the opposite is also true; that is, niche innovations and those linked to the regime may also pressure and dislocate the landscape over time [10].

In the beginning, MLP was designed as a perspective of structural analysis to explain transitions that took decades and were, for the most part, spontaneous and not planned [23]. Geels and Schot [24] propose that it becomes a typology to unify studies on transition, unlike Genus and Coles [25], who claim that it just is not enough to determine the role of daily practices and their agency in processes of change. Bui et al. [18] corroborate the notion that MLP does not exactly explain how the niche helps reconfigure regimes since it does not allow for an analysis of the role of civil society actors [26].

According to Van De Poel [27], MLP is a typical structural model that is mainly used to study global transition processes. Its original format, however, does not preclude the idea that local scale-based models may be developed to help understand transition phenomena from smaller scales like, for example, the territory scale. This notion is in keeping with what has been suggested by Poole and Van de Ven [28]: that it would be appropriate to include both local and global scales in studies regarding processes. The global model would be suitable to describe the development process of an innovation and the stages it follows in the long term. In turn, a local model would be centred on short-term patterns and on the agency of those involved, mapping ideas, decisions, and actions. Authors like Knickel, Brunori, Rand and Proost [29], and Geels [4] also concur with this perception when they say it is necessary to establish the connections between microscale innovation processes and the macro conditions of changes. Geels [30] suggested it was possible to overcome these limitations by combining the discourses and narratives of the actors involved with the Transition Theory and the MLP for the benefit of further research.

1.2. Agroecological Transitions and Their Treatment by Multi-Level Perspective

In agricultural transition studies, the use of MLP is more recent. El Bilali [31] has mapped 57 publications up to 2017 that used this analytical perspective to study transition

in agriculture and in the agri-food sector; also, these publications referred mostly to research that had been carried out in the Netherlands. According to the author, they used different methodologies to better address the many aspects involved in the transitions. El Bilali [31] points out that one of the main scientific gaps that researchers are faced with has to do with the concepts of niche, regime, and landscape and with their limitations and how to adapt MLP to the study of transition in agriculture. In the absence of better definitions, research gaps affect one's understanding of how the three levels articulate themselves. In order to circumvent this reality, researchers have been using MLP, combined with several research techniques and perfected by other analytical tools, to provide a better description of complex transition phenomena in agriculture. El Bilali's research [31] has been instrumental in revealing the fragility of the MLP when addressing transition processes in agriculture, mainly when trying to explain governance, anchorage, and political issues related to such processes.

In this article, we conducted a literature review that sought to gather information on the specific use of Multi-Level Perspective, namely in studies on the transition towards sustainable agriculture in agroecological contexts. A consultation to Web of Science and *Scopus* databases has produced a list of 21 articles, published up to December 2019, in which "Multi-Level Perspective" or its acronym "MLP", or even "transition" (in a context of change of the sociotechnical regime), is associated with agroecology. The articles are either theoretical or deal with empirical cases of MLP applications and the analytical levels and concepts associated with it in agroecological transition studies. A summary and details of their reference to MLP are presented in Table 1.

Table 1. Multi-Level Perspective (MLP) applications and its analytical levels and associated concepts in agroecological transition studies.

Main Contributions in Terms of the Use of MLP	Publication	Article Summary
(1) Analysis of policies that lead to agroecological transitions and to questions of power and governance stressing the importance of local movements or transition scales.	[32]	Addresses the role of politics in enhancing the agroecology niche as opposed to the regime. Identifies the lack of studies relating MLP to governance towards agroecological transition.
	[33]	Does not explain the use of MLP but combines ecological, socioeconomic, and technical transformation aspects of the agriculture of Iowa, making it possible to understand multi-level transition processes.
	[34]	Addresses the role of food democracy. Advocates for the creation of specific entities within which the interested parties may assess food systems and develop reform proposals.
	[35]	Points out the need to develop a scientific perspective to deal with transitions in the food system by using an operational bias that can characterise the diversity of systems and identify patterns.
	[36]	Looks into studies using MLP in order to have a better understanding of communities' participatory self-organisation regarding agroecology. Develops the concept of six 'transformation areas' linking the agroecological niche to the regime.
	[37]	Looks into how commercial patterns are related to the use of agricultural resources. Food diets not only reflect changes in power relations but also in social relations.
	[38]	Contributes to eliminating gaps between such concepts as sustainable intensification and food sovereignty.
	[39]	Transitions may be represented as a sequence of steps in the process of changing the current system. An agroecological system would be affected by the sum of transitions.

Table 1. *Cont.*

Main Contributions in Terms of the Use of MLP	Publication	Article Summary
(2) How agroecological innovations are developed and how they are linked to the regime.	[40]	Addresses the disconnection between innovations in agriculture and in the food system, which causes irregularities concerning the design of innovations towards sustainability.
	[41]	Departs from the assumption that organic agriculture is an alternative model that challenges the corporate food diet. The aim here is to understand how agricultural niches may influence the regime as concerns growth, replication, learning, and questioning.
	[42]	Suggests the use of Agricultural Innovation Ecosystems (AIES) as a strategy to create innovation niches. Although it does not explicitly refer to the use of MLP, it makes use of its concepts and mentions the existence of multiple scales in transitions.
	[43]	Mentions solutions and challenges related to the development of agroforestry both at niche and regime level.
	[44]	Examines the creation of "hybrid forums", using an agroecological formation programme in Barcelona as an example. It depicts these forums as spaces where links between both niche and regime actors can be established.
(3) Transitions showing the appropriation of agroecological concepts and principles by the business and commercial universe misrepresenting agroecology's original ideals.	[45]	Looks into transitions in Europe that have been highlighted by agendas that might have appropriated discourses once associated with alternative movements. It does not explicitly refer to the use of MLP, but it makes use of the concepts of regime transition.
	[46]	Examines agroecological transition cases in developing countries that led to the loss of agroecology's essential values. Proposes an adaptive transition that includes the properties of complex adaptive systems.
(4) Transitions associated with family farming, small-scale producers and agriculture of traditional and indigenous varieties.	[47]	Views agroecology as a market niche with the potential to not only foster an agricultural transition but also human well-being and sustainability.
	[48]	Innovations in sustainable family farming niches in Colombia are still few and far between. However, they are being systematically identified and used to serve as a basis for replication projects.
	[49]	Alteration to the regime indicate the system's prevailing rules favour the current hybrid maize production. The niche would be connected to the growing of indigenous varieties.
(5) Consumers' preferences and ethical, cultural, and collective aspects.	[50]	Supports a better understanding of the innovation and sustainability concepts for the agri-food sector. It emphasises the fact that innovations in agri-food systems should also take cultural and ethical aspects, rules, and values into account.
	[51]	Looks into the possibility of creating a market niche from the use of dual-purpose chickens in Germany. It considers consumers' choices as an integral part of transition processes.
(6) Learning dynamics and sharing of multidisciplinary knowledge.	[52]	Legume cultivation could contribute to agroecological transition. It resorts to MLP to analyse transition to legume cultivation-related agricultural systems.

The bibliographical references that have been found, mainly focusing on agroecological transitions, show that both transitions and the use of MLP are basically looked into from the following viewpoints: (1) The policies that lead to agroecological transitions as well as to questions of power and governance, strengthening the importance of local movements or transition scales. (2) How agroecological transitions develop and how they adhere to the regime. Some studies focus on the agroecological dimension from the

perspective of principles and of how they can be misrepresented by their appropriation in a transition context. (3) The appropriation of agroecological concepts and principles by the business and commercial universe, both within the agricultural sector and the food sector, misrepresenting the original ideals of agroecology as to their true meaning. Some of these publications focus on the study of transition in the context of (4) family farming, small-scale producers, and agriculture of traditional and indigenous varieties. There are also studies regarding (5) consumers' preferences as well as ethical, cultural, and collective values. There was one study that did not fit in the five literature strands that have been listed and was, therefore, included in a sixth strand dedicated to the study of transitions that focused on (6) learning dynamics and the sharing of multidisciplinary knowledge.

From our literature review, we highlight the works of Levidow [45] and Tittonell [39], insofar as they both claim local scales imply the coexistence of transition paths, which is exactly the subject we wish to examine. Tittonell [39] even specifies that agroecological transitions are the sum and overlapping of transitions he deems "technical productive", "socioecological", and "political and institutional". For the author, transitions would occur fully between levels, departing from the soil/plant/animal system and going through productive subsystems; the farm and the family; the landscape and the territory; and, finally, the region and the state. The publications that have been mapped do not, however, examine transition processes as regards all that can occur within the same territory, that is, in terms of particular trajectories towards an agroecological transition.

2. Materials and Methods

2.1. The Study Area

The empirical research focused on the surroundings of the Douro River that correspond to one of the oldest demarcated wine regions in the world (Região Demarcada do Douro—RDD) [53]. Besides its historical aspects, the region has a unique landscape that made it possible to start procedures for the candidacy of "Alto Douro Vinhateiro" to UNESCO World Heritage in 2001, following the criterion that it is an "evolving and living cultural landscape". The region is also characterised by century old terraces locally called "socalcos" which have shaped the landscape, making it suitable for winegrowing in steep slopes (over 40% of the planted vineyards are on an incline above 40%) [54]. From there, the wine produced in this region, of which Port is its greatest exponent, reaches the world market [55].

The Douro region is also important for its biodiversity [56]. Ever since 2010, a number of innovative agroecological practices have been widely adopted, namely the use of several techniques that are oriented towards a biodiversity-based viticulture. These innovating practices result from the implementation and management of EI that have been developed in the course of cooperation projects between public and private entities, involving university research centres, local winegrowing enterprises, and one sectoral development association. In vineyard areas, the EIs involve several techniques and practices that range from sowing species of interest to maintaining native vegetation, creating ecological corridors, preserving nesting areas, and restoring historical terraces, among others. Hence, besides scientific knowledge, EIs have a practical side, which requires farmers to do field tests, observations, assessments, records, and make decisions over several harvests.

The innovation of EIs has originated in events that took place from the 1990s onwards. Madureira et al. [9] have identified events that justify the development of an innovation as complex as the EIs. The first one is related to the extension of EU legislation on food safety production as a response to consumers' concerns over human health and environmental questions. The second event happened in the beginning of 2000 and is the very classification of the vineyard landscape of Douro. In a way, this classification is also a response to the demand for more sustainable agricultural practices, since it was seen as a possibility to add historical and scenic value to the wine produced in this region, giving Douro international visibility. The third event has to do with New World countries entering the international wine trade, which they did with sustainable products since, in order to stand out in this

market, they could not rely on a production tradition they did not have. Besides changing the global winegrowing scenario, this event forced traditional wine-producing countries, including Portugal, to adjust their products, processes, and marketing. Consequently, the Douro region has created a sectoral development association (the ADVID—Associação para o Desenvolvimento da Viticultura Duriense) to scientifically support the development of the sustainable innovation farmers needed to face the new global commerce.

2.2. Sample and Data

Firstly, exploratory research was conducted in the study region build on in-depth interviews with key actors. This research enabled understanding the origins of the EI innovation and how it evolved in the study region. It helped to identify the innovation pioneers and the actors currently involved in its development and support. It became clear that the EIs could be understood and implemented quite differently by different winegrowers.

Next, individual structured interviews to farmers or farm managers, and representatives of commercial grape and wine farms were made. The interviewees were selected through snowball sampling [57]. The number of interviewees was determined by exhausting the introduction of new information.

The interview script was developed within the purview of the H2020 AgriLink Project [58] and included 50 questions that could be either open or closed and whose purpose was to obtain both qualitative and quantitative information in addition to being structured to: 1. Characterise the farm; 2. Identify the farmer's or farm manager's sociodemographic profile; 3. Capture information regarding the farm structure and its business model; and 4. Understand the interviewee's relationship with innovation. Interviews were conducted in such a way as to capture the farmers' narratives concerning innovation-related concepts and the practices they develop regarding the subject, from the perspective of establishing how and along which paths innovation evolves. It should be pointed out that interviews were recorded following the participants' consent, thus ensuring future transcription of excerpts that might be of interest and eliminating those that did not qualify as such. In total, 40 farmers or farm managers were interviewed, of which 20 agreed to have their narratives recorded for future treatment and analysis. Narratives were treated according to the participants' age group, school education, extent of the vineyard area, and business model. Table 2 shows the characterisation of these 20 interviewees, the dataset used by this paper that has applied content analysis to the farmer's narratives describing the respective innovation path. The transcripts of non-recorded interviews did not allow recovery of the farmer's narratives with comparable structure and detail and, hence, were not used in this paper.

Narratives collected in the interviews were treated using content analysis [59,60] which was carried out using Iramuteq software (Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires), 0.7 alpha 2 version. This software allows for an in-depth analysis of the lexically component of the interviewee's narratives. It also uses multivariate statistics to classify the interviewee's discourses. The transcription of the narratives constitutes the dataset for the textual analysis, which is known as the corpus [61,62].

This software was used to obtain the following results [63]: (1) identification of categories of interviewees' discourses according to lexical roots of words through the Reinert Method, displayed through a dendrogram of Descending Hierarchical Classification (DHC); and (2) a Similitude Analysis that identifies the co-occurrences between words, helping to identify the patterns of connectedness among the words and the structure of social representations underpinning the speeches.

The Reinert Method [63] is a divisive hierarchical clustering algorithm that identifies clusters by maximising the chi-squared distance between different clusters. It enables creating classes of textual segments (from the corpus), presenting similar semantical discourses built on similar vocabulary, which is different from other classes' vocabulary.

Table 2. Characterisation of the interviewees whose narratives were recorded and subject to treatment.

Coding of Interviewees	Interviewee	Age Group (Years)	School Education	Agricultural Education	Vineyard Area (ha)	Farm Commercial Activities
09	Farm manager	51–60	No university degree	Yes	250	Vine and winemaking with wine tourism
11	Farm manager and owner	51–60	University degree	No	8	Vine growing with bulk selling
12	Farm manager and owner	61–70	No university degree	No	3	Vine growing with bulk selling
13	Farm manager and owner	51–60	No university degree	No	1.50	Vine growing with bulk selling
17	Farm manager and owner	31–40	No university degree	Yes	3	Vine growing with bulk selling
18	Farm manager and owner	81–90	University degree	Yes	40	Vine growing with bulk selling
20	Farm manager and owner	31–40	University degree	Yes	55	Vine and winemaking with wine tourism
21	Farm manager and owner	71–80	No university degree	No	2.50	Vine growing with bulk selling
22	Farm manager and owner	51–60	University degree	No	31	Vine growing with bulk selling
23	Farm manager	51–60	No university degree	No	7	Vine growing with bulk selling
26	Farm manager and owner	41–50	No university degree	No	2	Vine growing with bulk selling
28	Farm manager	31–40	University degree	Ys	20	Vine growing with bulk selling
29	Farm manager and owner	31–40	University degree	Yes	25	Vine growing with bulk selling
31	Farm manager	31–40	University degree	Yes	50	Vine and winemaking
32	Farm manager and owner	41–50	University degree	No	3.80	Vine growing with bulk selling
33	Farm owner	61–70	University degree	No	16	Vine growing with bulk selling
34	Farm owner	51–60	University degree	No	8.20	Vine growing with bulk selling
36	Farm manager and owner	31–40	University degree	Yes	20	Vine and winemaking with wine tourism
37	Farm owner	41–50	University degree	Yes	130	Vine and winemaking with wine tourism
39	Farm manager and owner	51–60	University degree	Yes	27	Vine and winemaking

The Similitude Analysis is based on graph theory [64]. A graph consists of an ideal mathematical model to study the relationships between discrete objects, allowing for the identification of co-occurrence among words. The software Iramuteq enables visualisation of the relationship between words in each class and how they are related with other classes.

The content analysis was driven by the MLP framework to assist the identification of different innovation pathways building on the winegrower's textual narratives on how they understand and implement the EIs agroecological innovation.

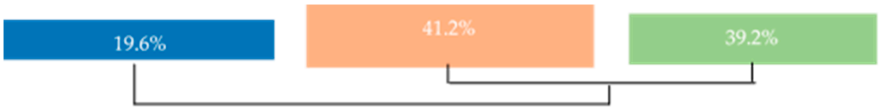
3. Results

A descriptive analysis of the interviewees, presented in Table 2, evidences the co-existence of different business models. The majority of the interviewees (70%) grow the grapevines and then sell them to larger winegrowers or local wine cooperatives. The others (30%) produce and bottle their brand of wine, and in most cases, they also offer farm wine

tourism services. These different business models tend to be associated with the size of the farm estate: "vine-growers" tend to hold smaller areas of vineyards, while "brand winegrowers" tend to hold larger areas of vineyards, often together with large plots of wooded areas alongside olive groves and bushland areas. Smaller vine-growers are generally familiar farms relying mostly on their labour. Larger winegrowers rely on hired labour and are in most of the cases established as legal entities, both familiar commercial firms and corporate companies with hired farm managers. Henceforth, two business models are distinguished: (1) the commercial family farm vine-growers; and (2) the corporate winegrowers, including mostly SMEs.

The interviewee's differentiation according their business model, "family vine-growers" or "corporate winegrowers", was associated with the farmer's narratives in the content analysis. Based on this classification, we have analysed the content of the interviews, which has generated a corpus that is described as follows: 20 texts (the narratives) arranged in 1397 segments with 10,174 occurrences (words).

The application of the Reinert method, with the Iramuteq software, makes it possible to group the interviewees' speeches according to their social representations because, by lexically associating the words, it also groups the corpus into stable categories. The creation of these categories is based on statistical analyses of chi-square distribution (χ^2) for the words. That is, by using the χ^2, the software makes inferences about how "strong" the link is among the words and between each of the generated categories [65]. It thus allows for a qualitative analysis of the discourses, but one that also has a quantitative component. Each category is associated with a set of words with the highest chi-square (χ^2) (that is, χ^2 represents how "strong" the link between the active form and the category is) [65]. The result is shown in Figure 1, which presents the DHC of the corpus in different categories and words according to the highest χ^2. The application of Reinert's method for our case is shown graphically, in Figure 1, in which the classification of the corpus into three different categories, generated by the software, based on the highest χ^2 of the words employed in the speeches, is visualised.



Class 3		Class 1		Class 2	
Form	**X²**	**Form**	**X²**	**Form**	**X²**
Talk	70.98	Year	82.03	Vineyard	95.11
Try	59.56	Time	37.76	Say	38.29
Hand	48.37	Find	36.26	Want	38.06
Douro	44.20	Grass	28.83	Wine	28.44
Work	41.44	Slope	27.37	Understand	26.83
Use	41.44	Get	25.89	Hectare	25.25
Person	37.26	Level	23.23	Give	23.68
Insect	33.08	Line	22.95	Area	23.63
Treatment	330.8	Stay	21.53	Company	18.84
Agriculture	28.92	Grapevine	20.29	Thing	16.11
Labour	27.67	Apply	18.56	Treat	15.67
Pass	24.76	Inter-row cultivation	15.89	People	14.09
Take	20.61	Cover cropping	14.81	Production	12.51
Vitis	20.61	End	14.22	Philosophy	12.51
Fruit	20.61	Vine bards	12.97	Project	12.51
Protect	20.61	Delete	12.97	Side	11.40
Missing	20.61	Day	12.97	Start	10.98
Avoid	20.61	Cost	12.97	Sustainability	10.93
Engineer	20.61	Cut	12.97	Viticulture	9.41
Corridor	20.61	Control	12.78	Zone	9.36

Figure 1. Classification of the interviewees' speeches according to DHC. Source: research data analysed by the Iramuteq software.

Class 2, designated "global winemakers" (39.2% of the interviewees), has a discourse centred on winegrowing (using words such as "vineyard", "wine", "viticulture") at a certain production scale (illustrated with words such as "hectare", "area", "production"), and reflects a company philosophy which includes sustainability (to which words like "company", "project", "philosophy", and "sustainability" bear witness). This class includes the EIs' innovation frontrunners that are largely responsible by the "niches" where the innovation has been tested and experimented along the years. These are the local actors lined up with the "landscape" of the global wine demand and market sustainability requirements. Hence, they want to change, and are changing, the winegrowing "regime" at the region level. Their influence exerts both by controlling a large area of vine in the region, buying the grapevines of hundreds of small-scale vine-growers, and being institutionally organised into a winegrowers association strongly networked with the scientific sector and with the global wine markets. This group of winegrowers is aware of EIs effect in enhancing the quality of grapes and wines, hence amplifying the competitive marketing advantages of the innovation highlighted by all the respondents. They also show being aware of the importance of the ecosystem services provided by the EIs to their vineyards, comprising the biological pest control, the control of soil erosion and, in some cases, the soil humidity. They handle scientific knowledge on agroecological aspects well and are engaged in generating in-field empirical knowledge through experimenting, monitoring, and registration practices.

The middle category generated by the DHC, class 1, which has been called "observing and reproducing the techniques", corresponds to the largest group of interviewees (41.2%) and refers to those farmers who use EIs by way of imitation and in-field learning. This is related to the occurrence of purely technical words in the discourse, such as "slope", "grass", "inter-row cultivation", "cover cropping", or "vine bards", which seems to indicate they are engaged in active learning processes focused on the technical aspects of implementing the EIs. The discourse of these winegrowers suggests they have transition pathways that are less advanced than "global winemakers" regarding lining-up directly with the landscape. On the other hand, these discourses evidence a change in the regime regarding the winegrowing at the regional scale. In addition, they also show an agency role of the "global winemakers" directly lined up with the landscape.

Finally, the category furthest from the global winemakers group (class 3), called "labour constraints", corresponds to 19.6% of the interviewees and represents those who face labour constraints when setting up EIs; this is evident in the use of the words "trabalho" (work) and "mão" (hand); in Portuguese,"trabalho" (whose χ^2 is 41.44), together with "mão", refers to "mão-de-obra" (labour); the second occurrence of "work" has a χ^2 of 27.67. This group comprises mainly small and medium winegrowers that do bulk sell of their grapevines, hence perceiving the agroecological benefits of the innovation by observing it on others' winegrowers. Their transition pathways are still emerging, and they emphasise the difficulties they experience, likely due to the cognitive burden of the learning process alongside their labour shortcoming.

The Similarity Analysis, on its turn, represents another possibility of content treatment offered by the software. If the Reinert method provides a stable classification of the corpus, based on the use of information about the largest χ^2 of the words used, the Similarity Analysis provides other interpretation possibilities. It represents, graphically, which subjects are more relevant in the discourse, demonstrating the connections between words in the textual construction. We call this connection co-occurrence between words, and it reveals the interviewees representations when dealing with a given theme as well as the semantic relations they make when discussing a given subject [64,65]. Figure 2 graphically represents the result of this analysis, revealing the connections between words and concepts that are mobilised by the interviewees when talking about IEs.

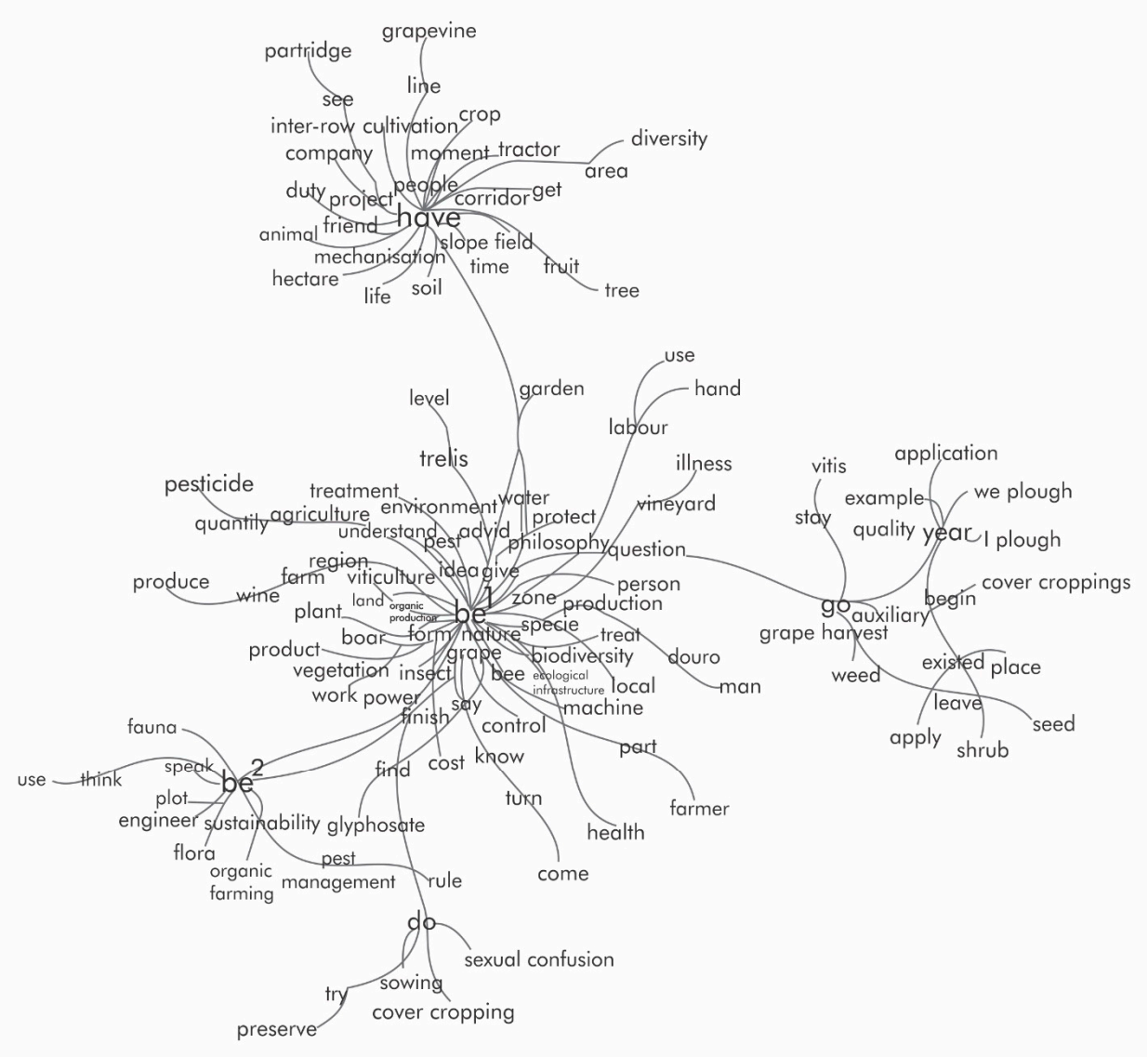


Figure 2. Co-occurrence between words. Source: research data analysed by the Iramuteq software

Figure 2 documents the co-occurrence of the words in the corpus. It is obtained by applying Similarity Analysis to the interviewees' discourse. In this analysis, words are connected according to how they relate to each other. The visual form of the Similarity Analysis makes explicit the diversity of representations that were used and the connections between underlying concepts, ideas and meanings of the words used by the interviewees to describe how they use EIs.

A first look at the Similitude Analysis chart (Figure 2) has revealed that at the core of discourses are verbs used by farmers to describe their EIs practices. However, before we go any further, there is an aspect regarding the translation of interviewees' discourses from Portuguese to English that needs to be clarified.

In Portuguese, the verb "be" can actually be translated into two different verbs: "ser" and "estar". The first verb, "ser", refers to the state of existing, expressing the essence and, somehow, conveying a certain notion of permanence; as to "estar", it refers to what someone/something is at a given moment in time. In Figure 2, "ser" is represented as be^{1} and "estar" as be^{2}, respectively.

Thus, "be^{1}" is central and relates to dynamic verbs like "go" and "do", to a verb for possession, "have", and to a verb expressing a temporary situation, "be^{2}". "Have" is connected with words reflecting the conditions (resources) for EIs to be implemented

(time, hectare, area, people, and tractor) as well as to those indicating more sustainable practices (animal, diversity, partridge, tree, and life). The term "be[1]" also relates to words expressing conditions and indicators, but it is also connected to words referring to human aspects (farmer, man, consumer, person, and labour), and to space (region, environment, Douro, zone, and background). On the other hand, "do", "go", and "be[2]" have to do with agricultural practices associated with EIs (sowing, cover cropping, I plough, seed, and apply) and the wine product (grape harvest, wine, product, production, produce, and grapes).

4. Discussion

The first analysis, the Descending Hierarchical Classification (Figure 1), shows how categories are formed according to the value of the chi-squared of the words used by interviewees in their discourses; that is, it highlights which words are more expressive in their narratives. The categories were designated as "global winemakers", "observing and reproducing the techniques", and "labour constraints". This classification as well as the designation of each category has been strengthened by another interface resource: the identification of text segments associated with each category, which makes it possible to do a qualitative analysis of the corpus [63] based on the most statistically relevant words.

The category "global winemakers" associates EIs with "wine" production occurring within the "company" and with the "philosophy" of producing towards "sustainability". Therefore, this category includes grape growers who also transform and trade wine products. This association of words and ideas is corroborated by the following segments: "You have to agree that our business is making wine, growing grapes and then making wine . . . " (interviewee no. 13); "the wine we have, there is also this commitment, is a food product, too, that is much more sustainable, consumers know they are consuming this" (interviewee no. 9).

It is worth mentioning this group's discourse does relate winegrowing sustainability with companies' financial management by applying agroecological techniques that have been properly tested and gradually replaced. However, it is not enough to ensure the companies' economic sustainability—the wine itself must be "eco-friendly" and associated with the "consumer's health". Let us exemplify: "Nowadays, in terms of EIs, we have fauna and flora and a number of means that do not have to be built, what is important is to preserve, and not to destroy; this is not about a policy, it is about a philosophy, a change of paradigm, more than a silly and radical concern over ecological enhancement "(interviewee no. 9).

The "observing and reproducing the techniques" category associates EIs with managing vine auxiliary insects, since the word "corridor" refers to those that are ecological, helping displace insects between and within cropping areas. This practice is highlighted in some passages of the discourse: "We have created corridors because I get it that I have more auxiliaries in a certain part of the farm . . . . It has already happened that I grabbed small pieces of wood that had auxiliaries, eggs, and I disseminated them" (interviewee no. 31); " . . . we have ecological corridors surrounding almost all over the farm, we always have spots where there is undergrowth and vegetation" (interviewee no. 20). Farmers in this category associate EIs with several practices like "cover cropping"; "grass" management between vineyard "rows"; grass in "slopes" or "terraces": "Cover cropping started already with integrated pest management (IPM), it has been going on for many years . . . , it was with these programmes that cover cropping began. We do the two variants, sown and natural . . . " (interviewee no. 39); "I leave the grass between the rows all over the farm, not only because IPM requires it but also because it does not allow me to use herbicide between the rows. In the rows we do use herbicide, though; we use what is feasible (interviewee no. 31)". Hence, the dominant discourse of this group of winegrowers shows a very technical conception of the EIs innovation, very much focused on vine cultivation. This suggests they are deeply engaged in the learning processes on how to implement the EIs properly.

The "labour constraints" category clearly shows the difficulties of operating innovation due to labour limitations; in fact, interviewees claim EIs demand much labour: " . . . there should not even be herbicides; because of the lack of labour we use them. If that does harm to the soil, it does harm to vineyards, too, to their quality and longevity" (interviewee no. 12); "Afterwards, the result is that one has to have much labour and labour is not only expensive but scarce" (interviewee no. 32). The discourse of these winegrowers unveils economic barriers to the expansion and to the agroecological transition at the region level. However, on the other hand, it shows that path-dependency of conventional winegrowing sociotechnical regime has been unlocked by the local social capital, given that the discourse of this group of winegrowers is lined up with sustainability concerns and beliefs expressed by the other groups, in line with the "landscape" demands.

The Similitude Analysis shown that interviewees resort to a wide vocabulary when discussing EIs. Farmers use words from various contexts, revealing their knowledge of such matters as agronomy, oenology, and ecology in relation to agricultural practices, markets, work, and legislation. Besides the lexicon, they appear to dispose of a whole cognitive universe that enables them to discuss the relationship between human beings, agriculture, and nature using environment-related words like fauna, flora, tree, animal, bee, environment, and species; and others regarding agricultural practices, the transformation sector, and the market, such as terrace, mechanisation, slope, vine row, I plough, vine, vineyard, produce, consume, quantity, quality; and social component-related words like man, person, and people.

EIs are associated with and operationalised through many practices, such as "corridors for auxiliary insects", "sexual confusion", "organic farming", "cover cropping", and the use of "herbicides", or even the native vineyard cohabiting fauna ("wild boar" and "partridge"). When dealing with EIs, interviewees also mention the "soil" and the "water", indicating that they manage innovation in a complex and comprehensive way vis-à-vis the whole agroecological system. All these practices may have different degrees of sophistication, going from what the legislation imposes (like determinations of the IPM) to farmers perfecting and implementing their own methods of managing the vineyard agroecosystem. On the other hand, the use of such words as "sustainability" and "diversity" points to these farmers' discourse being connected with a shift in social rules, suggesting there lies the beginning of a sociotechnical transition.

As to the spreading of innovation throughout the Douro socioprofessional fabric, it is clear that as important as the sectoral development association may have been in proposing and incubating the techniques at the beginning of the process, it is not often mentioned by the interviewees. However, those who mentioned it remember having collaborated in experiments carried out in their cropping areas: "This company is part of . . . , is associated with, . . . we are a little bit ahead of everybody because we participated in several trials, we were part of the operational group" (interviewee no. 39); " . . . we have noticed that in our EIs some (insects) auxiliaries are there thanks to the cooperation with the association, because we are members and auxiliaries living in this EI have been observed and identified" (interviewee no. 31)

The "engineers" mentioned in the "labour constraints" category play an essential role in spreading information about EIs, and there is one who is referred to in several interviews, which means there is a personal and professional flow of knowledge between farms regardless of their being small or large holdings, family-run, or corporate-run. With regard to disseminating innovation and knowledge, the IPM also stands out. In DHC, IPM occupies the 31st position in the chi-squared relation of the forms for category of "global winemakers" ($X^2 = 7.58$).

To examine these trajectories under the MLP, we will admit, as the best conceptual delimitation, that the niche is represented by the type of viticulture that uses agroecological techniques, that the regime is territorialised around the Douro wine sector, and that the landscape represents commercial winegrowing at a supranational level. Figure 3 represents

each of these trajectories that have been combined in one Multi-Level Perspective scheme to make the analysis more concise.

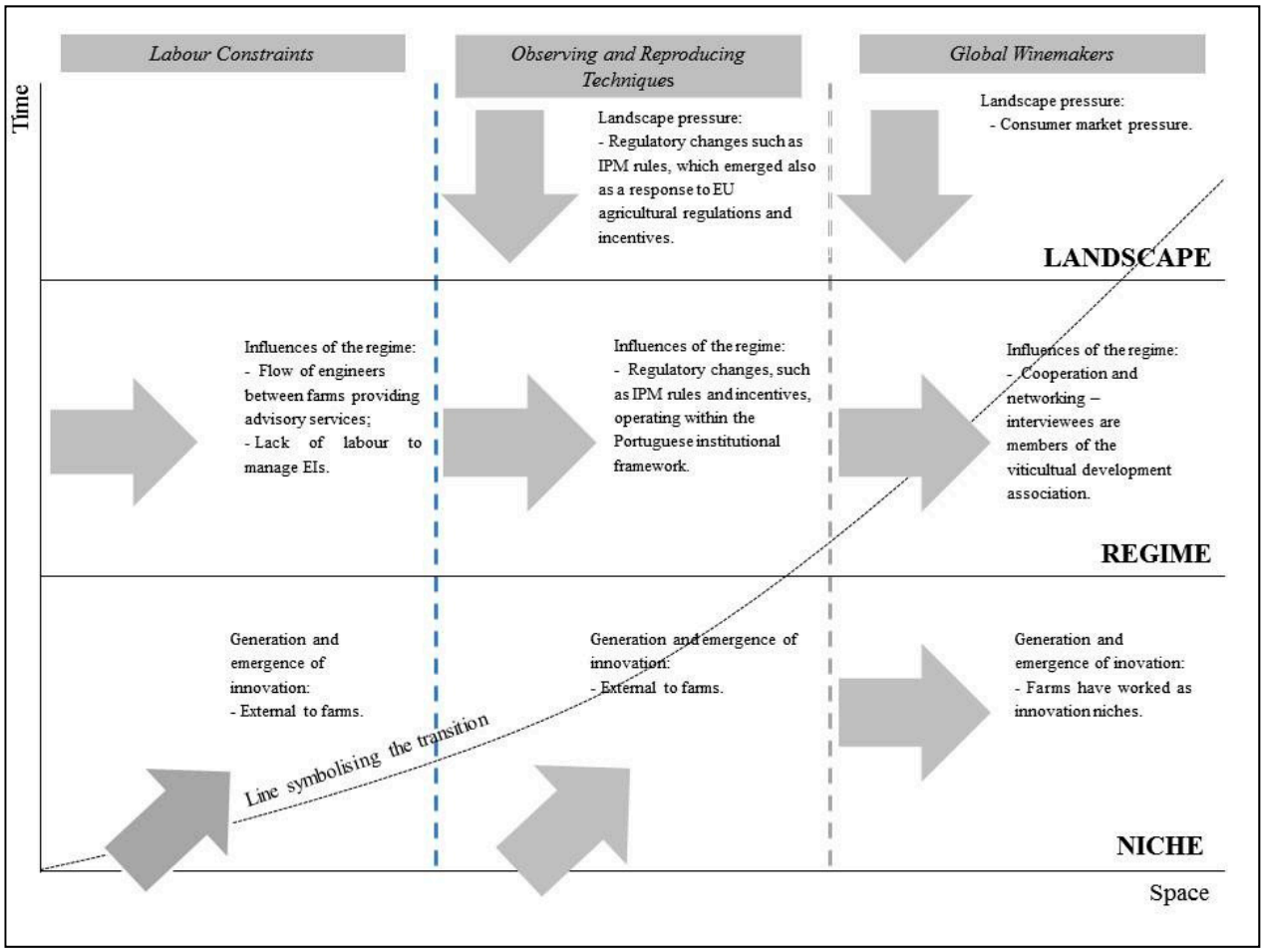


Figure 3. Representation of the overlapping of niche, regime, and landscape influence, creating different trajectories of adopting innovation and an ongoing transition. Source: Adapted from Geels [14] and created from data gathered in the course of the present research.

It is assumed the dotted trajectory represents the winegrowing transition engendered by farmers in space (Douro wine region) × time. These transitions are non-linear, distinct phenomena for each of the categories that have been identified. On the other hand, the arrows represent the niche, regime, and landscape elements that interact with each group and motivate them to adopt innovation.

The analysis has shown the "global winemakers" group is composed of winegrowing companies which have had cope with the competition from the non-traditional "new world" wine regions that have recently expanded their position in the premium quality wine global markets. This has caused more competition in an increasingly globalised trade that is now ruled by new consumption trends that value environment and production aspects extrinsic to the product. Seeing as winegrowing areas all over the world have begun to associate their products to environment-related characteristics deemed competitive edges, adopting EIs is believed to be an adaptation strategy of the Douro winegrowing companies that have begun to articulate agroecological practices with the demands of this new market [66,67].

Some of the interviewees belonging to the "global winemakers" category are also involved in wine tourism activities (wine tasting, hotels, and gastronomy). This way, they are directly exposed to the influence of the international guests they receive. As followers of new consumption trends and lovers of wines that "tell a story" [68], these

guests put pressure on this model of doing business, forcing owners/managers to transform their processes, products, and marketing. In this case, it is clear the importance of the sociotechnical landscape on the transition process: assuming that the landscape is defined as the wine trade at global level, it follows that some farmers in Douro have a saying in how the landscape is operated, integrating and directing it. Obviously, this must be done in articulation with the niche and the regime if the changes that are necessary to operate internationally are to take place.

Narratives show that those included in this category have been able to develop EIs that are more suitable to their farms' ecological component. This is the result of these companies having worked with innovation niches by collaborating with the sectoral development association, which is well connected with the scientific sector, and having used their farms as testing environment. Because they have engineers in agricultural and oenological managerial positions, one may assume these farms are not only more fully equipped to systematise experimental data but also possess more scientific knowledge to treat information in a more ordained manner and create their own strategies to manage the agroecosystem. This is in keeping with another aspect that has already been addressed by scientific literature: farmers' need to develop specific skills to carry out sustainable agriculture [69].

The "observing and reproducing the techniques" category is made up of farmers who are incorporating knowledge regarding vegetation management within cultivation areas. They report the use of several techniques, have the necessary conditions, and are (both technically and financially) motivated to implement them. They emphasise the role of politics in their decision-making process and they mention IPM rules. At this point, it should be noted that we represent IPM rules both at landscape and regime level, since they result from adjusting Portuguese legislation to EU directives, placing it in both levels in territorial terms (of what legitimately influences local viticulture) and in terms of global pressure on the wine sector. Again, in this case, the sociotechnical landscape influences territorial transition.

The "labour constraints" category includes farmers who did not mention any landscape elements likely to have influenced them. These are farm owners who face labour shortage to work in the vineyards. In addition, they tended to be older than the average winegrowers from the other categories. Most of them sell their grapes to local cooperatives (which, in turn, do not seem to acknowledge the use of differentiated agroecological management techniques and, consequently, fail to pay them accordingly). For these farmers, innovation was designed outside their farms and its techniques introduced by "engineers" who act as advisors. Despite not mentioning any landscape element, these farmers are, nevertheless, under the influence of this level, since their discourse is in line with the practices of EIs they implement, although technically not so accurately.

These findings unveil that the agroecological transition at the Douro wine region is underway, although encompassing uneven farmer-level transition pathways. The knowledge flow between farmers of the three different categories and the fact that some of the smaller vine-growers are grape suppliers of the "global winemakers" has reconfigured the local social capital towards the agroecological winegrowing in the region. Despite the persistence of economic barriers related to labour scarcity of family farms, the sustainability beliefs are shared and are part of the novel social norm in favour of agroecological winegrowing in the region.

5. Conclusions

In order to contribute to the strand of studies that make use of the Multi-Level Perspective (MLP) to investigate transitions towards sustainability in agriculture as well as to contribute to enhancing the MLP framework, we focused on the microscale transition pathways of winegrowers implementing an agroecological innovation, the EIs, in Portugal's Douro wine region.

The available evidence offered by the literature review stresses the existence of research gaps concerning understanding of the sociotechnical transition phenomena occurring at territorial scales [70,71]. Additionally, the literature points out the shortcomings of MLP, respecting its ability to capture these microphenomena of transition [27–30].

The first conclusion is that understanding transitions triggered by agroecological innovations at the territorial level entails studying microscale farm-level transition pathways. Even when analysing a single territorial space, agroecological innovations able of triggering transition processes are of complex operationalisation when they express themselves as a different set of practices to each farmer. On top of that, these different sets tend to be carried out and monitored differently by farmers according to their agroecological, economic, and cognitive resources endowment. The fact that farmers hold different understandings of the innovation accentuates the unevenness of the farm-level transition pathways. These variable meanings of what innovation is are also a consequence of farmer's uneven perceptions of the influence of the different levels of the MLP framework.

By combining the MLP with the discourse of the agents of innovation themselves, in this case the winegrowers of the Douro wine region, we could conclude that the MLP, if aligned with a methodology that allows it to be more far-reaching, can reveal transitions at smaller scales. However, Geels [4] already indicated that research on complex phenomena, such as transitions, cannot be reduced to the application of methodological procedures and will always demand elements of creative interpretation by the researcher.

This second conclusion suggests there is a need for more in-depth research on the transitions undergoing at the territorial scales, alongside efforts to a clear delimitation of the analytical levels of MLP.

The methodological approach introduced by this study shows potential interesting for mapping transitions at the microscale and to understand territorial level transitions. Besides, our research approach to the MLP revealed the agency done by individuals. It unveiled actor's interactions which shape both individual and territorial trajectories. Employing collection and analysis tools that help one see these microscale pathways broadens the scope of the MLP and, therefore, contributes to a better understanding of all niche, regime, and landscape elements that align to make room for a transition process. This use of MLP also gives it a practical edge as it enables it to provide inputs for understanding the emergence and diffusion of endogenous innovations, which start from the universe of individuals who create and adopt them.

Regarding the definitions and delimitations of niche and regime that are still considered to be a sign that the MLP has weaknesses needing to be overcome [72], first, we have been able to observe that in regard to the Douro wine region, the niche does elude the classical concept. It is not exactly a protected environment or an incubator where radical innovation can be tested until it is structured [16]. This definition does not apply to those farms whose owners/managers took the initiative of allocating a part of their areas to test innovation.

In addition, it is our opinion, the landscape dynamics and influences should be further developed in future studies [31]. In Douro, we are faced with a situation in which a group of farmers not only feel the pressure of the landscape, but also determine how to operate it. Because their farms are niches where EIs can be developed, these farmers contribute to implementing and spreading innovation, keeping up with the dynamics of viticulture at a global level while disrupting it locally. In the end, this influences those who, despite being part of the regime, are not under the direct influence of the landscape. In other words, our research has shown that there may be some transition cases where there is a close cause-and-effect relationship between the dynamics of niche and landscape. Therefore, the latter cannot be underestimated by transition studies.

With regard to the regime, it is worth mentioning its heterogeneous nature in terms of practices, technologies, rules, and institutions [19], and also of how it responds to introducing innovation. Wigboldus et al. [1] have drawn the attention to the fact that the regime is a "constellation" of systems of practice and interactions that must be taken into

consideration by studies on the subject. Hence, the use of MLP as an analytic tool must be done in articulation with research methodologies that are capable of capturing the regime's diverse nature.

Another weakness of the MLP that is also reported in the literature is its inadequacy to understand the role of practices and their agency in transitions [73]. Nevertheless, a second look at how the actors relate to innovation shows there is room for improvement. The analysis of farmers' narratives and the subsequent display of the results in a MLP scheme has helped us bring to light the agency of all those involved, thus ratifying the notion that agroecological transitions are, indeed, based on changes in rules, institutions, actors, and organisations [74]; furthermore, the present case highlights the importance of professionals' agency and the role of legislation, which were crucial in encouraging new ideas and practices.

However, proposals of public policies for transition towards sustainability and the design of strategies to achieve the desired transition must not dismiss the fact that innovation can take many paths, especially when one is dealing with agroecological innovation, which depends on a sum of overlapping and complementary systems, as is the case of agroecological, sociotechnical, and socioecological systems [6]. The innovation in question seems to be linked to interpersonal relation aspects and the sharing of knowledge, since EIs-related knowledge and philosophy have spread among all the farmers in Douro, albeit in a fragmented manner. In addition, this is clear from the introduction of some practices, the "observing and reproducing the techniques" category, and the shift in discourse among those in the "labour constraints" category. Moreover, this type of innovation depends not only on agricultural, technical, and ecological aspects but also, and to a great extent, on the available social capital.

Further research on multi-niche transitions remains open, based on the assumption that the agricultural transition is accompanied by sociotechnical changes in food processing, distribution, and consumption. Multi-niche approach to the study of the transitions would enlarge MLP amplitude to disentangle cross-sectoral transitions interconnecting multiple niches and regimes to line up to a broader landscape.

Moreover, as regards the innovation niche, more thorough analyses should be done in order to ascertain the specificities of transition management from the perspective of innovative companies, seeking to understand innovation of actors' personal and professional characteristics and their subjective goals and beliefs.

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