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MULTI-DIMENSIONALITY OF LAND TRANSFORMATIONS: FROM DEFINITION TO PERSPECTIVES ON LAND ABANDONMENT

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Abstract: Among land transformations, agricultural land abandonment is increasingly attracting attention of both the scientific community and the policy makers. However, studies have often showed contradictory findings on agricultural land abandonment. This is because, land abandonment is a process which is often differently defined, measured, studied and compared across regions. The aim of this study is to disentangle the multi-dimensionality of this process for a better understanding of its role within land change systems. Based on a synthesis of the scientific literature and policy documents, we first discuss the various understandings of abandonment by presenting the definitions and terms used in literature, then, we identify the multi-dimensionality of land abandonment by presenting the perspectives that have been adopted in studying it, as well as the various research topics linked to it. Finally, we discuss the implications for comparative research and the need of new research paths on how to further develop the understanding of abandonment and its different dimensions, as well as their interconnections.

Keywords: land transformations, Earth System, Land system science, land abandonment.

1. INTRODUCTION

Land is currently under continuous pressure from urban expansion, soil sealing and degradation caused by unsustainable management practices. Thus, there are growing concerns over the need to protect land resources. In the context of ongoing climate changes (IPCC, 2019), desertification, massive wildfires and depletion of food providing areas (Wang, 2019), understanding the ongoing changes in land systems becomes imperative. This is particularly important for fragile land ecosystems and regions where communities depend on land for survival.

Land transformations, encompassing changes in land cover, use and function (Verburg et al., 2009), are among the processes with the potential to undermine human welfare and the long-term sustainability of human societies, including the resilience of the Earth System. Ongoing major land transformations at global scale are soil sealing due to expansion of built areas (van Vliet, 2019), land abandonment (Campbell et al., 2008), forest depletion and intensification of agricultural activities (Creutzig et al., 2019). Gaining an understanding of these transformations is an important task for land system science as well as the connected fields. From local to global scales, characterizing land transformations is helpful in understanding the impacts on human and natural environments.

Among land transformations, land abandonment is increasingly attracting attention of both scientific community and policy makers. However, land abandonment describes a process which is often differently defined, measured and studied. Keenleyside et al., (2010) noted that it is a complex and gradual process that proved difficult to define and recognize as it can have a temporary, transitional or permanent status. Moravec & Zemeckis (2007) highlighted that there are different interpretations between the legal context and the scientific texts. Furthermore, there is no consensus on whether abandonment means the cessation or deintensification of management activities. Over time, studies have seen land abandonment as a process, a land use/land cover change or an output of socio-economic and policy drivers, all these perspectives leading to unclarities regarding its consequences.

In this paper, we consider land abandonment to be a multidimensional land transformation which manifests differently depending on the land use/land cover classes included in its definition, the time passed since abandonment started, and the perspective from which it is studied (Fig. 1). Each of the three dimensions we proposed influence the way abandonment is measured and conceptualized. Thus, a clear understanding of land abandonment as a particular land transformation is needed. For the research community, clarifications will improve the transferability of the findings and consequently, estimations of the extent of abandoned areas could be conducted consistently. For policy, it will offer a clearer view on transferability of mitigation measures.

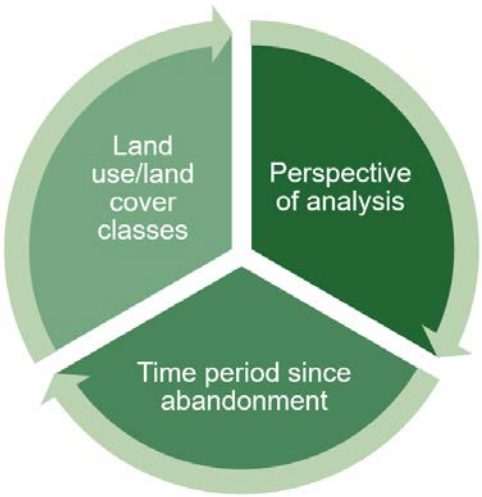

Figure 1. Multiple dimensions for defining and understanding land abandonment

The aim of this study is to disentangle the multi-dimensionality of land abandonment process to better understand its role in land systems change. This is achieved through addressing the following objectives:

a) reveal the diversity of definitions of land abandonment,
b) identify the various perspectives, typologies and research topics in land abandonment studies,
c) discuss challenges arising from the various perspectives on land abandonment.

2. METHODS

2.1. Literature selection

To identify the different perspectives on land abandonment, we conducted a review of peered-reviewed scientific literature published in international scientific journals and reports from organizations or international government bodies. To select the peered-reviewed scientific literature, we conducted a systematic search in Web of Science, with the search words “land abandonment” OR “abandoned land”. OR “cropland abandon” OR “abandoned crop” OR “vacant land” OR “marginal land”, for the timespan 1995 – 2019. We did not include studies which address fallow land. The search resulted in 1549 potentially relevant publications, out of which, 136 were selected for inclusion in this study after screening the title and abstract first, and subsequently reading the full paper. The final database included 129 scientific articles, 4 review articles, and 3 reports from organizations or international government bodies.

Selected literature covers different regions of the world and address different research topics. We were interested in aspects such as variety of definitions and the number of the papers published on a specific topic linked to abandonment. Since the concept of land abandonment encompasses a broad range of understandings, our approach allowed us to integrate both scientific and practice-oriented documents.

2.2. Protocol for literature review

All the documents were imported in MAXQDA then read in order to identify the following: (1) publication year, (2) type of document, coded as research article, review article or report; (3) geographical coverage of the study, coded by country name, region or global; (4) the definition of land abandonment, which we coded as explicit, if there was one provided in the document, or as implicit, if any part of the document provided the context for understanding what the authors mean by abandonment; (5) years passed for land to be considered abandoned; (6) the type of land uses included in the definition of abandoned land; (7) the terminology used to define abandonment; (8) perspectives from which abandonment is defined; (9) the topics of research. The information gathered is presented both qualitatively and quantitatively in the results section.

3. RESULTS

3.1. Case study evidence

Most studies on land abandonment were conducted in Europe (Fig. 2). This included country investigation (57% of the studies) and Europe wide

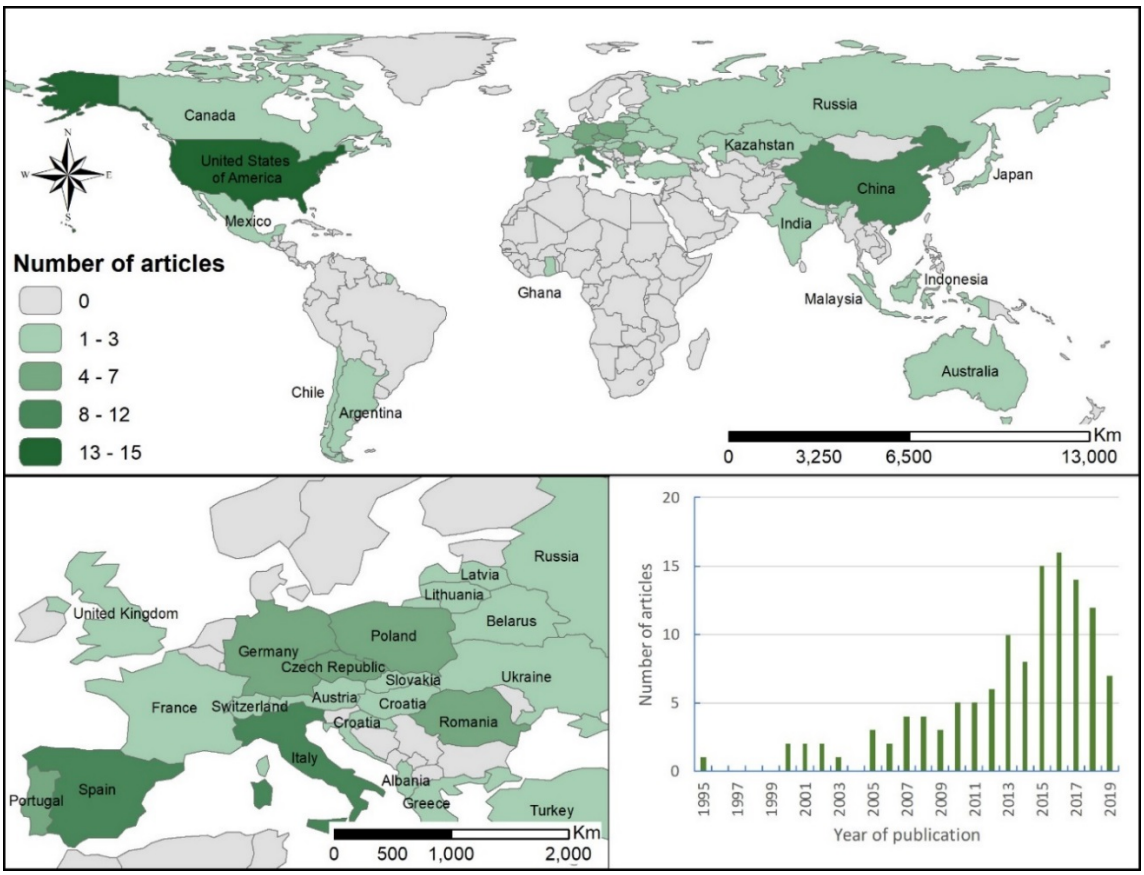

Figure 2. Country coverage of studies on land abandonment and the dynamics of publication

assessments (13% of studies). Several studies were conducted in the United States (11%) and China (9%). Interestingly, most studies are conducted in the Global North, with only few assessments conducted in the Global South. Global assessments consisted 5% of the total number of reviewed documents. The number of studies increased steady after 2007, with a peak registered in 2016.

3.2. Definitions of land abandonment

Out of all the reviewed documents, 41% provided an explicit definition of abandoned land. Explicit definitions made clear reference to the loss of the production function, plot characteristics (e.g. size, shape) or transition from one land cover to another. Table 1 provides examples of definitions provided by various authors.

In terms of land uses/land cover, the largest share of the reviewed documents focused on abandonment of agricultural land (87%). Additionally, studies make explicit mentioning of open spaces (15%), pastures (6%), forests (2%), orchards (2%), paddy fields (1%). Only few of the studies include built spaces (8%), such as commercial and industrial land, in the abandoned land definition.

Only 11% of the documents referred to a specific time period for a plot to be unmanaged or uncultivated to consider it abandoned. Out of them, most studies classified land as abandoned if plots have been unmanaged or uncropped between two to five years (Table 2). Longer time periods are generally mentioned in studies based on remote sensing imagery or pre-existent land cover databases, where data availability conditions analysis. While scientific documents made use of more diverse definitions depending on the context and the research topic, reports included clear time periods with no management for a plot to be considered abandoned, mainly as a way to standardize the concept and ease comparison along different regions and countries. For example, Bulgarian authorities defined abandoned agricultural land as a "land that has not been cultivated and/or cropped for at least 3 years", while other authorities in parts of Central and Eastern Europe defined it as land which has not been used for agricultural production for at least two years (IEEP, 2005).

Studies used various synonyms for the term abandoned land, including *abandoned cropland* (Baxter & Calvert, 2017), *abandoned agricultural land* (Prishchepov et al., 2012), *abandoned farmland* (García-Ruiz & Lana-Renault, 2011), *idle land*, (Ardiwijaya et al., 2015), *vacant land* (Brito-Henriques & Morgado Sousa, 2017) and *underutilized*

Table 1. Definitions of land abandonment by various authors

Definitions of abandoned lands/land abandonment	References
Lands that occur in the center of the city to outskirts, who intentionally and unintentionally are abandoned by speculators;	Ardiwijaya et al., (2015)
A shift from a cropland system to a mosaic cropland system or a (semi)natural system, or as a shift from a mosaic cropland system to a (semi)natural system;	Van Asselen & Verburg (2013)
Land area that was once used for, or declared as, agricultural cropland but is no longer (considered to be) performing that function;	Baxter & Calvert (2017)
Areas that have been abandoned to crop and pasture due to the relocation of agriculture and due to degradation from intensive use;	Campbell et al., (2008)
Land cultivated in 1988 but re-colonised by shrubs (new abandonment) or by more advanced vegetation successional stages (old abandonment) in 2007 aerial photos and/or field surveys;	Carlesi et al., (2013)
Land is either pitched for redevelopment or, more often than not, ignored given its little political constituency;	Desimini (2013)
Former agricultural land that has been abandoned or land that were occupied with buildings prior to their demolition;	Gavrilidis et al., (2016)
Any parcel that previously has had an agricultural use (either arable, pasture, orchards, etc.), and has been unutilized or underutilized for more than three years;	Grădinaru et al., (2015)
Abandoned in the process of zoning primary farmland, as their potential values of primary farmland were low;	He et al., (2016)
Land in urban neighbourhoods, resulting from housing foreclosures and subsequent abandonment and demolition;	Johnson et al., (2014)
A change in land use from the traditional or recent pattern to another, less intensive pattern;	Kosmas et al., (2015)
Areas in the vicinity of artificial surfaces still waiting to be used or re-used;	Krekel et al,. (2016)
Farm abandonment can be seen as an extreme form of transition: the pursuit of income alternatives which are not related to agricultural activities at all;	Lange et al., (2013)
Alterations in the surface conditions, for instance type and density of the vegetation cover;	Löw et al., (2015)
Abandoned pixels were defined as pixels that were covered by cropland in the first time step, but not in the subsequent time step;	Müller et al., (2013)
Alteration in land-use from a traditional or recent pattern to a less intensive form or a termination of the use of managing soils;	Pazúr et al., (2014)
Land that was once under human control is released and left to nature;	Zumkehr & Campbell (2013)

Table 2. Years passed without management or cultivation for land to be considered abandoned

Years passed	Study areas	References
2-3 years	Bulgaria, Romania, Latvia, United States of America, Europe	Abolina & Luzadis (2015); Accordino & Johnson (2000); Grădinaru et al. (2019); IEEP (2005)
3-5 years	Greece, Albania, Russia, India	Kizos et al., (2011); Müller et al., (2013); Prishchepov et al., (2013); Ranganathan & Pandey (2018); Smaliychuk et al., (2016); Sojneková & Chytrý (2015)
9-12 years	Russia, Lithuania, Belarus	Prishchepov et al., (2012)
More than 15 years	Italy	Carlesi et al., (2013)

land (Li et al., 2019). Studies on the urban environment often dealt with land abandonment as included in the broader definitions of *vacant land* or *abandoned property*. For example, the study by Pagano and Bowman (2000) refers to vacant land as consisting of agricultural abandoned land, brownfields, land with recently razed or abandoned buildings and structures, uncultivated and derelict land, while for Accordino and Johnson (2000), abandoned property can include houses, apartments, commercial and industrial buildings and lots.

3.3. Perspectives on land abandonment and subsequent abandonment typologies

We identified nine broad perspectives to define and study abandonment, addressing from land cover to management practices and economic viability (Table 3). Perspectives varied according to the geographical context and emphasis on environmental, political, socio-economic or agricultural issues. Studies often defined abandonment from more than one perspective. From each perspective a certain typology of abandonment (i.e., process) or abandoned land (i.e., land cover) could be identified. The text bellow provided details on each perspective, while Table 3 provides a summary of the findings.

The largest share of studies focused on abandonment as a type of ***land cover***, either by investigating it at a certain moment in time or by observing its dynamics. Most studies adopted this perspective in parallel with one or several of the other perspectives. For example, abandoned land changes were studied in respect to the drivers and implications for agricultural policy (Cheng et al., 2015).

Studies which adopted the ***land use intensity*** perspective referred to abandonment as a deintensification process (Gellrich et al., 2007; Sroka et al., 2018). Abandonment does not necessarily mean just the transition from intensive use to cessation of activity (Kizos et al., 2011). Authors have also understood abandonment as a transition to a less intensive use in terms of agricultural production (Kosmas et al., 2015).

The ***land function*** perspective emphasized that the initial function of the land was lost. Studies mention abandoned agricultural land lost the production function (Hatna & Bakker, 2011), as vegetation developed spontaneously into grass, shrubs or even forest after a longer period. Abandonment can also mean a change in function to spaces for development of residential or service areas (Grădinaru et al., 2015). In areas with tourist

Table 3. Perspectives from which land abandonment was defined and typologies of abandonment/abandoned land

Perspective	**Typology of abandonment (process) or abandoned land (land cover) according to each perspective**
Land cover	a) Agricultural b) Built spaces c) Mixed use
Land use intensity	a) Land not used at all b) Deintensification of production
Land function	a) Agricultural production b) Habitat for species c) Space for development d) Space for recreation e) Carbon and nitrogen storage
Management activities	a) Abandonment as cessation of management activities b) Abandonment as management deintensification c) Abandonment as hidden management
Planning and policy	a) Ex-ante response to planning and policy measures b) Ex-post response to planning and policy measures
Land degradation	a) Abandonment to mitigate soil degradation b) Abandonment favours land degradation
Economic viability	a) Abandoned lands due to changes local in environmental or socio-economic changes and translocation of cultivation b) Abandonment due to land becoming more profitable if converted to other functions c) Abandonment as consequence of a sudden collapse in demand for land for development
Biodiversity	a) Abandoned land as new habitat b) Abandoned land as lost habitat
Marginalization	a) Physically marginalized land b) Economically marginalized land

attractiveness, conversion to tourist accommodation can occur. In peri-urban areas, especially in Western Europe, conversion may be to recreational areas formed by horse-breeding areas, a process known as horsification (van der Zanden et al., 2017).

Understandings from the ***management activities*** perspective referred to the abandonment process as a decision of the land owner. According to management type, abandonment can be classified as cessation of all management activities (Baxter & Calvert, 2017), a deintensification of management activities (Pazúr et al., 2014) or as hidden abandonment (IEEP, 2005), when the land is not formally abandoned but is subject to a certain form of management in order to keep it available for future use, for example in conversion to built-up areas, or to obtain subsidies.

The ***planning and policy*** perspective was adopted by studies discussing the implications of land use planning decisions on land abandonment. Abandonment is either regarded as a response to past measures (Grădinaru et al., 2015) (i.e., ex-post response) or the output of land owners' decision to a wait for future changes in planning and policy measures (Paül & Tonts, 2005) (i.e., ex-ante response). Literature proposed measures to mitigate abandonment in cities (Accordino & Johnson, 2000), and assessed as the role of agricultural policy as driver of abandonment (IEEP, 2005).

Land degradation perspective was adopted by studies on impacts of abandonment on water resource availability, soil erosion and runoff or land restoration. Abandonment can occur as a result of land overexploitation and depletion of soil nutrients (Wang et al., 2017), but can also lead to development of unmanaged vegetation prone to fire and favouring soil erosion (Bajocco et al., 2012).

From the ***economic viability*** perspective, land abandonment is understood three-fold. First, it was considered the process which occurs when agricultural activities cease to be profitable (Lange et al., 2013), such as when farming costs are higher than the profit. Secondly, abandonment can occur if agricultural land became more profitable if converted to other functions. This situation is often linked to land speculation in urban and peri-urban areas (Ardiwijaya et al., 2015). Thirdly, abandonment can be the consequence of a sudden collapse in demand for land for development (Hackworth, 2014). This situation is characteristic to shrinking cities.

The ***biodiversity*** perspective is adopted in studies on the impact of land abandonment on species and habitats. Findings largely depend on the geographic region where the study is conducted, the assessed taxa, the conservation focus (i.e. pre- or post-abandonment) and the metrics selected for assessment (Queiroz et al., 2014). Studies either consider the abandoned land as a loss of habitat, such as in areas were species depend on agricultural practices, or as a gain of habitat, particularly for bird and plant species.

Studies emphasized ***marginalization*** of the parcels as one of the defining characteristics of abandonment. Abandonment thus occurs in physically remote or socio-economic marginal areas, such as the mountain regions and areas affected by depopulation (Smaliychuk et al., 2016). Some parcels are abandoned because they are poorly suited for modern agriculture, for example because of the slope. Marginalization can also occur in urbanized areas, being represented by the periphery of the cities or the urban fringes (Li et al., 2017; Mattogno & Romano, 2016; Russo et al., 2014).

3.4. Diversity and distribution of research topics on land abandonment

A large majority of studies on land abandonment investigated drivers of land abandonment (25 % of studies), abandonment as part of an area`s land changes (14 %), the urbanization – abandonment interlinks (11 %), impact of urban growth on land abandonment (9%) and farmland protection policies (8.0%). The other research topics accounted for less than 4% each and included connections between abandonment and water management, energy production, human health, ecosystem services, spread of invasive species, wildfire incidence, nutrients storage, food security and natural hazards. Most studies presented the situation in one country, either as country wide assessments, either by focusing on smaller areas such as counties or cities (Fig. 3). Regional assessments were conducted for the European Union, the European Mediterranean area and the Global North, while global assessments were the fewest.

We observed an emphasis of the European located studies on the drivers of land abandonment topic. In contrast, studies in United States and Asia pursued more diverse topics. Several topics were addressed in specific regions or countries: wildfire incidence was documented in the European Mediterranean, while the connection between land abandonment and traditional farming and landscape perception was investigated in Europe. The impact of agricultural policy on abandonment, particularly the Common Agricultural Policy in the European Union and the prime land zoning in China, were investigated.

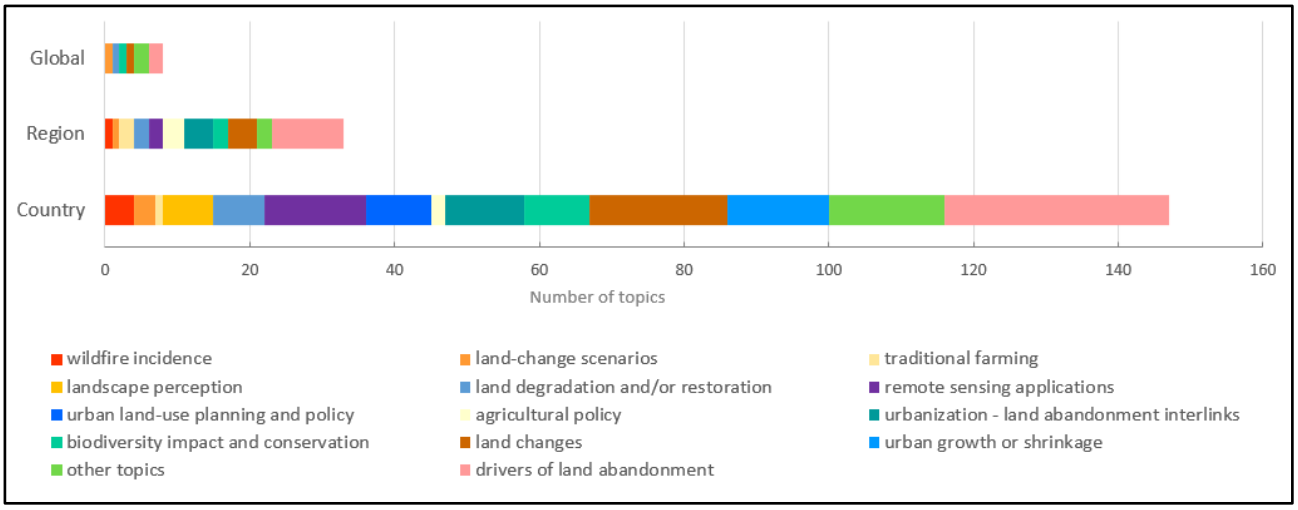

Figure 3. Research topics by geographical coverage of the studies

4. DISCUSSION

4.1. Land abandonment as multi-dimensional process

In this study we aimed to disentangle the multi-dimensionality of land abandonment based on a review of peer reviewed literature, reports by government bodies and publications on land abandonment by agriculture-oriented international organizations. Our review differs from other publication in the sense that it does not focuses on drivers and implications of abandonment (Benayas et al., 2007; van Vliet et al., 2015). Instead, our study highlights the different definitions of abandonment, perspectives on it as land transformation and its link with various research topics.

Findings show that we cannot speak of one type of land abandonment. The reviewed documents define abandonment differently, and not always explicitly. For land to be considered abandoned, periods with no management can vary between 2 and 15 years, depending on the study. Furthermore, there is a variety of terms that can be used to define abandonment. The land covers considered abandoned range from agricultural land to land uses specific to cities, such as open space and built structures. The differences can be attributed to the variety of scientific methods applied in abandonment identification. Standard procedures to identify abandoned agricultural land have been adopted by governments in the United States (Baxter & Calvert, 2017) and China (Liu et al., 2017), but are missing or unreliable in many other countries.

Irrespective of the research perspective, studies should strive for clarity in what they define as abandoned land. Involvement of public authorities in monitoring abandonment would pave the way for development of measures to mitigate the process. For example, a clear picture of land abandonment in urban regions could support its integration in green-blue infrastructures (Csete & Gulyas, 2019; Iojă et al., 2018). Furthermore, mixed methods, such as remote sensing imagery combined with field interpretations and perception surveys, could help capture the various dimensions of abandonment.

We identified nine broad perspectives to define abandonment. They included perspectives specific to land system science (i.e., land cover, land use intensity, land function, land management, land degradation), but also of related fields (planning and policy, economic viability, biodiversity, marginalization). This proves that land abandonment has broad implications which interlink the process with social, economic, political and environmental aspects. The perspectives helped classify abandonment in typologies. We are confident that the classification will support a better understanding of abandonment as a specific type of land transformation.

4.2. Implications for comparative research

Comparative investigation should be sensitive to the issues which could make generalization of findings difficult (Badiu et al., 2016). That is because land abandonment encompasses a wide array of interpretations, as different aspects of land abandonment are taken into consideration. For example, specific forms of land use change generate extremely different forms of abandoned land, to the point of creating totally different understandings and terminology (Newton, 2010). Former use of the abandoned land implies different perspectives, understandings and methodologies, agricultural land abandonment being seen as one of the most important research areas (Levers

et al., 2018; Renwick et al., 2013). Locations where the land abandonment takes place is also a differentiating aspect, as it occurs from rural to urban landscapes (Hackworth, 2014; Newman et al., 2018). Social frameworks, ideologies, major events and political orientations create further differentiation in the way land abandonment is understood. Land abandonment in the (former) communist countries has different interpretations compared to market economy and democratic countries (Prishchepov et al., 2013; van der Zanden et al., 2017).

Contrasting land abandonment implications can be reported in areas with similar characteristics. For example, in post-communist countries, land abandonment can lead to both increase in forest cover and expansion of built-up areas. When studying abandonment in an alpine part of Switzerland, Hunziker (1995) found that the abandonment is perceived both negatively and positively by locals and tourists, largely depending on the opportunities and trade-offs associated with changes in the landscape. Abandonment can negatively affect migrant farmland species and benefit resident woodland species due to the differences between the two in adaptability to resource availability and specialization. Abandoning agricultural land is considered as decreasing the fire regulation capacity and the fire protection ecosystem service, but increased fire frequency is expected from intensification of agricultural practices (Bajocco et al., 2012). Thus, contrasting impacts are explainable by specific site conditions or what the studies focus on. To allow for comparison, studies should include sufficient details on characteristics of abandoned lands and the context in which studies are conducted.

Land abandonment is a process whose impacts and consequences develop gradually. Thus, impacts identified in the studies are difficult to compare if methodological clarities regarding the stage of abandonment is not specified. For example, on abandoned lands vegetation grows progressively, in associations which differ in density and species composition. Even soil composition changes over time, having implications, for example in carbon storage capacity (Trigalet et al., 2016). Ecosystem services provision can also vary, as are the weights of the subsequent impacts (Ciocănea et al., 2019). To improve comparative research, studies need to be clearer about the characteristics of abandoned land over time (e.g. years since abandonment, vegetation dynamics, species composition over time).

5. CONCLUSIONS

Our analysis showed that understandings and definitions of abandonment vary greatly from study to study. We argue for clearer methodologies in measuring land abandonment as specific type of land transformation. In the following paragraphs we point out several research topics which would benefit from further investigations.

A thorough understanding of the underlying mechanisms that relates urbanization to changes in agricultural system is needed. Most studies have focused on drivers which affect land abandonment, and are mostly linked to macro-economic and political aspects. Studies have highlighted the potential impact of policy in driving land abandonment, but studies are needed to systematically analyse this impact. The variety of planning instruments and practices as they vary across countries should be considered in future research.

An overview of the best policy approaches to include agriculture, particularly abandoned lands, on the urban policy agenda is needed. Several studies have proposed integrating abandoned land in green infrastructure. However, there is still a need for studies that adopt a critical view on address aspects such as property rights and interest from land owners.

Very few researches investigated the impact of land use displacement on land abandonment. Placed in the context of teleconnections thinking, land use displacement is interpreted as development of new agricultural land to compensate for the agricultural land lost or abandoned. The consequence of land abandonment on food provision in the context of land use displacement has broad implications on food security and livelihood of local communities.

Finally, poor connections are made between land abandonment and cultural aspects, except for traditional farming in Europe (Hartel et al., 2020). Aspects, such as the impact of cultural believes on abandonment mitigation, is worth further investigation.

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